SUPPLEMENTI di GEOGRAFIA FISICA e DINAMICA QUATERNARIA

SUPPLEMENTO III - 1997

TOMO 1

The International Association of Geomorphologists
L'Association Internationale des Géomorphologues

FOURTH INTERNATIONAL CONFERENCE ON GEOMORPHOLOGY

QUATRIÈME CONFÉRENCE INTERNATIONALE DE GÉOMORPHOLOGIE

Organized by/Comité d'organisation
GRUPPO NAZIONALE GEOGRAFIA FISICA E GEOMORFOLOGIA
del Consiglio Nazionale delle Ricerche

Bologna (Italia) - 28-VIII / 3-IX, 1997

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1997

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FOREWORD

The «Gruppo Nazionale Geografia Fisica e Geomorfologia» of Italy, on behalf of the International Association of Geomorphologists, takes pleasure to give a warm welcome to Italy to all partecipants to Fourth International Conference on Geomorphology. The Conference intends to collect all new results in the geomorphological research. It intends also to focus on some of the topical problems and of the environment (with particular regard to the Mediterranean) with the contribution of the geomorphological studies.

Italy has examples of several different types of landscape ranging from coastal cliffs and beaches to glacial and periglacial alpine peaks, from lakes to alluvial plains and karst morphology, from active volcanoes to seismic areas, all supported by a complex geological structure. Furthermore Italy is affected by numerous natural or man-induced hazards. In fact, Italy is a country of ancient civilization and the landscape is partially modified by human activity but the intensive development of economic and urban patterns could provide an interesting subject for a study in man-made geomorphology. The organizing committee invited «Geografia Fisica e Dinamica Quaternaria» to publish the main proceedings of the Conference and the journal put at disposal its editions.

Hoping that you enjoy the Conference and Italy, very best wishes on behalf of the Italian Organizing Committee and the International Association of Geomorphologists.

The Editor in Chief
PAOLO ROBERTO FEDERICI

AVANT-PROPOS

Le «Gruppo Nazionale Geografia Fisica e Geomorfologia» d'Italie, au nom de l'Association Internationale de Geomorphologues, est heureux de souhaiter une bienvenue chaleureuse en Italie à tout les participants à la Quatrième Conférence Internationale de Géomorphologie.

Le but de la Conférence est de rassembler les derniers résultats de la recherche en géomorphologie. Son objectif est égalment de mettre l'accent sur certains problèmes d'actualité et concernants l'environnement (en particulier de la Méditerranée) avec la contribution des études en Géomorphologie.

L'Italie présente de nombreux exemples des types de paysage géomorphologique differents qui vont des côtes à falaise et dès côtes basses jusq'aux sommets alpins glaciaires et periglaciaires, dès lacs aux plaines alluviales et aux morphologies karstiques, dès volcans actifs aux zones séismiques. Le tout dans un cadre structural complexe. Par ailleurs, l'Italie possède de nombreux exemples de risques naturals ou d'origine anthropique. En effet l'Italie est un pays d'ancienne civilisation et le paysage est partiellement modifié par l'activité humaine, cependant, l'intense dévelloppement de l'économie et de l'urbanisation ouvrent la possibilité d'une suggestive extension du champ de recherche en geomorphologie. Le Comité d'Organisation a invité «Geografia Fisica e Dinamica Quaternaria» à publier les actes principaux de la Conférence et la Revue a mis à disposition ses éditions speciales.

Dans l'espoir que votre participation à la Conférence soit agréable je vous salue au nom du Comité d'Organisation et de l'Association Internationale de Geomorphologues.

le Directeur
PAOLO ROBERTO FEDERICI

PROGRAMME

Thursday, August 28th

9.00 Registration of Participants (A)
18.00 Meeting of the IAG Executive Committee (Council Room - Department of Geoenvironmental Sciences)
20.00 Dinner of the IAG Executive Committee

Friday, August 29th

8.00 Registration of Participants (A)
10.00 Opening Ceremony (St. Lucia Hall)
10.30 IAG General Assembly (St. Lucia Hall)
11.30 Pienary Lecture (St. Lucia Hall)
12.30 Lunch (E)
14.30 Opening of the Postal Office (A)
15.00 Opening of exhibition and commercial stands (D)
Session - Glacial Geomorphology (B1)
Session - Arid and Sub-arid Geomorphology (B2)
Symposium - Geomorphology and Environmental Impact Assessment (B3)
28th Binghampton Symposium - B (B4)
19.00 Welcome Party (E)

Saturday, August 30th

9.00 Session Fluvial Geomorphology - A (B1)
Session - Tectonic Geomorphology - A (B2)
28th Binghampton Symposium - B (B4)
10.30 Meeting of the Gruppo Nazionale Geografia Fisica e Geomorfologia (B3)
12.30 Lunch (E)
14.20 Plenary lecture (B1)
15.00 Session - Fluvial Geomorphology - B(B1)
Session - Tectonic Geomorphology - B (B2)
Symposium - Methods and Tools in Geomorphology (B4)
16.00 Meeting of the IAG National Delegates (B3)
19.00 Welcome of the Academic Authorities to the IAG National Delegates
20.30 Dinner of the IAG National Delegates

Sunday, August 31th

8.00 Optional local trips

Monday, September 1st

9.00 Session - Littoral and Sub-marine Geomorphology (B1)
Symposium - Geomorphology and Global Change - A (B2)
Session - Trupical Geomorphology (B3)
Symposium - Landslides Management (B4)
12.30 Lunch (E)
14.20 Plenary Lecture (B1)
15.00 Session - Volcanic Geomorphology (B1)
Symposium - Geomorphology and Global Change - B (B2)
Session - Karst (B4)
16.00 Meeting of the IAG National Delegates (B3)

Tuesday, September 2nd

9.00 Session - Applied Geomorphology - A (B1)
Symposium - Geomorphology and Global Tectonics - A (B2)
Session - Weathering and Soils (B3)
Young Geomorphology Workshop (B4)
12.30 Lunch (E)
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Wednesday, September 3rd

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Symposium - Magnitude and Frequency in Geomorphology (B2)
Round Table - Geomorphology Hazards: a European Strategy (B3)
11.00 CERG open General Assembly (B3)
12.00 Closing of the exhibitions and commercial stands (D)
12.30 Lunch (E)
14.20 Plenary Lecture (St. Lucia Hall)
15.00 IAG General Assembly (St. Lucia Hall)
17.00 Closing Ceremony (St. Lucia Hall)
18.00 Exhibition of «Collegium Musicum Almae Matris» (St. Lucia Hall)
20.30 Farewell Dinner (Parco Nord)

Thursday, September 4th

8.00 Departure for the post Conference trips
9.00 Meeting of the new IAG Executive Committee (Council Room-Department of Geoenvironmental Sciences)

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TIM B. ABBE & DAVID R. MONTGOMERY

Patterns, processes and geomorphological consequences of wood debris accumulations in channel networks

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In unmanaged forested landscapes wood debris can comprise a significant portion of the sediment budget and form the principle physical element defining the morphology of channels and alluvial valleys throughout a wide range of sizes. In small channels, wood debris can account for a significant portion of the elevation loss, whereas in larger channels such debris can form the dominate roughness element and force flow constriction, pool formation, and textural variance of the bed surface sediment. Accumulations of wood debris exhibit distinctive patterns that reflect their formative processes in different parts of a drainage basin. Field surveys in the 724 km^2 Queets River watershed on the west slope of the Olympic Mountains in Northwest Washington reveal basin-wide patterns in distinctive structural types of log jams that arise from differences in the mechanism of log recruitment, hydraulic geometry, the physical characteristics of logs, and the position of logs relative to one-another and the channel (jam structure). Classification of logs comprising wood debris accumulations into three stability categories (key, racked, and loose members) defines unique domains on a dimensionless plot of log diameter and length relative to the depth and width of the bankfull channel. Although log length is an important factor, it's influence on log stability becomes less significant as channel size increases. Our results show that log diameter and geometry are important factors governing the stability of in-stream wood debris, especially in large channels. The magnitude of local wood debris inputs also influences jam formation and becomes more important with increasing channel size. The presence of rootwads or multiple stems was also found to be an important control on log jam stability. Ten fundamental wood debris jam types can be distinguished based on the orientation of key, racked, and loose debris relative to the channel axis. The position of a jam within the channel, jam width to length ratio, channel planform geometry, topographic and bed texture variations, and spatial patterns in the age structure of trees growing on and around a jam also serve to delineate different jam types. The stability and structural integrity of a jam depends on the presence and arrangement of key and racked members. Specific jam types fall into three basic jam categories based on whether these members underwent transport once introduced into the channel. In-situ jams consist of logs lying approximately at the point they entered the channel. Transport jams form from logs that were routed downstream before coming to rest and combination jams consist of both elements. Jam types exhibit a systematic spatial distribution as a function of drainage area and channel gradient. In-situ jam frequency per unit channel length tends to decrease with increasing drainage area, whereas the frequency of combination and transport jams tends to increase to a maximum at progressively larger catchment areas before decreasing with further increases in channel size. Although some jam types have little geomorphic impact, others form stable in-stream structures influencing alluvial morphology at both sub-reach and reach length scales. Stable log jams directly influence channel anabranching, planform geometry, floodplain topography, and establishment of long-term riparian refugia. Because the formation of stable jams depends on the size and supply of wood debris introduced to the channel, these structures and their effects are integrally linked to riparian forest management. Systematic patterns and physical attributes of log accumulations and their relationship to channel morphology and gradient throughout a large drainage basin provide a basic model for patterns and processes of wood debris accumulations in forested environments. This template of natural wood debris structures offers a foundation for managing channel debris and developing stable in-stream log structures for habitat restoration and engineering applications.

ESSAM ABD EL-MOTAAL

Neotectonic and morphotectonic implications, the Nile Delta Basin, Egypt

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The present work is concerned with the study of the influence of Neogene and Quaternary tectonics (Neotectonics) on the configuration of the Nile Delta basin. Nature and distribution of the Late Miocene thick clastic sediments reveal the occurrence of three main morphotectonic units (fault - scarp, mid - delta canyon and alluvial fans) in the Late Miocene Delta basin. Morphotectonic map and diagram showing the configuration of the basin, which experienced neotectonic activity along the Hinge Zone faults during this time, have been suggested.

Comparison of the isopach maps of the Delta deposits, from Pliocene to Holocene, gives evidences of more neotectonic subsidences in the eastern reaches of the Delta basin. Distribution of the ancient Delta branches seems to have been significantly influenced by such subsidences. Changes in the configuration of the Mediterranean coastline, along the Nile Delta, may reflect neotectonic oscillatory movement during the Holocene time. Neotectonic activities of the Delta seem to be due to rejuvenations along the WNW Hinge Zone and NE Pleusium faults.

Available seismic records of the Nile Delta suggest that the area has experienced a number of shocks which, though few in numbers, are indicators of neotectonic activity. It is concluded that the Nile Delta site seems to be affected by

basement-related tectonics as it is located in a downwarped basin with numerous active normal faults. This activity can be attributed to the continuous convergence of Eurasia and Africa plates. However, regular geodetic measurements are necessarily required to quantify the recent movements of the Nile Delta faults.

YOUSEF ABU-RUKAH

Granitic terrain geomorphology of South Jordan

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Major and minor features of granitic forms and landscapes are encountered in the study area. These were shaped by fractures that were controlled by subsusface weathering and moisture driven alteration. The granitic forms and landscape include boulders of various sizes, Inselbergs landscape, nascent dome, rillen, recent exposed rocks platform on granite, bush manland surface cut in granite, stock of granite intruded into schist and partially exposed, pseudobedding in granite, stepped slope in granite, spilt rocks, core stone set in matrix of mineral banded weathered rocks, Nerviacoines in granite, contrasted granitic terrains and luminae of various thickness.

HEMA ACHYUTHAN & R. CHANDRASEKARAN

Late Neogene-Quaternary ferricretes of Jalsalmer basin, Rajasthan, India, with special reference to its formation

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Field observations of «ferricretes» in Jaisalmer basin, Rajasthan, India, reveal a variety of ferruginous horizons and crusts formed over the middle Jurassic and Eocene limestones and sandstones. They are exposed at several locations along the rain cut gullies, channels forming table land surfaces near Pokharan, Sam, Khuiyala, Khian, Shumar Wali Talai, Laki and Devikot in Jaisalmer basin. Based on geomorphological observations and field studies, three broad categories of ferricrete formations have been recognised: a) ground water, b) pedogenetic, c) combination of a and b which have been transported and deposited in the form of lag.

This paper aims to present a classification of ferricrete types and to demonstrate that the chemistry and mineralogy of ferricretes reflect varying mode of formation and modification. Micromorphological studies reveal that the groundwater and pedogenitic ferricretes have a grain supported fabric in which quartz forms 70 to 80% of the frame-work grains. Within the pore spaces, voids, cracks and fractures, Fe has formed without significant alteration of feldspars and micas. The mottles in iron mottled bedrock zones represent local oxidising environment in which Fe has precipitated from mobile solutions. Field studies and micromorphological analyses point clearly to the formation of mottled zones under ground water conditions. There is no evidence of mineral alteration or replacement in ooliths and pisolithic lag deposit which appear to have been limonitic at the time of formation. No nuclei was detected in ooliths. Concentric zones of FeO clays were observed, probably formed due to diffusion and oxidation of iron. Multiple phases of FeO mobilisation and precipitation occurs within individual ferricrete. Magnetite, goethite and hematite are the dominant minerals present with a low degree of alumina substitution. Clay mineral and chemical studies indicate that their formation has taken place mainly by chemical weathering at surface, in a very dilute acidic conditions.

Ferricretes with the greatest mineralogical diversity appear to have more complex and lengthy histories of evolution than ferricrete mottles with simple iron oxide mineralogy. Different facies of ferricretes indicate changes in chemical environmental conditions during their formation. Therefore, detailed characteristics of different ferricretes represent their epigenetic histories.

Vertical and lateral groundwater movements have accumulated FeO, while induration may have been caused by irreversible drying processes during periods of seasonal water table lowering. Geomorphological studies indicate weathering of a landscape of some relief would have led to considerable lateral variations in microenvironmental conditions causing bleaching of iron from some higher parts of the landscape and accumulation in adjacent low areas forming ferricreted sediments, slabby and vesicular ferricretes within the zone of water table fluctuation. As surface weathering, mass wasting, and erosion continued, the hematitic mottles may have been progressively exposed at the surface, where they hardened, disintegrated, transformed partially to goethite and formed lag comprising pisoliths and ooliths.

Borehole litho-log data reveals that former uniform blankets of ferricretes may have not existed covering large areas, but different types of ferricretes, mottled, bleached zones may have developed in specific sites in response to local environment. No thick residual lag deposit have been formed on steep slopes, but only thin layers of pisoliths developed within the soils that directly overlie the mottled material. Lag deposition and its formation in these areas reveal physical transport from higher to lower parts of the landscape. Thus the formation of ferricretes and their types reveal a complex combination of pedologic, hydrologic relationship covering a long span of geologic time - since the Late Neogene-Early Quaternary period.

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Integrated geomorphological analysis of a drainage basin of Sicily (Italy) as basis for the correct territorial management

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In Sicily, like in other mediterranean regions, the shaping of the relief is mainly determined by slope processes. These processes are principally surface water erosion phenomena and mass movements, and are particularly active at the time of very intense rainfall, with disastrous effects, following which the interventions usually involve great expense for the public but often have unsatisfactory results.
The correct management of a territory thus requires proper geomorphological studies, which are indispensable for the identification of relief shaping processes and the definition of their role in the evolution of the physical environment.
The case considered consists in the geomorphological study of the basin of the Fiume Imera Settentrionale (Western Sicily). The study was conducted in integrate manner. On one hand geomorphological survey and the compilation of thematic maps on various scales were carried out, with the aim at identifying active geomorphological processes; on the other hand quantitative analysis technique were used in order to assess the entity of these processes.
The examined basin flows to the Tyrrhenian shore and extends for 342 km^2; it is characterized by the presence of extensive outcroops of claystones in the middle-low sectors of the slopes and in the valley floor areas, while the upper parts of the slopes consist of successions of calcareous rocks. The whole basin presents considerable problems with regard to processes of geomorphological evolution, mainly evidenced in widespread landslide phenomena of marked cyclic character and in highly active linear and areal erosion processes affecting extensive portions of the slopes and determining diffuse geomorphologically hazardous conditions. This state has strongly influenced human activities and given rise to an agricoltural and pastural subsistence economy; while the building in the basin of a stretch of the Palermo-Catania motorway (of fundamental importance for Sicily) led to considerable impact on the environment and to drastic modifications of the river bed, which has enhanced the geomorphological risk.
This study is divided into various phases regarding geomorphological cartography on various scales and detailed field analyses of important landslide phenomena. An assessment was made of the extent of areal erosion processes by means of surveys and detailed enquiries in significant areas and through quantitative analysis of the main morphometric features of the watershed.
The findings of the research, in association with quantitative results based on measuring of solid load effected in the last few years, have made it possible to correlate theoretical data with directly measured ones. The study has allowed to assess the role of landslide and erosion phenomena in the slope processes of sample areas characterized by different geological and geomorphological conditions. It has also been possible to define the variability of the intensity of these processes in climatically homogeneous zones and to quantify the entity of erosion by the compilation of erosion index maps for homogeneous areas, thus providing the premisses for the correct management of the territory.

VALERIO AGNESI, CIPRIANO DI MAGGIO & TOMMASO MACALUSO

Morphostructural setting and geomorphological evolution in the Madonie Mountains (Northern Sicily, Italy)

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Geomorphological studies conducted in the Madonie Mountains have made it possible to identify various morphostructures responsible for the differentiation of the landscapes in this sector of the Sicilian Apennines. The tectonic style of overthrust nappes and faulted fold, which distinguishes this sector, and the lithological features of outcropping rocks have determined the occurrence of relief forms strongly controlled by structural setting. On the basis of the different geomorphological configuration it is possible to distinguish four broad sectors:
1. the Monte dei Cervi massif, consisting of rocks with different geomechanical behaviour affected by a faulted anticline; these conditions have favoured the development of forms of selective erosion and the activation of deep seated gravitational slope deformations, which have given rise respectively to structural slopes, large morphoselection depressions, trenches and areas with isolated and variously rotated blocks;
2. the Pizzo Carbonara and Pizzo Dipilo reliefs, consisting of intensely faulted and fractured calcareous rocks which have determined the presence of small and large karst forms aligned along the main tectonic directions;
3. the Monte Quacella-Monte Daino massif, consisting of intensely fractured dolomitic rocks, the escarpments of which are considerably degraded by mechanical disgregation and gravitational phenomena and are delimited by thick debris nappes;
4. piedmont areas, characterized by marly-clay and arenaceous outcrops, with cuesta type monoclinal structures that are widely affected by mass movements and surface water erosion phenomena.
The highest portions of many of the reliefs consist mainly of calcareous rocks, and present remnants of suspended

«abandoned landscapes», of extremely low relief energy, which are not consistent with the extent hydrographic systems. These forms are the oldest to be found in the Madonie area and are related to phases of shaping which, starting from the emergence of a large part of the area (Early Pliocene?) and the successive removal of the terrigenous covering, have affected the exhumed calcareous units.
The presence of great fault slopes, with fault throws of hundreds of metres, which delimit the edges of the calcareous reliefs, testifies to the existence of a distensive tectonic phase (Late Pliocene). This phase has dislocated the previous landscapes at various altitudes, determining the consequent formation of deep canyons, and the activation of fluvial deviations and stream capture.
The elevated relief energies always present in the sector, together with phases of general lifting and disjunctive phenomena, are the causes that determined accelerations in the phenomena of selective erosion and deep and superficial gravitational slope deformation (Monte dei Cervi massif and piedmont areas). The karst morphogenesis intensely affected the platform limestone outcropping in the Pizzo Carbonara and Pizzo Dipilo sectors. The thick debris talus, stratified and/or variously cemented, which border the large escarpments in the Monte Quacella-Monte Daino sector, accumulated particularly during the coldest phases of the Middle and Late Pleistocene, and are now affected by mass movements.

A. I. Agwu

Global boundary fractures controlling the morphology and dynamics of the Earth: (a) boundary tracing

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Geology accepts that similar structures tend to occur in belts, zones or regions and that of the resultant lineaments the diagonal megalineaments are the most prominent. More recently E-W trending transform faults have also become prominent but they are known to be confined mainly within the oceans and do not encircle the globe. Six rill field juctions (RFJ's) coincide with six local latitude circles and are concentric with the equator. Together with the equator they define seven rill pattern zones of the earth. We have employed a standard world atlas which includes charts of the ocean floors, traced each RFJ around the globe and found that each coincides with major tectonic structural and prominent physiographic features, including major rivers and major transform faults. The RFJ's and their latitudinal positions are given in Table 1 (a) below. Part of the paper derives the law of motion connecting the oceanic and continental megalineaments and discusses possible implications of its findings to plate tectonics.

Table 1 (a): The seven rill pattern zones of the earth and their boundaries.

Lower limit and name of latitude zone	RFJ Position (Degrees Lat.)
Latitude zone	
Equatorial	0-12. 857142S6
Tropical	12.36 - 25.71
Subtropical	25.71 - 38.57
Midlatitude	38.57 - 51.43
Highlatitude	51.42 - 64.29
Subpolar	64.29 - 77.14
Polar	77.14 - 90.00

Hassan Ahmadi

Etude de la géomorphologie et du système d'erosion dans le bassin-versant de Taléghan (Affleurements du bassin-versant du Séfid Rud, Ouest d'Alborz)

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Le bassin-versant de Taléghan, situé au Nord-Ouest de Téhéran dans l'Alborz central, en haute altitude, est l'une des ramifications du bassin-versant du Séfid Rud. Les études de la situation géomorphologique et de l'érosion se sont révélées nécessaires. La région de Taléghan est formée de trois unités géomorphologiques:
– La première unité est composée de terrasses alluviales récentes et anciennes. Les terrasses récentes appartiennent au Würm, et les colluvions ont une place importante dans leur composition. Les terrasses anciennes se trouvent pour la plupart en haute altitude et appartiennent au Riss. Elles sont souvent protégées par une cro te calcaire; aux endroits où cette croûte calcaire est absente ou a disparu, l'altération a commencé. Dans cette unité, l'érosion latérale est particulièrement visible là où les cours d'eau traversent les terrasses inférieures. Il faut prendre en considération la destruction et la quantité des matériaux transportés.
– La deuxième unité est composée des matériaux non cohérents du Miocène. Elle comporte deux sous-unités:
- Le Miopliocène est limité à l'aval de la rivière Taléghan; il ne présente que peu d'intérêt au point de vue de l'érosion, mais il a un rôle important dans la formation des faciès à cause de la pente.
- La sous-unité du Miocène se trouve dans la partie supérieure de la vallée principale. Elle comporte du gypse et du sel. Différents faciès y sont observables. Cette unité est très importante en ce qui concerne la destruction et l'érosion: la plus grande partie des matériaux transportés dans le bassin-versant de Taléghan proviennent de l'érosion de cette unité.

– La troisième unité est limitée aux hautes altitudes. Les matériaux sont surtout d'origine volcanique. Seul l'altération semble y avoir un rôle fondamental.

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GIS modelling: applications in morphological and hydrological basin analysis

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In many earth studies or research activities it's fundamental have a surface physical rapresentation. Tradictionally, topographical rapresentation describe the land morphology by point features (altitude points), linear features (contour lines) or polygon features (land forms like rocks or glaciers etc.). Therefor three-dimensional land aspect construction is let to observer's deductive interpretation. The early Regione Piemonte map production, called Ctr - Carta Tecnica Regionale (Regional Technical Map), at the scale 1:10,000, provides a large set of digital altitude informations that now can be used on the entire regional area. This typical digital data form opens wide capability in three-dimension surface modelling, allowing to represent land surface like a geometric solide and then to calculate or derivate those fundamental variables useful in geographical phenomena investigations.
After November 1994 Piemonte flood, Csi-Piemonte started a specifical activity for the regional Assessorato alla Pianificazione Territoriale (Territorial Planning Assessorship), whose primary purpose was a methodology identification for geomorphological analisys based on Dtm's use (Digital Terrain Model) by Geographical Information System. To this aim, a pilot project started trough the collaboration between Csi-Piemonte and Turin University, Dipartimento di Scienze della Terra (Earth Science Department), focused on the analisys of a small regional basin (Langhe area), chosed for the availability of the complete numerical (raster and vector) data set concerning most of necessary environmental factors and for a rich heritage of other information deriving from past traditional research. Due to this characteristic, the project became a true prototypal research, either evaluable in terms of operativity either controllable in terms of results. In particular we tested some innovative software tools oriented to the hydrological analisys (Arc packages) useful to surfaces modelling and then for morphological parameters quantification and for evaluation of factors regarding hydrographics erosion systems. Scientific and technical purposes of this parameter characterization are dual: by one hand to provide an information grow up of the physical and morphological knowledge of regional area, and by the other hand to set a generalizable methodological approach. The first one is useful for basin characterization, expecially concerning slope stability, and for hydrogeological hazard location and mapping. The second one leads to an extensive methods usability, with a significative time and resource saving in comparison with a simply use of traditional approaches (land survey, traditional cartographic analisys, etc.).
Activities (completed or in progress) may be summarized as follow: surface modelling and slope and exposure evaluation; flow-direction definition; watershed delineation and automatic classification; hydrographic net-work individuation and automatic hierarchization (Strahler method); surface concavity and convexity evaluation; automatical analisys of morphometric parameters either linear and areal, characterizing the basin evolution stage (shape factors, Horton and Melton parameters, ipsometric curve, etc.); software algorithms development for concentration time evaluation and integration with hydrological and hydraulical models; spatial rainfall modelling (Thiessen polygon, isoietes, etc.).
In the following some other supported activities are listed: road infrastructural main design; suitability evaluation of activities concerning territorial planning; waste siting; civil protection planning; correlation between actual and potential soil use.

ASMA AL-FARAJ & ADRIAN M. HARVEY

Use of desert pavement characteristics to correlate wadi terrace and alluvial fan surfaces: Wadi Al-Bih, United Arab Emirates and Oman

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Wadi Al-Bih drains Mesozoic limestone terrain in the Musandam Mountains (Northern U.A.E. and Oman). Sustained dissection since Miocene uplift was followed in the mid Pleistocene by massive filling by gravels then by alternating cutting and filling seqeunces to create a series of Late Pleistocene wadi terraces and alluvial fans. Three main aggradational phases can be recognised prior to modern dissection. The aggradational surfaces of these terraces and fans can be correlated and differentiated by degree of desert pavement development together with soil characteristics.
The fan and terrace surfaces have been mapped and grouped into relative ages on the basis of topographic and stratigraphic relationships. Desert pavement characteristics have been studied at 12 terrace sites and on 37 fans. At the terrace sites pavement classification criteria were developed, based on: clast fracturing, angularity and size, sorting, packing and surface texture. Other surface properties, rock varnish and clast surface weathering characteristics, were also recorded, but these proved to be less discriminatory than pavement characteristics. The pavement data ha-

ve been augmented by observations on soil development. Comparisons have been made between terrace surface and subsurface particle size distributions which also reflect pavement development. For the fan sites the same criteria can successfully differentiate between relative age groups, when the sedimentological differences between terraces and fans are taken into account.

Four age-related surface types can be recognised: (1) Unaltered depositional surfaces, (no pavement, no soil) occur on the modern valley floor. (2) Weakly developed pavements (little fracturing, sub-rounded clasts, some modification of the depositional fabric, some soil development, Stage 1 $CaCO_3$ accumulation) can be recognised on the youngest terrace and fan surfaces. (3) Moderately developed pavements (clast fracturing, sub-angular clasts, moderate sorting and packing of the pavement surface, deeper soil development, Stage 2 $CaCO_3$ accumulation) can be recognised on the middle terrace and fan surfaces. (4) Well developed pavements (complete clast fracturing into small angular fragments, mature sorting and packing of the pavement surface, deep soil development with strong horizonation, Stage 3 $CaCO_3$ accumulation) can be recognised on the highest terrace and oldest fan surfaces.

In the absence of datable sediments, pavement and soils can be used to suggest approximate ages for the sequence. The oldest terrace relates to a period of accelerated weathering and sediment production from the high mountain environments sometime prior to c150 ka BP; the second terrace and the most important fan aggradation phase to accelerated hillslope debris flow activity between 100 and 50ka BP; and the youngest phase to aggradation by coarse bouldery fluvial gravels during the late Pleistocene.

ANDREI M. ALABYAN

Magnitude-frequency concept and river channel patterns

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A magnitude-frequency concept offers methodical basics for effective (channel-forming, dominant) discharge calculation and channel pattern analysis using effective discharge curves (Edc). In alluvial rivers the water flow transporting the most sediment in long-term is considered to be effective. In practice, the value of effective discharge is determined from the special diagram (fig. 1), Edc, where values of product of sediment load and frequency are plotted against corresponding water discharge values (Makkaveev, 1955; Wolman & Miller, 1960). The effective discharge corresponds the maximum of sediment-frequency product, and a shape of Edc provides an information for analysis of channel pattern. The most important is a location of Edc elements relatively to three horisontal lines, corresponding the bankfull flow (1), critical flow for meandering-branching threshold (2), and critical flow for transition from alternate side bars to medial bars. Critical flow determining is based on the conventional wisdom that river channel pattern is controlled mainly by slope and discharge, that is confirmed by numerous gradient-discharge charts - diagrams where points corresponding to various channel types are separated from each other by inclined straight lines (for logarithm scale). An energetic treatment of gradient-discharge plots assumes transition from single-thread to multiple channel as a result of the growth of stream power being in direct proportion with the product of water discharge and slope. Analytic equations for discriminant lines differ depending on examined structural level of channel forms: for meanders and island splits critical flow power is several times higher than for alternate and medial bars. Critical values of water discharge can be calculated from critical stream power if the slope of examined river is known.

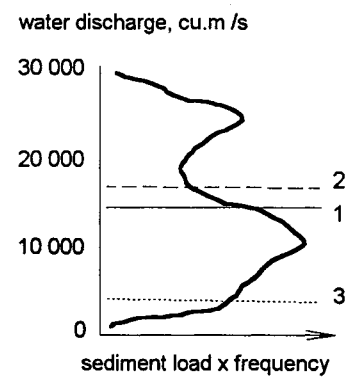

FIG. 1 - Edc for the Lower Ob River (Siberia, Russia).

The Edc can have from one to three maximums depending on hydrological regime features (Chalov, 1976). If the upper maximum is well encountered and located above the meandering-branching threshold line which in turn plots above the bankfull line there is high possibility of anastomosing channel development, typical example of this phenomenon is the Lower Ob River (fig. 1). It is because of a concentration of channel-forming activity when the floodplain is submerged that promotes its dissection and long life of meander cut-off branches. For further examination of any anabranch of anastomosed channel similar Edc can be constructed if water and sediment distribution among branches are available. In complicated braided channels forming activity concentrates below floodplain filling level, such rivers usually have Edc located entirely above the side bar - midbar threshold line, so midchannel bars may be formed and maintained during every hydrological season. High-water part of Edc is situated above the meandering-branching threshold line, so stream power during a flood is enough to form island splits. Meanwhile meandering rivers are characterised by Edc situated below meandering-branching threshold line. Alternate bars predominate when sidebar-midbar threshold line dissects significant low

portion of Edc, the more part stays above this line the higher is a possibility of medial bars to be formed.
This method of analysis is suitable mainly for alluvial rivers with wide floodplain where channel widening or horisontal shifting are not restricted by hard slopes of narrow valley. However some elements of this analysis are appropriate for incised and confined rivers as well.

IRASEMA ALCÁNTARA-AYALA

Slope stability in semi-arid mountainous terrain: modelling controlling factors

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Interactions between geology, topography and climate determine complex processes, such as mass movement. In semi-arid environments the magnitude and frequency of different meteorological events have a major control on short term, seasonal and long term groundwater conditions, inasmuch as seepage is related to topography and topography is related to river under-cutting, depending on the geological conditions.
In the Alpujarras, Southern Spain, mass failure processes take place over a large area due to the interrelationships among these elements. Phyllites outcrop over a large part of the region and cause slope stability problems not only in Southern Spain, but within the Mediterranean. A conjugate faulting system existent on these rocks is reflected in a set of preferential planes of weakness, which in addition to the material properties enhance mass failure. The analysis of the interrelationships of these structural, morphological, hydrological and climatic factors by means of modelling and in order to predict mass movement in space and time under semi-arid environmental conditions is the aim of this research. Three models have been coupled to test this kind of interactions. First of all, a hydrological budget model for percolation to groundwater has been used, followed by a finite element model for groundwater flows, and finally, the results are incorporated into a slope stability model. The modelling results suggest that failure is, in general, strongly related to morphology and erosional processes, rather than climate, except in the case of the shallow failures controlled by events of high magnitude and low frequency.

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Geomorphology of the Russian Eastern Arctic Shelf

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The geomorphological features of the Russian Eastern Arctic shelf seas were formed under the interaction of Late Cenozoic tectonic processes and changes of transgressive/regressive cycles. This has conditions several repeated marine and continental environments: periglacial lowland and shallow marine. Several marine regressions in the Pliocene were recorded. In Quaternary five regressions stages were recognized. Among them the Late Quaternary regression was very deep and wide areas between present shoreline and continental margin were opened for the subaerial and periglacial sedimentation and for the formation of terrestrial landforms. The most part of Laptev and East-Siberian Seas was being developed as lowland area. The great siberian rivers Lena, Jana, Indigirka and Kolyma were crossing this area from the South to the North. In the Holocene time this area was covered by sea as a result of transgression.
The system of recently developed faults and graben-type structures of submeridional orientation are being recorded by means of geomorphological and chronostratigraphical studies. These structures have formed the straits between Novosibirskie Islands and morphology of coastal zones.
The submarine landforms of present offshore areas of Laptev and East-Siberian Seas and the composition of bottom sediments have evidenced on absence of traces of the land glaciation during the Middle and Late Pleistocene. The eastern limit of extension of land glaciers is the Severnaja Zemlya Archipelago. Eastward the typical periglacial environments were spreaded with formation of permafrost. At present the frozen ground and ice wedges could be recorded on the bottom of shallow seas.
The main system of disjunction tectonic structures is traceable on the Laptev shelf as an extension of Middle Arctic (Gakkel) Ridge. There are some evidences of the tectonic activities in this zone in present time: the eastward inclination of the Lena Delta, the geomorphological position of valleys on the coastal/nearshore areas and location of earthquake epicentres. The geomorphological evolution in the East Arctic shelves in accordance with the Late Cenozoic stratigraphical slices is shown on the paleogeographical maps.

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Water quality of flash floods in the semiarid Northern Negev, Israel

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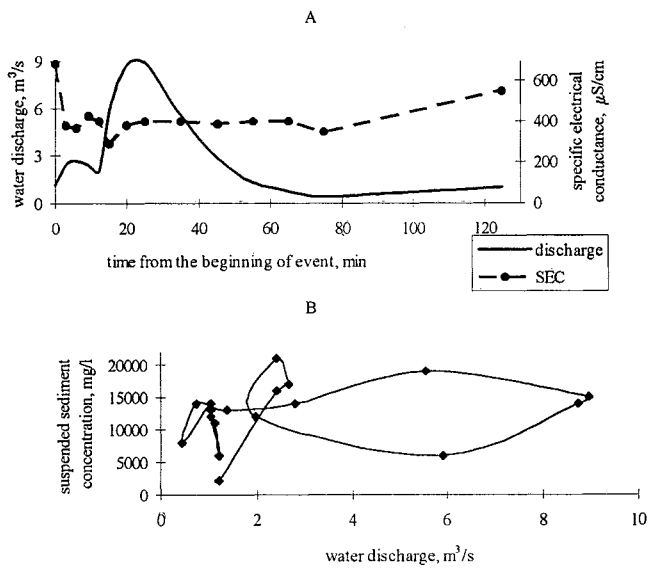
One of the unknowns of arid-land geomorphology is the chemical quality of storm flow. The present investigation incorporates initial results, received by author for her MA thesis. The water quality investigations are carried out at the Ben-Gurion University of the Negev in Nahal (= Wadi) Eshtemoa, Northern Negev Desert, Israel. Water catch-

ment area of Eshtemoa is 119 km^2 with a mean annual rainfall 220-350 mm. Bedrock of the drainage basin is late Cretaceous limestone with a cover of Holocene loess. Vegetation is seasonal herbs and grasses.
Water samples were obtained automatically by a programmable pump sampler. Sample analysis was undertaken at the chemical laboratory of the Ben-Gurion University of the Negev in accordance with standard methods.
The chemical composition of runoff does not vary significant. Total dissolved solids varies from 130 mg/l to 310 mg/l during a given event; the chemical composition of the water is bicarbonate calcium. Specific electrical conductance reaches its maximum at the beginning and at the end of the event (up to 600 (S/cm) and does not change within peak time, obtaining its minimum at the leading edge of the flood waves (370 (S/cm and 270 (S/cm). This is the so called «dilution effect» (fig. A). Suspended sediment concentration rose from 5000 mg/l to 25000 mg/l during first flood wave and from 7000 mg/l to 20000 mg/l after second peak. There is an anticlockwise hysteretic behaviour of suspended sediment concentration (fig. B).
Specific electrical conductance (A) and suspended sediment concentration (B) for the runoff event of 05.11.1993, Nahal Eshtemoa.



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Alongshore variability in shoreline and foredune mobility: space/time scaling

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Rhythmic, alongshore patterns are identified in shoreline and foredune mobility at different scales in space and time. Offshore and nearshore processes control shoreline behavior directly whereas the intervening beach buffers foredune change from lower magnitude events. Some of the alongshore shoreline/foredune cycles are linked and others are independent. Both natural processes and human activities contribute to the variability in behavior.
The dataset for the 50 km long Fire Island, New York, USA, describes shoreline changes at centurial, decadal, annual, seasonal, and single-storm event scales; duneline change is presented at the decadal to single-event scales. Highly accurate, digital data sources range from differentially-corrected, dynamic mode Gps traverses and Gps georegistered aerial photographs, maps and field surveys. Using Gis technology and statistical analysis, the assembly and subsequent decomposition identifies alongshore periodicities with wavelengths of hundreds of meters to tens of kilometers, and that some of the features are phase-coupled. The results improve theoretical knowledge of alongshore barrier island morphology and identify where predictability and uncertainty dominate coastal dynamics on the island. The data and results are directly applicable to coastal hazard assessments, resource management planning, and engineering designs.

PHILIP A. ALLEN & NIELS HOVIUS

Sediment delivery to basins from landslide-driven fluxes

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Mapping of several time series of landslides in the rapidly uplifting and eroding Southern Alps of New Zealand demonstrates that landslides have a power-law magnitude-frequency distribution. Power-law relationships characterize landsliding in other mountain belts around the Pacific rim. The magnitude-frequency distribution is described primarily by a rate constant κ and a scaling exponent β. Assuming β. to be constant for the landsliding process, variations in κ may simulate the effects of, for example, earthquake activity at the time scale of 10^2 y, or of climate change at the time scale of 10^5 y. Volumetric estimates of the landslide efflux can be made by integrating the size distribution over the entire range of length scale at which landslides occur. Calculated volumetric effluxes from the mountain belt due to landsliding compare well with the suspended sediment loads of rivers draining the western flank of the Southern Alps, suggesting that landsliding effectively accounts for all of the erosion of the mountain belt.
Sediment delivery to basin margins due to landslide efflux acts as a boundary condition for sediment dispersal within the basin. Sediment may be distributed within the basin by a diffusional algorithm in which the sediment flux is proportional to the local topographic slope. For a constant

tectonic subsidence, such as due to flexural downwarping in the proximal parts of foreland basins, variations in the landslide efflux boundary condition should therefore be registered as phases of progradation and retrogradation of coarse clastic sediments in the basin fill. These movements of facies belts are quite independent of base level change and are driven purely by variations in the rate constant κ. Examples will be presented from the stratigraphic record of where this effect may be recognisable.

ROBERT J. ALLISON & OWEN G. KIMBER

Modelling failure mechanisms and the characteristics of rock slope retreat along coastal cliffs

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A computer modelling study has been completed to examine the failure mechanisms and rates of rock slope retreat for coastal cliffs. Computer modelling has used the distinct element method and combines data on material intact rock properties on the one hand and rock mass discontinuities on the other. Field data and samples for laboratory analysis were collected for the Portland Limestone outcrop along the Isle of Purbeck coast, southern England. The Portland Limestone is a hard, shelly, crystalline sediment of the Upper Jurassic. It has a regular discontinuity pattern throughout the outcrop in Purbeck. While joint orientation remains relatively constant spatially, bedding changes from horizontal towards vertical, a consequence of the Purbeck Monocline. Information was collected for 11 sites and from preliminary data analysis four were selected for detailed investigation. Distinct element meshes were designed and the model run over a number of iterations for each site, with between site comparisons being made at the same time interval. Results highlight marked changes in failure mechanism along the Portland outcrop, differences in cliff retreat rates and changes to the resulting slope profile as cliff collapse occurs. The modelling exercise enhances previous knowledge on rock failure mechanisms and slope development along the coast.

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The role of geomorphology in landscape ecology: the «Landscape Unit Map of Italy» at the scale 1:250, 000 («Carta della Natura» Project)

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The «Carta della Natura» Project (Law 394/91) aims to evaluate the natural environment conditions in Italy, identifying the natural values and the environmental vulnerability. It will constitute the Government tool for addressing the fundamental lines of the territorial setting, referred to the natural and environmental values (interventions of national interest, environmental and soil conservation).

The theoretical approach starts from the conception of Nature in contemporary sciences, well syntetized in the following definition of the Universe: «not homogeneous, dynamic, multiscalar and hierarchically organized» (Prigogine & Stengers, 1984). To address this organized complexity, an holistic approach is necessary; in this context, an eco-systemic model of interpretation has been chosen for the Nature, that, according to this model, results organized in hierarchical levels of complexity, varying with the scale (O'Neill & *alii*, 1986; May, 1989). At each hierarchical level specific phenomena can be identified, and for this reason to different scales correspond the knowledge of different phenomena.

Starting from these considerations, two scales have been chosen for the thematic maps of the «Carta della Natura» Project: 1:250,000 and 1:50,000. In this framework, the first step, here presented, is the realization of a thematic map (at the scale 1:250,000) in which the main landscape units are represented for the entire country. As «landscape unit» we define a wide territorial portion, uniform from a lito-morphologic, vegetational, climatic and land use point of view. The second step for the realization of the project will regard the definiton of ecosystems and habitats at a more detailed scale. According to the theoretical considerations, the 1:250,000 scale permits to focus on generalised territorial phenomena. Therefore, the geomorphological studies played a primary role in the realization of the «Landscape Unit Map of Italy», allowing to define the morphological pattern that marks each unit, and that is strictly related to the vegetation, the climate and the functional relationships with the other units. The map has been realized mainly working on aerial photographs (Volo Italia, 1989, ~ 1:75,000), and paying attention to some criteria. First of all, a number of «landscape types» have been identified and characterised by a general description, keeping into account the scientific literature (from Sestini, 1963, to Pignatti, 1994) as well as already existent regional studies. Secondly, the single units have been recognised starting from the types but defining their local and unique characters. Finally, they have been mapped and organized in a Gis.

The final result, the «Landscape Unit Map of Italy» shows that, at a synthesis scale, the holistic characters of the landscape are strictly linked to geomorphological patterns; therefore, geomorphology is the most important tool at this hierarchical level of the landscape study.

ANNALISA AMATO

Estimating Pleistocene tectonic uplift rates in the South-Eastern Apennines (Italy) from erosional landsurfaces and marine terraces

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The Southern Apennines are part of an arc-shaped East-verging thrust system whose activity occurred mainly between Late Miocene and Early Pleistocene and whose last phases of thrusting are well recorded along the outer front of the chain. In this paper a tentative reconstruction of the Southeastern Apennines tectonic uplift during Pleistocene time is made using two main sets of data. Those regarding the Early Pleistocene time interval refer to the erosional landsurfaces that were cut on thrusts and imbricates of the chain front and were uplifted during the very last phases of compression. The second group of data come from a stair of ten orders of Middle to Late Pleistocene marine terraces cut on both the deformed units of the chain and the uplifted sedimentary infilling of the last foredeep. This second set of data accounts with more detail for the vertical movements occurred after the end of thrusting.

By analysing their spatial and altimetric distribution and their relationships with Pleistocene piggy-back basin sediments, the erosional landsurfaces relics have been ascribed to two main generations modelled during the middle and the late parts of Early Pleistocene, respectively.

The flight of marine terraces analysed here is up to 450 m a.s.l. high and covers a period starting from the beginning of the Middle Pleistocene untill the end of the Late Pleistocene. The terraces are not regularly distributed since their number, extension, and elevation vary from place to place. In particular, proceeding from North to South (i.e. from the outer foredeep toward the chain) the terraces increase in number and become narrower, while the intervening scarps become higher and steeper. The correlations among terraces of different sections are based upon three marker terraces, which are well preserved and almost continuous along the whole coastal segment. Chronological data as well as correlations with glacio-eustatic highstands suggested by the oxygen-isotopic record are used to infer the age of each order of marine terraces, while the elevation data refer to the inner edge of each abrasion platform. The chronological and altimetrical data sets regarding both erosional landsurfaces and marine terraces have been plotted on time-elevation diagrams. Then, the derivative of these curves are calculated in order to analyse how the uplift rates vary during the Pleistocene. From this analysis it emerges that at the time scale of the whole Pleistocene a generally increasing trend of the uplift rate occurs, which can be estimated in about 0.25 mm/a.

Beyond this basic long term tendency, a more variable tectonic behaviour can be noted at least in the Middle and Late Pleistocene times. For this span of time, in fact, the more numerous available data allows to appreciate fluctuations of the uplift rate between the two limit values of 0.55 mm/a around 0.500 Ma, and 0.92 mm/a around 0.125 Ma. Furthermore, during this period the uplift rates are sistematically higher on the chain than on the foredeep. However, this tendency seems to stop at 0.055 Ma, since the marine terrace related to the isotopic stage 3.3 stands at the constant elevation of 20 m a.s.l. along the whole coastal sector here considered.

ANNALISA AMATO & NICOLETTA SANTANGELO

Watershed migration in the Southern Apennines Chain: tectonic-erosion interactions in recent orogen

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The Southern Apenines Chain is an asymmetric wedge that accreted onto a NE-wards retreating subduction slab (roll back of the Apulia foreland) between about 14 and 1 Ma. While the chain was accreting and migrating a back arc basin (seat of the present Tyrrhenian sea) opened gradually to the SW side of the wedge. As a consequence of this evolution the chain discloses an asymmetrical cross profile with a steep southwestern slope which carries evidences of the youngest phases of back-rifting, and a northeastern slope that, on the contrary, appears more gentle and dominated by features of compressive tectonics.

Due to the young age of the orogenic events, the hydrographic network of the Southern Apennines still retains some characters that permit to reconstruct how the tectonic history of the wedge influenced the evolution of its drainage system. The main peculiarity of the river network of the Southern Apennines are: 1) an asymmetric development of the drainage in the opposite slopes of the chain; 2) the widespread presence of superimposed gorges in the western side and of antecedent gorges in the eastern side; 3) the concentration of the main intramontane pleistocene lacustrine basin in the western slope too; 4) a decoupling of the main watershed from the ideal highest summit line which rests many kilometers to the SW of the watershed.

A large scale analysis of the areal and altimetrical distributions of erosional landsurfaces of different ages, coupled with data related to the geomorphological evolution of the main rivers valleys, allowed to recognize that the main watershed has been migrating eastwards during Pliocene-Quaternary times. This migration is the consequence of several factors which help the tyrrhenian rivers capture the adriatic ones and progressively cause the main watershed to shift towards the East. The main important among them are: i) the progressive emersion of the chain; ii) the asymmetric cross-profile of the chain; iii) the increase of the longitudinal gradient of the tyrrhenian rivers caused by the rifting of the back-arc basin; iiii) the strong subsidence of

the intermontane basins. The anomalous position of the highest summit line of the chain instead, results from the interaction of these active, tectonic factors with a passive one, i.e lithology, which drives the highest summit line on more conservative calcareous units outcropping on the west side of the chain.

DIANA E. ANDERSON & STEPHEN G. WELLS

Latest Quaternary lakes in Death Valley, California, USA: paleogeography and high-stands

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Death Valley basin, in south-eastern California, USA, was the terminus for the Owens, Mojave and Amargosa rivers during the Quaternary. Lake-building episodes in the basin, collectively referred to as Lake Manly phases, were related to input from these drainages, runoff from local highlands, and groundwater discharge. These lake phases are recorded in landforms and surficial deposits surrounding the basin, and in sedimentary sequences beneath the floor of Death Valley (Hunt & *alii*, 1966; Hooke, 1972; Hunt 1975; Lowenstein, 1994; 1996). A series of ten shallow (<26 m) cores taken from Devil's Speedway south to the Confidence Hills (a 75 km transect) in southern Death Valley, yield information on the paleogeography and lake history of the basin during the past 40,000 years BP. Four cores were dated using ^{14}C-AMS on bulk organic fraction; conventional ages are reported here. Lake deposits were defined following Smith (1991).

The northernmost core, DVDP96-10, from Devil's Speedway, on the northern periphery of Badwater Basin, is 18.7 m long and is floored in alluvial fan deposits. Lake deposits were identified from approximately 11-16 m depth (100-95 m bsl elevation), dating to <40,000 BP. This early lake phase was followed by deposits indicative of a mudflat environment until the onset of the next lake phase at >12,160±80 BP (dated sample elevation at 87 m bsl). The upper 2.5 meters of the core is dominated by playa facies. The Tule Springs core, DVDP96-9, contains evidence of lake from 14,450±60 to 9,780±60 BP (86-82 m bsl elevation), with shallow lake and distal alluvial fan deposits preceding the lake deposits and distal alluvial fan/playa deposition subsequent to the lake stand. Core DVDP96-6, from Butte Valley Junction, contains evidence of a lake stand dating from approximately 19,000 to 12,000 BP (86-79 m bsl elevation) with an earlier lake stand dating to >26,200 ±150 BP (dated sample elevation at 92 m bsl). These two lake stands are separated by an intermittent/shallow lake interval. The upper 12 m of the core are dominated by mudflat and distal alluvial fan facies. The southernmost core, DVDP96-2, shows evidence of a single lake stand at approximately 19,530±80 BP (dated sample elevation at 7 m elevation). The core was taken from the modern Amargosa River channel and contains fluvial sands and gravels above and below the lake deposits. These dated cores suggest the presence of at least two lake stand phases in Death Valley basin between <40,000 and 9,780±60 BP. Core DVDP96-2 suggests the presence of a latest Quaternary lake to at least 5 m bsl elevation south of the Confidence Hills.

KIRK C. ANDERSON & STEPHEN G. WELLS

Processes responsible for the development of accretionary desert pavements in the southwestern USA

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Desert pavements in the southwestern USA form by vertical accretion of desert dust below a gravel armor. Application of cosmogenic dating techniques indicates desert pavement clasts have been continuously exposed at the surface. Through processes of desert dust incorporation and subsequent pedogenesis, vesicular soil horizon formation appears to be an integral factor of pavement development, that may be related to climatic influences (Mc Fadden & *alii*, 1987). Desert pavement clasts on volcanic terrains dated by cosmogenic ^{3}He show internal and stratigraphic consistency and are statistically indistinguishable from pristine, continuously exposed bedrock nearby. Correlation between cosmogenic exposure ages of basalt flows and adjacent pavement clasts indicates flows and pavements have been exposed for the same period of time, and that pavement clasts were never buried; an important component of the accretionary pavement model. Such born at the surface pavements, therefore, show no evidence for deflation or shrink-swell processes in surface clast accumulation. Vesicular soils forming in desert loess deposits overlying basalt flows in the Cima volcanic field, Mojave Desert, California, have strong columnar and platy soil structure, and soil chemical and physical properties with distinct pedogenic domains across subsampled ped transects. Percent clay and calcium carbonate increase within peds with up to 40% clay and 12% calcium carbonate in ped centers. These properties also increase inversely with topographic position where ped centers in higher topographic positions classify as loam and those in lower positions as clay. Micromorphology shows laterally oriented argillans and siltans lining platy structures. Translocation processes within peds move material vertically down along columnar macropores and laterally along horizontal platy pores. The accumulation of fines and calcium carbonate below clasts increases soil volume, thereby moving clasts upwards on the vertically accreting mantle. Accelerator mass spectrometry radiocarbon ages on bulk soil from two separate ped centers yielded two ages of 4530 ± 50 BP and 4570 ± 50 BP. These ages correspond to a period of in-

creased aridity in the southwest USA during the Middle Holocene, and are comparable to thermoluminescence ages on nearby soils underlying similar aged pavements. These ages suggest a period of increased vesicular soil formation and corresponding pavement development possibly related to climatic changes. Although alluvial fan pavements may have a more complex geomorphic history than pavements forming on volcanic flows, similar trends in cosmogenic dating and soil properties support the accretionary mantle model.

MALCOLM G. ANDERSON & SUSAN M. BROOKS

Identification of climatic thresholds for slope failure: application of physically-based models

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Climatic triggering of slope instability has frequently been identified by geomorphologists (Selby, 1982; Freeze, 1987). From quantitative assessments of the climatic conditions under which failures occur it has been possible to identify both the intensity-duration thresholds for slope failure (Caine, 1981) as well as the combination of antecedent rainfall and storm intensity (Campbell, 1975). Most studies which link climate and slope instability pay little attention to the nature of the soil or regolith cover, but recent research has indicated that soil hydrological behaviour can be instrumental in dictating maximum stable slope angles (Brooks & *alii*, 1993; Anderson & Brooks, 1995).

There are two dimensions to consider when examining the interplay between climatic thresholds and soil hydrology. Firstly, the relevant intensity-duration-frequency thresholds will alter under progressive development and maturation of soil profiles. In particular, horizon development and profile differentiation can substantially alter the storm type required to promote failure (Brooks & Richards, 1994). Secondly, little attention is given to downslope enhancement of pore water pressures resulting from selective movement of constituent soil particles downslope. While investigation of the first element is possible using 1-dimensional modelling, the second aspect clearly requires 2-dimensional analysis.

Application of coupled soil hydrology-slope stability models operating in 2-dimensions is now possible, and at a level of detail relating to downslope changes in the soil cover. With this facility it is possible to explore in greater detail than previously, the climatic thresholds for promoting failure. This paper, therefore, uses physically-based modelling to consider the significance of lateral as well as vertical variation in soil cover to the relationship between climate and slope failure.

MARIE-FRANÇOISE ANDRÉ

Preglacial tors in Aurivaara (Swedish Lappland): geomorphic pattern and glaciological implications

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In previously glaciated nordic and arctic areas, tor-like features are often interpreted as indicators of cold-based ice conditions, whereas they were successfully used in southern European mountains to map the Quaternary unglaciated areas. New investigations in Swedish Lappland lead to question the validity of such an antinomic view.

Fifteen syenite tor-like features were closely investigated on the Aurivaara Plateau, west of Kiruna (68° N), a study site which was discovered and signaled to the author by Anders Rapp (University of Lund). The morphology of weathering residuals was studied in detail as well as the distribution and characteristics of glacial deposits and associated smallscale landforms. Petrographical diagrams of erratics scattered on tors and preliminary microscopic examination of rock samples were carried out.

The finding of pink granite erratics and till material trapped into joints up to two meters deep confirms the preglacial age of the tors, which is also suggested by the deep weathering of pyroxenes observed in thin sections of *in situ* syenite. Moreover, erratics were also found in clitters which formed at the bottom of tors. These observations confirm Rapp's hypothesis of a cold-based ice cover in Aurivaara and are in accordance with the pre-Weichselian age of the Pallentjåkka blockfield established by this author westwards in Swedish Lappland.

A wide range of morphologies was found among tors from rock pillars still embedded in grus to ice-scoured flat tor roots. This geomorphological variety appears to depend on the position of the tors both in the topographical and the glaciological patterns. As usual, the highest tors (up to 10 m) are found at the edge of the plateau, whilst landforms have a poor vertical development (1-2 m) in the heart of the plateau. At the same time, an asymmetric pattern is assumed to derive from the direction of glacial fluxes over the Aurivaara plateau: ice-scoured tor roots locally shaped into *roches moutonnes* are found in the northeastern exposed area, whereas rock pillars with spheroidal weathering, mushroom-rocks and *in situ* grus characterize the southwestern protected part of the plateau.

The Aurivaara plateau represents a smallscale expression of the «classic» mosaic of scoured and not scoured landscapes linked with contrasting basal thermal regimes as shown in Greenland by Sugden (1974) and in Arctic Canada by Dyke (1993). However, the interpretation of the geomorphological pattern observed in Aurivaara is complicated by the inding of erratics most probably belonging to several glacial episodes, which requires a global reconstruction of the «palimpsest glacial landscape» (Kleman 1992).

EDMUND D. ANDREWS

Magnitude and frequency of bed-material transport in the Virgin River, Colorado Plateau, USA

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Detailed understanding of the intensity and particle size distribution of bed-material transport over a range of discharges is necessary to fully characterize a stream. This information, however, can be very difficult and expensive to obtain, especially where peak streamflows are brief and the bed-material is coarse and poorly sorted, such as in the incised bedrock streams draining the Colorado Plateau. Although sand and small gravel make up only a few to several percent of the bed-material, the bed-material load of these streams consists almost entirely of these sizes. Furthermore, because the quantity of sand and small gravel in the bed surface is small, the portion of sand and small gravel in the stream bed varies significantly on times scales of a few months to a few years due to temporal imbalances in the supply and transport. In order to develop appropriate methods for computing bed-material transport in such streams, suspended and bedload transport rates in the North and East Forks of the Virgin River have been sampled over a wide range of discharges since 1992. In both streams, the transport rate of a given particle size was observed to follow a well-defined relation with discharge for a time, and then, subsequently, an equally well-defined but substantially different relation. The difference between two relations is too large to be explained solely by an increase or decrease in the percent of that size in the bed surface. Relatively small accumulations of sand and small gravel between the larger bed particles, however, significantly reduces the form drag of the large particles and increases the fluid stress on the finer material. This mechanism was shown to be sufficient to explain year-to-year differences of an order of magnitude or more in the transport rate at a given discharge.

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From monitoring to modelling: the Alverà mudslide case study (Southern Alps, Cortina d'Ampezzo, Italy)

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The research has been focused on the area of Cortina d'Ampezzo where mass movements are particularly numerous and widespread. In this area thirty landslides have been individuated. Mass movement are strictly connected with the geological structure and tectonic situation of the area. The repeated overposition of rocks with a fragile mechanical behaviour (Dolomia Cassiana, Durrenstein Formation and Dolomia Principale) on rocks showing a ductile mechanical behaviour (San Cassiano Formation and Raibl Formation) has made the area prone to the development of deep-seated gravitational slope deformations and landslides. The mudslide chosen for the monitoring and modelling is the Alverà landslide, situated in the vicinity of the built-up area of Cortina d'Ampezzo. This landslide is about 1 km long, with a slip surface developed, in the lower part, at a depth of about 5 metres. Analysis of the cores from the boreholes permitted to made a distinction in two separate layers. The upper one (about 20 m thick), within which the landslide has occurred, consists of irregular poorly blocks of the San Cassiano Formation dispersed in an argillaceous matrix and widely affected by cracks. The lower layer consists of more consolidated homogeneous clays.

A first monitoring system was installed in 1989. It consists of inclinometric tubes and piezometric standpipes. The later one equipped with electric transducers for the measurements of the hydraulic head in the slope. The inclinometric tubes are provided with a steel wire extensometer for the continuous measurement of the landslide displacements. The instruments are connected with an automatic system recording data every ten minutes. Also a meteorological station has been installed, in 1989, in order to record the precipitation values, the air temperature and the snow cover thickness. During the autumn 1994 other 10 boreholes were drilled, in the landslide and its vicinity, and equipped with inclinometric tubes, open pipe piezometers and deformometers. Now 16 deformemetric and piezometric stations are continually working. Moreover a network of topographic measurements has been realised (with almost 4000 points) and it has allowed that superficial movements to be detected.

In the Alverà landslide, an assessment on three dimensional analysis on landslide hydrogeology has been evaluated. The reconstruction of landslide hydrogeology in this area is very complicate and a first approach has been realised using a three dimensional distributed hydrogeologcal model, Modflow. It is a finite-difference groundwater flow model to simulate three dimensional area, transient and steady state flow in anisotropy, heterogeneous, layered aquifer systems.

The application of a distributed three dimensional model permits to analyse spatial distribution of the structure and the mass transfer elements of a hydrogeological system. In Cortina test site the analysis of field data permits to evaluate the different answer of this system; in fact the influence of hydrogeological parameters and balance factors change in space and in time. It has been possible to identify five zones in which the recharge typology, the fluctuation entity, the drainage time and quantity are different. For each zone has been assigned a permeability value to simulate the different recharge and drainage answers and a percentage

of effective precipitation to simulate the different peaks of water table. The applied model can simulate the positive fluctuations of the water table, with different answer of the hydrogeological system in each zone, in comparison with different rainfall intensities.
Concerning the slope stability modelling, in the classical approach to slope stability analysis, soil strength is regarded as a unique resisting force. As a direct result the movement starts when the equilibrium between driving and resisting forces is modified by a finite pore water pressure increase acting along the slip surface. At this moment a net force difference between driving and resisting forces becomes available. This net force is constant and the landslide moves subject to constant acceleration with an infinitely increasing velocity. This is in contrast with the field evidences which show that the velocity becomes constant with time, provided that the pore pressures along the slip surface remain constant. In order to give a clear explanation of this behaviour, the effects of viscous resisting forces developing in the montmorillonite clay composing the landslide had to be considered. This required the development of a visco-plastic rheological model in which an increase in viscous resistance corresponds to a velocity increase. In this model the velocity is dependent on the pore pressure variation only, when all other parameters are constant. Using observed pore pressures as input to a computer procedure, it was possible to obtain velocity as a function of time and then to predict a significant trend of landslide displacement.
Costs/benefits analysis concerning monitoring and modelling is discussed.

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The relative sea level changes in Brazil in the last 7,000 years: criticizing old and adding new data

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Pioneering studies trying to establish a Holocene mean sea level (MSL) curve for Brazil date back 30 years, when a series of radiocarbon dating of palaeo-sea level indicators were published. Since then, eight other regional curves have been proposed for different sites along the Brazilian coast. The majority of the curves follow the same general contour: a fall of sea level after a maximum of about 5 m at the end of the post-glacial marine transgression (Pmt ≅ 5,100 years B.P.), intercalated with two intervals of negative oscillations when sea level may have been at or below the present elevation (4,100-3,800 and 3,000-2,700 years B.P.). The purpose of this work is the re-evaluation of the sea-level data used to determine 1) the maximum elevation of the Holocene transgression and 2) the two secondary oscillations (4,100-3,800 and 3,000-2,700 years B.P.). The negative oscillations were inferred from data originated from shell middens, wood fragments and beach-rocks, and present problems of consistency and definition. An analysis of the spread of fossil vermetid tubes (93 samples) found along the Brazilian coast indicate a smoother decline of the sea level in the last 5,100 years (fig. 1). The data do not support the existence of the secondary oscillations, or at least oscillations with a range of 4-5 m. Eleven of the samples are in the intervals of the proposed oscillations, all indicating paleo-sea levels higher than 1 m. The sea level maximum at the end of the post-glacial marine transgression appears to have reached an elevation of about +3.5 m, as indicated by most of the vermetid samples as well as the elevation of paleo-beaches deposits in southern Brazil.

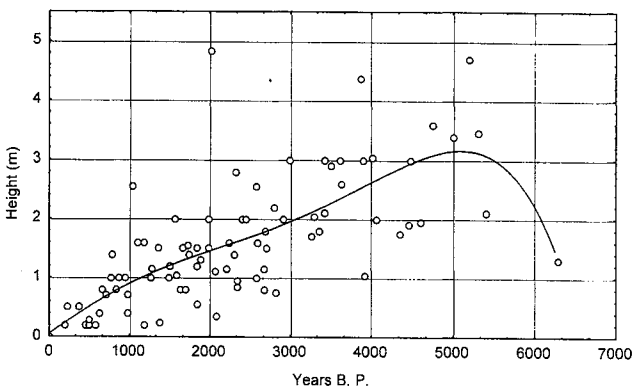

FIG. 1 - Elevation of the published and new paleo-sea-level indicators in Brazil derived from vermetid radiocarbon dates. The curve is a best fit 3rd order polynomial.

EFFIOM E. ANTIA

Prospects of sediment transfer diagrams in analysis of nearshore morphodynamics

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Sandy beaches and adjoining nearshore are one of the most valuable yet vulnerable regions of the coastal environment. While efforts aimed at beach protection and modelling largescale beach-surf zone change patterns are replete in the literature studies on intra-profile dynamics (IPD) of beaches are sparse. The latter knowledge is central to design of beach nourishment projects and monitoring coastal change characteristics. A simple approach to evaluating IPD of beaches, called sediment transfer diagram (STD), is presented. It is essentially a graphical multi-comparison of sediment volume change of pairs of beach zones (backshore, berm, upper, middle and lower foreshore), although surf and shoreface regions can similarly be evaluated. Each STD

is constituted of four fields within which sediment volume change data for any pair of beach zones are representable. These fields are: 1 (accretion), 2 and 4 (combined erosion and accretion), and 3 (erosional). The advantages of the STD are that it enables a quick visualization and assessment of the relative magnitudes of sediment volume change of any beach zone pair as well as evaluation of the modal sediment transport pathways between two adjacent beach zones. By implication, given the spatial distribution of data points, subtleties in beach dynamics for different locations are readily assessed. Copious examples of the applications and interpretations of STD from morphodynamically- and texturally-distinct Nigerian beaches are presented.

SERGEI I. ANTONOV

Small valley development in the center of Russian Plain during Pleistocene

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The study fluvial relief of the small river valleys of Volga bàsin (Protva, Moscow-river and its tributaries), which contain as buried forms (ancient erosion cuttings) and surface forms (terrañes and morden flood-plain), gives some regularities of development fluvial erosion and accumulativ processes. The erosion and alluviation were under the influence the climatic changers most of all. In accordance with the datas of the previous researchers (Aseyev, Goretsky, a.o.), the erosion took place in the end of glaciation epoch and during the first part of interglacials. The alluviation occured in the end of interglacials and the first part of glacials. The new datas show that the processes in the small river valleys have a same regularities as the processes in the large valleys of Russian Plain (Bolysov).
The special situation arised during the late part of glacials in the marginal glaciation zone, where river valleys were under the influence diferent glacioisostatic movement of the territory in connection with glacial margin fluctuations. During this short time as intensive cuttings and mighty alluviation developed in the cold climatic conditions. In these intervals the rates of erosion and alluviation were 2-3 times greater then for the interglacials. (The rate of erosion was 10-12 mm/year, the rate of alluviation - 1-3 mm/year).
For the Pleistocene the tectonic factor did not play the determinant role, it served as a special background, which intensified or reduced the climatic actions and glacioisostatic factors.
The fluctuations of the main base level of erosion of Volga basin-Caspian sea did not influence on the erosion and aggradation processes in the river valleys of peripheral parts of the basin.
For the Neogene-Middle Pleistocene time the main tendency of development river valleys was it's gradual alluviation, which sometimes was interrupted by erosion epochs. From the end of the Middle Pleistocene (Moscow Ice Age) for the last 130 k.y. territory did not undergo the actions of glaciations and the main tendency was gradual deepening river valleys interrupted by some intervals of intensification of alluviation processes. In the Odintsovo Interglasial of the Middle Pleistocene, after intensive accumulation during Dniper Ice Age, the plan configuration of river valleys was changed in some parts of basin. And the morden valley network was formed after degradation of the Moscow glaciation within the boundaries of river valleys of Odintsovo age. The mutual position of the ancient and more young cuttings, buried and morden terraces determined safety of ancient forms. For example, the Middle Pleistocene reorientation of river valleys determined the better safety of the Likhvin interglacial alluvium, but near location of the cuttings of the Odintsovo and Mikulino age became a cause of elimination Odintsovo alluvium by the erosion of the Mikulian interglacial epoch. So this sediment is very rare in the morden valleys.
Nearly all tributaries of the small river valleys in the Central Russia have a same age as a small valleys itself. The bad safety of it's ancient alluvium is a result of the nearly constant coinsidence the old and young cuttings within the narrow valley's bottom.

DOMENICO ARINGOLI, BERNARDINO GENTILI,
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Central Apennines Quaternary tectonics and gravity: chronology of main events

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The study area is located in the Umbro-Marchean/Latium-Abruzzi portion of the Apennines and on the periadriatic side, where limestones, marly limestones, sandstones and pelitic-sandy-conglomeratic turbidites crop out. A thrust and fold eastward vergent complex system, connected to the Neogenic compressive tectonics, built up the ridge. This process was continued during the Quaternary along the present coastline; furthermore, geologic evidence and earthquake focal mechanism interpretations testify its present activity.
The compressive tectonics and the consequent isostatic response caused the earliest and huge uplifting of the Apenninic area, probably during Middle-Upper Pliocene, in a feeble tectonics stage and likely in arid climatic conditions; a low energy relief landscape was formed. Therefore, this ancient landscape was modified and, at the end of Lower Pleistocene, underwent fast uplifting with an intense extensional tectonics phase. In the more uplifted areas, the ancient surface was dislocated with great offset and its vast portions underwent tilting, rotation and subsidence. The

adjacent areas were affected by minor deformations, but they clearly have regional undulations, as apenninic as antiapenninic. When the hydrographic pattern was still weakly downcut, very large translational slides took place, producing irregular stratigraphic contacts among the sedimentary sequence terrains.
During the initial uplifting phases, when the hydrographic pattern was feebly downcut, tectonic-gravitational (and/or gravitational) mechanisms were active and produced irregular stratigraphic contacts in the Umbro-Marchean sequence terrains. This ancient hydrographic pattern followed the tectonic and tectono-gravitational deformations causing evident anomalies (fluvial captures, rectangular, semicircular, radial and centripetal drainage patterns) and produced the rapid deepening and gave origin to high energy relief values.
The latter condition, together with the above-mentioned tectonic and tectono-gravitational ones, led to very considerable and frequent mass movements, which have great importance in the landscape modelling. About 500 of these are recognized as large landslides and deep-seated gravitational slope deformations (2 km^2 average extension, 20 km^2 and more at maximum); in this paper, only the phenomena clearly associated to the Plio-Quaternay fragile deformations are considered, together with a relative or absolute chronology.
In the more severely deformed areas clear and frequent evidence of mass movements, starting from Middle Pleistocene, are observed; the associated tongues are related to contemporaneous fluvial-lacustrine deposits and stratified slope waste deposits. Similar correlations are evidenced also for Upper Pleistocene-Holocene, where interferences between landslides and the hydrographic pattern are present.

IULIANA ARMAS

Continuity and discontinuity in the evolution of fluvial systems

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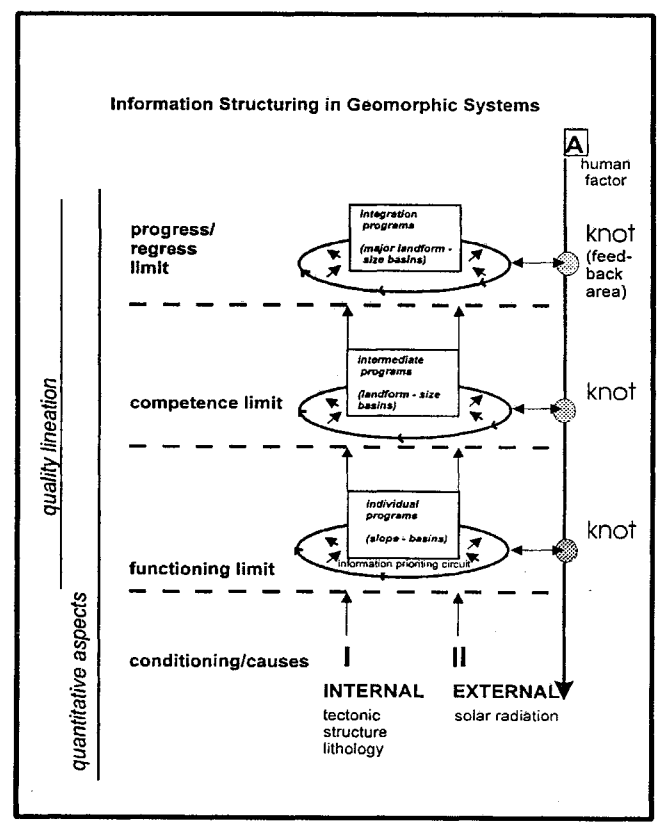
All systems imply a structure that gathers and organises the information. There are two main ways we can understand the fluvial systems structure, a hierarchical and a functional one. It could be compared, on the one hand, to the way the cells and organs of the human body use to structure matter, and on the other hand, to the metabolical chain reaction between the different levels of its organisation.
In either structuring approach, the most important thing is the available information, which does not equate the real one.
A normal phenomenon is the delay that occurs during the information circuit within all the systems. The delay is caused by the impossibility of simultaneously gathering, analysing and quickly delivering a piece of information. The action that follows is also delayed. At the level of the functional structure, feed-back circuits connect decisions, actions, the moods the system is in, and the information stored. The command that is given is based on the available information and not on the real one. The system's mood, as a result of the entire past evolution, ensures the continuity between the different development moments.
From the viewpoint of the idealised erosion cycle model, the fluvial system changes its quality from a positive feedback system (characteristic of its youthful stage) to negative reffiting in old age, expressed by the numerical reduction of its drainage network streams.
On the structural hierarchical scale, the blockings occurring inside the acces area of the prioriting circuits are the reason of discontinuity phenomena that affect the system's evolution. The subsystem which does not receive all the information from the hierarchically upper level, evolves according to the local available data, which sometimes means an antagonistic development way. When the blockings are remuved, the system reorganises, according to the newest information input.
As a conclusion, the blocking occurring on the hierarchical structural level is reflected on the functional one by modifying the rhythm of feedbackings, which determine the rapidness of the system's mood changes.



(I. ARMAS & I. BENEA, 1996)

DANIELE AROBBA [1], MARIA CRISTINA BONCI [2], MARCO FIRPO [2], MAURO PICCAZZO [2], FLAVIO POGGI [2] & AGOSTINO RAMELLA [3]

Environmental changes in the Centa River delta area (Albenga, Western Liguria, Italy)

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The morphology of the coastline between Caprazoppa Cape and S. Croce Cape is characterised by the presence of the Centa River and, above all, of its delta system, which, according to Galloway (1975), is «wave dominated». Its changes have been outlined through photo-interpretation, the analysis of historical sources and stratigraphic seismic sections of the continental shelf.
Sedimentological, micropalaeontological and palynological studies have been carried out on six vibrocores, sampled in the prodelta area, and on many rotary cores, drilled in the delta plain. A preliminary reconstruction of holocene evolution of the delta system could have been sketched out by means of these analyses, complemented by two radiocarbon dates performed on significant samples.
Four cores have been particularly informative for our research. K2 and K4 cores were extracted from the submarine delta on the 50 m isobath. Curia 1 and Curia 2 were drilled in the subaerial delta plain on the left side of today's Centa riverbed, in the area between the coastline and the buried vestiges of Roman *Albìngaunum*.
A chronological parallel between K2 and K4 cores has been made possible through a systematic comparison between the frequency curves of the homologous pollen taxa and their bottom levels can be considered approximately contemporary. Similar analyses have been carried out on a rich organic clay and peat level sample from a 40 m long core (S1), drilled in the delta plain, inland of Curia 1 and Curia 2. The bottom of this 30 cm thick level, located at a depth of 12 m below the surface of the plain, has been ^{14}C dated to 5,940±50 B.P.. The K2 base level returned an age of 2,495±60 B.P. On these bases the bottom of the S1 peat level can be referred to the Atlantic period (5,500-2,500 B.C.). This phase was characterised by a climatic optimum, the first holocene period marked by post-glacial conditions, to be defined as temperate-warm with slight thermic excursions, precipitation distributed with regularity throughout the year and progressively increasing humidity. In accordance with bibliographic data, this period's arboreal vegetation is characterised by the net prevalence of white firs and very low frequencies of beeches. Infact, the *Abieti-Fagetum* phytocoenosis has only been widespread in the Ligurian Apennine and French Provence since the second half of the Atlantic period, around 3,500-3,000 years B.C.. Examining the results of carpological and palynological analyses, the area surrounding the S1 core drilling site seems to indicate the presence of permanent swamps as well as zones flooded only periodically by fresh water. The shoreline was probably not far from this area. This is suggested by the not inconsiderable presence of coastal halophyte plants pollens. Hygrophylous woods characterise predominately water free zones or those experiencing only occasional floodings. These plants progressively colonise new and wider areas. The top of the peat level illustrates the effects of marine transgressions into the swamps, which gradually turn into coastal marshes.
A sudden depositional facies change, at a depth of 6 m below the surface of the plain (−4 a.s.l.), appears to be the main feature outlined by both sedimentological and micropalaeontological analyses carried out on Curia1 and Curia2 cores; infact, the deeper half of both cores demonstrates characteristics typical of shallow submarine environments while the upper portion is marked out by elements attributable to a subaerial continental facies. Some textural sequences of the «coarsening upward» type can be identified in the marine sediments. These intervals reflect a good fit in the forams distribution curve. Similar sequences have already been described in cores sampled in other delta plains.

LUIGI ARRIGONI, FILIPPO CATANI & UGO TARCHIANI

Some considerations on the slope evolution in the Island of Stromboli (Messina, Italy)

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The Island of Stromboli is located in the northern part of the aeolian volcanic arc and consist of an active volcano which extends more than 2,000 m below the sea level. The island, with conic shape, is 924 m high, with an area of about 12 km^2.
The outcropping terrains date back from 10^5 years to recent. In the past Stromboli was subject to volcano-tectonic phenomena, mainly located on the Sciara del Fuoco valley. The landslides, prevalently fall and toppling, involve volcanic materials (lapilli, tuff and lavas) with blocks with a volume up to some cubic metres reach distances of about 200 m. The areas of the island where the gravitative phenomena have the greater occurrence may be recognised near Cugno Anghiastro in the northern part in corrispondence of Sciara del Fuoco and in the western part along the cliff in front of Ginostra village.
As regard the coast, the south-western cliffs show the higher recession rate, while the low sandy coast seems to be in growth in the north-eastern side.
Since the action of the geomorphological processes appears to be very intensive, due to the morphological and litological conditions, the volcanic and seismic activity and

also to the intense erosive action of the sea wave, we were able to find out the areas with higher activity of mass movements by comparing the topographic map of 1994 with those of 1938. By means of the utilisation of 3D modelling software we were able to recognize the areas where the topographic differences between the two maps were largest.
In order to taking into account the different survey methodologies between 1938 and 1994, only the areas where topographic differences were greater than the tolerance value found, were included in our interpretation.
It was also possible to evaluate the mean rate of cliffs recession in the studied period, the coastline variation and the order of magnitude of the volumes of material involved in erosive and landslide phenomena.

CHEBO K. ASANGWE

Tidally-induced prograding mudflats along the Ondo coast of Nigeria

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The Ondo coastal area has its own peculiar geomorphic character when compared to other parts of the Nigerian coastline. It is the only part of the 800 km Nigerian coastline revealing muddy consistency on the marine and estuarine environments of deposition. The structure-free Ondo coastline with very low topography where areas less than 1 m are common presents a scenario of coastal flooding and saline water intrusion through tidal movements. This has been known to have far-reaching socio-economic implications on the people particularly with the pro-gradation of mudflats, making life extremely difficult in this fast degrading locality.
This paper examines the littoral process of tidally induced sediments dispersal in the progradation of mudflats on the barrier beaches and islands of the Ondo coast in Nigeria. Sediment drifting and deposition by the low energy, gentle waves in the estuarine environment of Molume and Awoye has evolved extensive muddy features on the active barrier beaches.
Laboratory analysis of collected samples revealed that sediments of the study area are of Ferrigenous clastic category with predominantly quartz consisting of not less that 95% composition in most samples. The analysis further revealed clay-rich minerals and silt grade sediments of detrital origin, implying long distances of the source of sediments to this estuarine environment.
It is envisaged that the management of the Ondo coastal environment characterised by fragile geomorphic features will be greatly enhanced with focus on the sedimentological analogue of the area.

ALESSANDRA ASCIONE & ALDO CINQUE

Tectonics and erosion in the long-term relief history of Southern Apennines (Italy)

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The Southern Apennines fold-and-thrust belt resulted from compressional tectonics events occurred between 14 and 1 Ma. It has a maximum elevation of 2,000 m and an average width (measured from the Tyrrhenian coastline to the inner border of the former foredeep basin, nowaday filled and emerged) 100 km. The height to lenght ratio (log H/log L) of the whole chain is 0.66; this value is exceptionally low compared with other recent orogenic belts of the world (Ahnert, 1984).
Within the belt, the relief energy is generally high, the local relief reaching several hundred metres within unit-areas of 1 to few km across. Only little of the total amount of the local relief represents the direct response to surficial deformation accompaning the belt accretion. Indeed, both synorogenic aggradation (filling-up of perched basins) and/or phases of prevailing erosion, reduced and smoothed the relief generated by compressional tectonics.
Post-compressional events dominated by extensional block-faulting generated tectonic relief only in localized areas, most of which are located in the inner belt. In particular, fault scarps drew the Tyrrhenian coastline between Late Pliocene and Early Pleistocene, and framed subsiding depressions between Early and Middle Pleistocene.
Among the relief generating factors, rivers downcutting in response to vertical tectonic movement played a major role. Indeed, vertical tectonic movements (both absolute and relative) exerted an indirect influence on local relief generation by controlling rates and magnitude of fluvial downcutting.
The available geological and geomorphological data allow to identify the time span ranging from Middle Miocene to Late Pliocene *pro parte* as the one in which reduction of the tectonic relief occurred in the inner belt. In particular, from Middle to Late Miocene relief reduction was favoured by the low elevation of the present inner portion of the thrust belt which, during that time interval, coincided with the outermost portion of the wedge. In the following period (from Late Miocene to Late Pliocene), although the thrusting had migrated towards the NE, relief reduction still prevailed on relief increase. Indeed, the elevation increase affecting the inner belt was compensated by the advance of the foredeep basin coastline and in consequence the mean river gradients were still low on the western slope of the wedge. Relief reduction by erosion was caused both by downwearing of the divides underlain by highly erodable clastic formations (at that time outcropping much more extensively than at the present time) and by karstic

planation affecting calcareous successions (which, conversely, in the past where much less exposed).
Relief generation and/or increase by downcutting prevailed, in the inner belt, starting from the Late Pliocene and during the whole Pleistocene. The increase in rivers downcutting rates (i.e. increase in river gradients) was due to: (i) shortening of river valleys due to migration of the Tyrrhenian rifting towards the NE which had drawn the coastline close to the present position by the end of Pliocene time; (ii) increase in regional elevation due to uplift affecting wide sectors of the belt; (iii) increase in local relief due to vertical displacements occurring in perityrrhenian and intramontane structural depressions.
In the outer belt, prevailing relief reduction occurred from Late Pliocene to the beginning of Early Pleistocene; it was due to both sedimentation occurring in wide perched basins and erosion affecting the intervening smooth highs. A major phase of relief generation and/or increase by downcutting started during the Early Pleistocene, even though its debut was diachronous being younger towards the foredeep that emerged and was uplifted only at the Early-Middle Pleistocene boundary.

ASFAWOSSEN ASRAT[1], OGBAIGHEBRIEL BERAKHI[1], LUDOVICO BRANCACCIO[2], FRANCESCO DRAMIS[3] & MUHAMMAD UMER[1]

Gravitational slope phenomena along the eastern escarpment of Welo (Ethiopia)

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The eastern escarpment of Welo is characterized by a number of north-northwest - south-southeast and north - south trending graben-like depressions, connected to normal faults which have affected Late Tertiary basalts («Termaber basalts» of Miocene-Pliocene age) and interbedded volcanic tuffs. The depression of Dessie is filled by a thick (up to some dozens meters) sequence of alluvial, colluvial and lacustrine deposits, mostly made of fine gravels, coarse (sometimes pyroclastic) yellow sands and white diatomites, also including two buried vertisols (*c.a* 1 m thick). The upper part of the sequence is made of blackish soil sediments and debris, which indicate a recent period of widespread slope denudation.
Due to regressive erosion, the Dessie depression was recently captured by the Borkena river, which cut a 300 m deep gorge (locally named «Doro Mezleya», literally «Chicken Jump») into the outer threshold. As a consequence of the valley cutting, deep seated gravitational slope deformations and large-scale landslides, including lateral spreadings, rotational slides, flows and rock falls (these latter affecting the inner fault scarp) were triggered. Particularly important in this context is a system of regressive rotational slides, migrating upslope towards Dessie. These landslides, which already affect the eastern outskirts of the town, could produce catastrophic consequences in the next future.

FRANCK A. AUDEMARD

Morpho-structural expression of active thrust systems in humid tropical foothills of Colombia and Venezuela

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Morpho-structural expression of thrust faults in fold-and-thrust belts is largely dependent on several factors, that may act independently or interact jointly, such as: dip of thrust fault planes (gentle or steep dip), kinematics of thrust faults (pure dip slip or oblique slip), lateral continuity of structures and depth of fault plane (outcropping or blind thrust). This paper will present geomorphological and/or geological evidences of either blind or outcropping, gently-dipping, tectonically-active, pure dip-slip thrust faults of fold-and-thrust belts associated to the Llanos (eastern) foothills of the Andes Cordillera of Venezuela and the Andean Eastern Cordillera of Colombia.
In any case, the best geomorphic evidences of active thrust faults in these foothills areas, where much thin-skinned tectonics is involved, are: A) flexural scarps that correspond either to the warping of the sedimentary sequence at the shallowest tip of blind thrusts (fault-propagation folds) or to the steeper forelimbs of foreland-vergent fault-bend folds; B) drainage patterns and anomalies which reflect very subtle topography modifications. Among these anomalous drainage behaviours we might mention: (1) radial drainage, indicative of periclinal clousure of folds, (2) densely dissected (morphological) scarps, (3) tilt of Quaternary alluvial units on the anticline backlimb, reflected by river pattern inversion (flow from the basin towards the range), (4) diversion (diffluence) of either large rivers or small river channels, suggesting either dyachronic and/or differential fold growth or faster tectonic uplift rates than linear erosion rates (erosion by river flow), (5) beheaded

river channels, (6) change of incision depth and river gradient along river course, (7) high (steep) river gradients associated to the flexural scarp, implying that the ground surface is being tilted, (8) dammed channels and rivers, implying erosion by river flow is smaller than tectonic uplift, (9) abandoned gullies or gorges (no river pouring through it) at the thrust front or across the flexural scarp (it frequently accompanies dammed or diverted rivers), (10) disproportion between present river flow and size of creek and/or gorge -previous evolutive stage of (9) or it comes with (5)-(11) abandoned alluvial wedges at the front of the foothills; C) tectonic «gutters» (rivers running parallel and close to the thrust front on the down-thrown block) and broom-shaped river patterns on the basinward side of these foothills, which suggest the occurrence of tectonic loading due to foreland-vergent thrusting; D) increase of tilt of ground surface or stratigraphic dip with age of Quaternary (and even older) formations or alluvial ramps (successive unconformities) and E) staircased alluvial terraces exclusively present in the hangingwall block, meaning that river flow is important enough to keep cutting through the area under uplift; and F) in many cases, the erosion has been so intense that anticline cores have been washed away and these bridged anticlines present and erratic river flow.

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Reconstruction of ice flow across Bunger Hills, East Antarctica

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Mapping of glacial drift sheets and examination of striae patterns throughout the Bunger Hills, suggests that the largely ice-free region records the imprint of several phases of ice sheet expansion during the late Pleistocene. In particular, ice moulded features and cross-cutting striae in the southern Bunger Hills suggest at least two episodes of ice sheet overriding. The older event relates to thin ice moulded to and strongly constrained by the topography, whilst the younger ice expansion event relates to regional expansion of thick ice. In addition, where salt weathering and freeze-thaw processes are least severe, the younger event is recorded by nail-head striae and well preserved glacial polish. Discrimination of the order of emplacement of the cross-cutting striae patterns is possible at many sites, although whether they relate to separate ice expansion events, or different phases of the same expansion of the ice sheet is not clear at present. Paleo-ice flow indicators confirm that ice sheet expansion over the southern Bunger Hills was from the southern and eastern margins, although minor advance of the Edisto Glacier onto coastal areas occurred at least three times following retreat of the last extensive phase of ice sheet expansion. Hence, the glacial history of the Bunger Hills appears to be more complex than had previously been recognised, emphasising the need for detailed glacial geologic work in this and other ice-free coastal areas of east Antarctica.

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Mass movement caused by rock block impact at the Soberbo slope, Rio de Janeiro, Brazil

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This paper refers to the causes of the Soberbo mass movement initiation in Rio de Janeiro, Brazil. The initial failure occurred at the middle slope in January of 1966 and runned out like a debris flow, dragging large volumes of soil rich in rock blocks causing demage to Furnas road, a paper factory and many others losses. In February of 1988 there was a new event reactivating erosion and causing new damages.

According to the literature, the initial failure was caused by the impact of a rock block against the saturated soil at a point downslope Soberbo road. To confirm that information it have been investigated the environmental conditions on Soberbo slope, before and after the initial mass movement. Undrained shock tests in a colluvium and saprolite occurring in the Soberbo slope were also carried out.

The history of the Soberbo mass movement has been reconstructed with data found in the literature and from aerial photographs interpretation taked in 1954 and 1967. The 1954's photos show mainly the occurrence of rock blocks in dropped position and the 1967's indicate the initial point of slope failure.

The shock tests results show that the failure of the Soberbo's soils happen with lower loads comparing to the static failure loads applied in triaxial tests. These tests also provided shock failure parameters.

A final analysis of a rock block ready to drop (identified at 1954's photos) and the shock failure parametersled to the conclusion that it is geotechnically possible that the initiation of the Soberbo mass movement was caused by the impact of this rock block.

SOKOL AXHEMI

The geomorphological features of river valleys in central part of Lura mountains in North-Eastern Albania

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This presentation deals with essential geomorphological features of river- valleys in central part of Lura mountains in North Eastern Albania. These valleys constitute one of the most interesting forms of this territory's relief.
The geographical position, morphografic and morphometric characteristics, morphogenetical analysis, where the factors that influence in their formation and evolution are defined, as well as the tendencies of development in the future are some of the mains points of this presentation. At the beginning of this presentation are introduced the main valleys as those of Lura mountains, Seta, Uraka, Malle Lura, in a general physic- geographical view. Further on, the author deals with geomorphological features of each valley introducing the morphological and morphogenetical characteristics.
The stages through which the development of river valleys has past as well as the factors that influenced in this development are of a special interest in this presentation. The forms of relief that accompany the valley-relief are present in this presentation. Also the influence of special factors on the creation of temble demolition and sliding processes in different parts of valleys, which have sometimes lead the degradation of territories is a important part of presentation.
By the end of material the author presents the conclusions of his work and also he is able to give special recommendations for the relief of Malle Lura's, Seta's and Uraka's valleys. Presenting these problems the author stresses always the environmental problems related to them. This presentation is accompanied with different sketches and slides.

KATERINA N. BADYUKOVA, A.N. VARUSHCHENKO & GALINA D. SOLOVIEVA

Coastal dunes relief as indicator of sea level changes

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Coastal dunes are widespread along coasts of all seas of the world being present in nearly all latitudes including high ones (for instance in Comandor islands). There is no the only concepcion in the interpretation of coastal dune relief, but as many authors we consider that the foredunes extended along the rear part of the beaches are the initial forms and represent the main element of eolian relief. They appear in those environments which are suitable for grass vegetation. If there are much sand sediments in coastal zone the foredunes with its height 3-8 meters are stable and some eolian materials migrate from their upper parts landward. The accumulation of sand material on the beach occurs if gradient of coastal plains is less than the submarine ones. Only in this case the beach of complete profile is formed, and sand does not withdrawn from the coastal zone. The fact that coastal dunes are widespread throughout coasts in all latitudes shows that climate does not practically influence their origin. It seems most likely that insignificant changes of the climate has not ever influence eolian factor on the sea coasts, though many scientists use to connect these processes.

All the diversity of coastal dunes comes to the two large-skale types. The first one is widespread on the coasts of Black and Caspian seas, in Brazil, South Australia, Vietnam, etc. Series of foredunes,so called beach ridge dunes, extend along these coasts. As a rule they are prograding ones and the presence of series of foredunes indicates the sea-level fall or tectonic uplift. Many investigators traditionally concider that sea-level fall leads to intensification of eolian withdrawn of material from mud flats. However, analyses of the coastal dunes relief (in particular dunes on the coasts of Baltic sea- Vistula and Kurschkaya spits, and dunes of the Black and the Caspian Sea coasts) showed that the sea regression does not lead to the intensification of eolian processes, on the contrary they are extinguished on the shores as the beaches supplied eolian materials landwards removes to the seawards.Sometimes these coasts are characterized by alternation of dune ridges. The latter usually stretch along the coast and are divided by flat depressions. As a rule, these depressions are swamped. In arid regions they are represented by solonchaks,as in Agrahan spit in Caspian, for instance. We consider every depression to be formed during consecutive rapid sea-level fall. The plain behind the foredune represented by regressive sand ridges is subjected to deflation and redeposition. We observed similar situation at the Caspian Sea coast during its regressive stage . If after the short halts the sea level continued to fall, formation of the next foredune took place. Such series of foredunes with the height of 3-6 m are well seen along many coasts, where Holocene sea-level considerably exceeded the modern one, and where foredunes mark stages of the sea level retreat complicated by positive oscillations .

The second type of coastal dunes relief characterized by some generations of secondary dune ridges. They consist of ridges of large parabolic, crescentic, blowount and transverse dunes separated with linear marsh or lagoon depressions. Such type is found on the coasts of Baltic sea, Western Europe, France, North America, South Africa, Australia, etc. We consider these dune ridges formed due to the sea-level rise. In that case waves begin to erode previously formed foredunes, sand is moved to the seaward part of the beach and then cast ashore thus increasing the beach thickness. This causes sharp intensification of eolian evacuation and formation of secondary dune ridges. Besides each flat surface between dune ridges have appeared after falling of sea-level. Its following rise promoted in the formation of the next dune with the synchronous flooded of landward areas. Continuing sea level rise promotes both: vertical growth of dune ridge and simultaneous swamping of the territory besides it, which results from ground water rise and afflux of river water in deltas. Marsches or solonchaks (under arid conditions) are formed there. That is why peat deposits among dune fields and in the cores of the coastal zone do not indicate weakening of eolian activity. On the contrary period of peat accumulation coincides with sea level rise and consequently with eolian phase.

MAGORZATA BAJGIER-KOWALSKA

Influence of longitudinal and transversal elevations and depressions on the pattern of montane ridges and landslide development in the Beskid Wyspowy (Flysch Carpathians)

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The Beskid Wyspowy is distinguished by different relief in the flysch Carpathians. It contains the area of isolated hills ca 1000 m a.s.l. high (Mogielica, 1171 m, Ćwilin, 1071 m, Jasień, 1062 m, Modyń, 1029 m, Luboń Wielki, 1022 m, Śnieżnica, 1006 m, Lubogoszcz, 968 m). That region is within the magura overthrust which is the widest and the southermost unit of the Outer Carpathians running from the Vienna Forest in the west to Uzhgorod in the east. Amplitude of deposits of magurska overthrust overlap on foreland units is 40-50 km. The northern edge of it is erosional-denudative whereas the southern boundary is made by fault running along the northern edge of the Pieniny Klippen Belt.

Magurska overthrust is characterized by differentiated lithology and rock hardness. The youngest magurskie sandstones are thick-bedded and they are very hard. Sub-

magurskie layers, hieroglyphic and others are medium resistant or soft. The roof of the overthrust is folded into numerous anticlines and synclines and in some places there were developed small overthrusts. Anticlines are mainly very narrow with thrust slices and their axis zones are built of soft rocks. Synclines, in hard magurskie sandstones are wide and flat. Besides there are numerous horizontal faults. Deposits of magurska overthrust have been flattened by the Beskidian planation surface, age of which was estimated for the sarmatian. In the result of epicyclic uplifting, lower planation surfaces have been formed and relief inversion has taken place. Inversion has been the most clearly marked in places where wide vales have been formed. Wide, isolated hills have also been formed and plateaus of them are on axes of crossing synclines. Wide, flat plateaus turn into steep slopes with 30-50° inclination and into gentle foothills of glacis-pediment character. Isolated hills are separated by inversional valleys or dales formed on anticline axes. Analyzing the valley pattern it can be stated that big valleys were formed in soft deposits and they are accordant to the run of layers. They are subsequent-inversional valleys, longitudinal profiles of which are smooth. The valley pattern is rectangular and is accordant to longitudinal and transversal elevations or horizontal faults.

Evolution and transformation stages of relief in the Beskid Wyspowy was greatly influenced by varied lithology, resistance of deposits and rectangular pattern of anticlines and synclines within the magurska overthrust.

Hill slopes are modelled by numerous, deep, rocky landslides which mark present development and pattern of valleys which cut the slopes. Researches on origin and pattern of landslides pointed out that in spring areas of the Beskidian streams there is a step-like pattern of deep, post-landslide embarked niches or crevices filled in with debris. Landslide pattern is often radial or bifureated and their niches, formed within resistant sandstones, are very clear. There are subsequent landslides within loosening zones and within schists. Landslides within the Beskid Wyspowy have been many times rejuvenated and presently they move back up the slopes. In the result bodies of younger landslides are stopped in bottoms of old landslide niches and form step-like profile of landslide slopes. Bodies of fresh landslides built of clay-debris material are easily dissected during heavy rainfalls. Mud- and debris-flows take place in depressions then. In the result of those processes valleys are formed. Majority of valleys radially cutting the slopes of the Beskid Wyspowy were formed on traces of old, big landslides.

Valleys which are cut in slopes create different patterns which cannot be explained only by an activity of flowing down waters. Distribution of longitudinal and transversal cracks, location of rocky packs and stages of development of landslides going backwards up the slopes or rejuvenated in their lower parts make conditions for v-shapped valleys. They are formed in depressions, often without outlet within the landslide areas.

– Wide, valley landslides in the upper part form single, forked valley pattern which in the first stage of development is irregular. It often consists of depressions without outlets in which periodically or continuously flowing water disappears (northern slope of Sałasz, Jaworz).

– Landslides rejuvenated in their lower parts make semicircular (western slopes of Wielka Góra) or zigzag (eastern slopes of Łopień) valley pattern.

– Narrow, valley landslides influence formation of concentric pattern of v-shapped valleys (southern slope of Sałasz and northern slopes of Łopień). It can be disturbed during landslide rejuvenation.

– Wide, frontal slope landslides made forked-parallel valley pattern (north-eastern slopes of Lubogoszcz and Śnieżnica).

– Subsequent landslides on flaked flysch deposits make post-landslide basins with steep slopes and often with swampy, flat bottoms. Above the landslide niches there are low passes in soft rocks.

JEAN-LOUIS BALLAIS

Evolution of a gully in Lower Provence (France): preliminary results (October 1991-February 1996)

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The Aurigon gully is about one hundred meters long ant its watershed is about one hectare. It is cut into Upper Cretaceous claystones on the Sainte-Victoire mountain southwestern piedmont.

In view of putting in an erosion measurement station, a preliminary equipment has been made using 42 pegs. The goals of this equipment were to locally measure accumulation and erosion and to know the present day processes. The main methodological problem has been the instability of pegs: we were obliged to use 275 of them. This instability is due to natural causes (pegs washed away mainly in the main talweg or in the rills) and to human causes (pegs pulled out by strollers). 54 series of measurements have been performed but the longest continuous series is only 51 measurements. The uncertainty about the true location of the lost peg and the disruption of the claystones due to driving in of the new peg reduce the validity of the results. On the whole, 2734 measurements have been performed that is to say 63,5 per peg.

Fields observations show that claystones are superficially altered by several processes: hydroclasty and pellicular solifluction everywhere and gelifraction and pipkrakces gelifluction in winter on the ubacs. This centimetric layer produces small dry screes that can be assisted by wind or by strollers passages. This thin layer is also removed by hydraulic processes during rains: very efficient splash and rill erosion. Rills are cut into the non altered claystones, excepted on the ubacs. The most important part of erosion occurs during intense pluviometric phenomenons (september 1993).

DAN BALTEANU

Slope instability in the Vrancea seismogenic region (Romania)

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The most active subcrustal earthquake province in Europe (the Vrancea seismogenic region), lies in the South-eastern part of the Carpathian Mountains; it is characterised by an average of three seismic events in every century, including strong earthquakes of magnitude 7,2-7,4. The region is formed predominantly of folded and faulted Cretaceous and Palaeocene flysch and Neogene molasse and is characterised by an eccessive human pressure on the environment. Mass movements play a most significant role in the evolution of the relief and show a great diversity. The main controlling factor influencing the range of mass movements and their spatial and temporal distribution are the geological structure, seismic activity, climate and human activity. The papezr presents the distribution and variety of mass movements (landslides, mudflows and rockfalls) in connection with land use changes and different extreme events during the last century. The closely studied earthquake of March 4, 1977, magnitude 7,2 had marked effects on the relief of the epicentral area.

The following phenomena were triggered by the March 4, 1977 quake (magnitude M ÷ 7,2 on the Richter scale): 1. distinct movement of fault-line divided compartments; 2. emergence or reactivation of some mudvolcanoes; 3. deep slidings; 4. regression of steep slopes through fall and topple of rock fragments; 5. intensification of creep processes; 6. formation of cracks in channel-beds and on slopes; 7. suppression of clays and marls at the bottom of channel-beds; 8. formation of sinking dolines on salt breccias; 9. collapse of gallery roof in some deserted mines; 10. liquefaction of loess deposits and sands; 11. underground water level changes; 12. emergence of highly mineralized springs.

Our study will focus only those phenomena which brought changes in the morphology of slopes.

SUNANDO BANDYOPADHYAY

Coastal erosion in Sagar Island, Hugli Estuary, India: causes, consequences and human adjustments

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The reclamation of Sagar island (21°37'-58'N; 88°02'-11'E) from the Sundarban mangrove wetlands of the cyclone prone western Ganga-Brahmaputra delta was initiated in 1811. Mainly due to different government policies that viewed the wetlands as waste lands and ignored the eroding nature of the coastal delta, the island has now become almost wholly settled with an agrarian population of 184,942 (1997 estimate), growing by 40 per cent per decade. Coastal erosion, that steadily reduced the supratidal area of Sagar by a quarter within the last 143 years (from 285 km^2 in 1851-55 to 213 km^2 in 1996) and at places triggered dune encroachment over farmland, forms the most important natural environmental hazard affecting this resident population. The conditions at Sagar are closely comparable with rest of the sea-board sections of the 5,360 km^2 reclaimed Sundarban (Indian part) and the island can be used as a model for the region.

Among other factors, the erosion of the island can primarily be linked to the reclamation process itself. It disturbed the morphological steady state of the resonant macrotidal Hugli estuary by reducing the intertidal area and increasing the mean depth of the channel. The abandoned and subsiding nature of the western delta as well as sediment sink in the Swatch of No Ground submarine canyon and in the post-independence (1947) river valley projects also contributed to the problem. The erosional trend of Sagar is likely to continue in the future.

Generally, most of the erosion takes place during the rainy monsoons (June-September). During this season, a destructive wave climate, increased occurrence of tropical cyclones and a raised local sea level owing to increased fresh water input-all coincide. The severe cyclonic storms of Beaufort force 10 and above have a recurrence interval of 3.28 years within 100 km of Sagar. The most destructive of these struck the island in 1833, 1864 and 1942, causing damages of the highest magnitude.

The human adjustments to the erosion hazard include elementary technological control, acceptance, relocation, regulation and emergency measures-in that order. The erosion management schemes of Sagar are managed by seven government/semi-government agencies often with little coordination. These include 61 km of low-tech marginal earthen embankments, built at US$ 7.2 per metre of length and requiring extensive unskilled maintenance; 14.5 km of comparatively more permanent brick-paved marginal embankments, built at US$ 62.9 per metre of length and requiring skilled maintenance not always available locally; 580 ha of mangrove plantations in 11 localities, three relocation projects involving about 250 families and 13 degraded storm refuges dating from the late 19th century. In a typical year, the calm late post-monsoon period (December-January) is the best time for repair or construction of the erosion prevention structures.

For the present, achieving rational and coordinated use of the available resources with proper understanding of the natural feedback mechanisms would significantly ameliorate the efficiency of the existing management schemes. For the future, in view of the possible effects of the global greenhouse warming that might further increase the mean depth of the estuary and rate of coastal erosion, possibilities of gradual abandonment of the island for wetland restoration and relocating its population need to be considered.

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Geomorphological impact assessment in the River Mincio Plain (Province of Mantua, Northern Italy)

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The research takes into account the landscape modifications induced by man's activity in the past 40 years in the sector of the River Mincio plain located between the Pleistocene morainic hills of Lake Garda to the north and the Mantua lakes to the south. From the geomorphological standpoint the study area is comprised within a stretch of territory made up of the outwash plain deposited by the spills of the Garda glacier and the wide triangle-shaped depression cut by the river Mincio, north of the city of Mantua.
The morphological setting within this depression is characterised by several scarps of varying height, mainly developed in a N-S direction, which form various orders of terraces. The study includes a detailed bibliographical research, the examination of maps and of aerial photographs taken in different years and a morphological survey carried out in the present day.
The plain sector considered has been subjected to intense quarrying activities since the beginning of this century, because the outcropping sediments have good characteristics as building materials. Indeed, the outwash plain and the terraces inside the Mincio erosional depression are mainly made up of rounded coarse gravels. From a petrographic viewpoint, carbonatic, magmatic and metamorphic rocks are present in various percentages.
The open quarries are classified as trench quarries exploited above the water table and trench quarries exploited below the water table. The first-type quarries are excavated only up to a depth of a few metres below the original ground surface and, in any case, up to about 1 m above the maximum level of the water table. When no longer in use, these quarries are reclaimed for farming after the laying of a pedogenised level of organic soil on their floor. The second-type quarries can reach a depth of up to 20 m and when no longer in use are abandoned or in some cases used as occasional dumping sites or equipped for recreational fishing.
All these quarrying activities have caused relevant landscape changes. The trench quarries above the water table appear as large, deep rectangular holes, which impress an «artificial» look on the area affected; also the trench quarries below the water table have formed several small ponds which are extremely different in shape from natural bodies of water (moreover, the interception at ground level of the most superficial aquifer causes potential pollution hazards owing to the possible uncontrolled inflow of waste materials). More in general, quarrying activities have implied the partial or total obliteration of relict fluvial landforms, such as terraces and paleo-riverbeds.
The reclamation of the quarrying areas implies their restitution to farming practices, according to management criteria based on the safeguard of natural assets and landscape values.
Another aspect of man's activities during the past decades concerns the construction of important artificial canals (Scaricatore Pozzolo-Mincio and Diversivo Mincio) which, besides modifying the natural flow of both surface and sub-surface waters, have altered the natural morphological features of the areas affected.
In this research a simple methodology for the assessment of the scientific quality of landforms was applied. According to this model, the scientific quality for each element of the landforms is given by the product of their intrinsic scientific value and their condition of preservation. The impact on the landscape is defined as the reduction in scientific quality due to the assessment of the degree of damage produced by man's activity in the past 40 years.

ILONA BÁRÁNY-KEVEI

Connection between morphology and ecological factors of karstdolines (Aggtelek Hills, Hungary)

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The Aggtelek Karst Region was declared as a part of World Heritage on 2 December 1995. Its surface and subsurface karst formations are worth protecting. Since the formation of the Aggtelek National Park (1985) the measures taken to limit human activity have brought about some predictable improvement in maintaining a state close to the natural conditions.
The karstdepressions in Aggtelek are situated in various orographic, lihologic and tectonic situation. On this basis three main groups may be distinguished (Bárány & Mezõsi, 1995): dolines situated at the height 310-350 m, 270-280 and around 500 m. Present paper permitted to identify first of all the connection between the doline assymetry and ecological processes. Karstdolines are environmentally very sensitive site point of the karst region, for this reason the research of environmental change in this form is very important, too. Morphology of dolines indicate the characters of doline-development depend on exogenic factors.
The climate and the microclimate play the most important role of doline development. The soils covering the karst-forming rock, through the a-biogeneous and biogeneous processes going on in them, indicate the nature and the order of magnitude of the corrosion process.
From this point view by the side of climate and microclimate the vegetation play an important role in the intensity of corrosion. In Aggtelek we have found lot of degraded

grass plots in the dolines where animal grazing used to be intenzive. The stamping and natural dunging led to a uniform grass assotiation. Pasturing and animal grazing had been preceded by deforestation, having led to the formation of secondary grass assotiaton.
This paper presents the analyzing a few more various ecological factors and their effects on development of doline morphology in Aggtelek Hills.

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Geomorphological features and petro-structural and geochemical analyses of vulcanites found in the central-western part of the Piana del Cavaliere, L'Aquila, Italy

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This paper shows the preliminary results of a series of geomorphological, petro-structural and geochemical studies carried out in the central-western part of the Piana del Cavaliere (Oricola, AQ), as part of the Geomorphological «Tagliacozzo» Sheet n° 367 research. The area concerned is geographically located in a wide tectonic depression, midpoint between two different paleogeographical domains, separated by a section of the «Olévano-Antrodoco» tectonic line.
Inside the Piana del Cavaliere, lake-type deposits are generally found, limited in their upper part by a sub-horizontal erosion surface, dried up by small valley formations with steep slopes, often subjected to solifluction and by minor landslides. Particularly interesting are the piping phenomena causing pseudokarstic formations along the valley carvings.
Nearby the Bosco di Oricola area, by a process of erosion, volcanic deposits cover the lake sediments. Two main systems can be distinguished in these deposits: lithologic vulcanites and incoherent red vulcanites. The most lithoid part appears as a canalized body, within a preexisting small valley, cut into the lake deposits. Following selective erosion, which in time has created an inversion of the relief, today the vulcanites are found along a ridge, above the more easily erodible surrounding relief, yielding sub-horizontal tabular forms in contrast with the rapid slopes shaped within the lake deposits.
The present geomorphologic shape and the contrast between the lithologic volcanic complex and the lake sediments below have caused numerous gravitational phenomena around the edges of that formation, as by the presence of large rocks, placed below as a result of a roto-traslational movement.
On the other hand, the incoherent vulcanites is the backbone of a series of hills found between Highway A24 and Via Tiburtina. The smaller hills are perfectly conic, giving the landscape its characteristic feature. From a mineralogical point of view, all the lithologic vulcanites are characterized by the presence of leucite, pyroxene, biotite and glassy scoriae. The petro-structural analysis suggests petrogenic characteristics similar to scoriae tuff (with $25 < An < 40$) similar to tephritic-leucititic litotype, very rich in carbonatic clasts. Radiometric determinations of the area carried out by Bosi & *alii* (1991) suggest an age of 0,531 Ma. The Strontium isotopic ratios were determined on some vulcanite samples lacking secondary calcium carbonate. The results ($^{87}Sr/^{86}Sr$ equal to 0,71087 ± 0,00002) fall within the Quaternary magmatism variation interval of the tyrrhenian zone, but do not seem to be related to any of the provinces mentioned in the literature. Therefore, we infer, together with Bosi & *alii* (1991), that this volcanic zone is the result of an independently developed local magmatism.

CARLO BARONI

Geomorphological evolution of the Victoria Land coastal area since the Last Glacial Maximum

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During the last glacial maximum (Lgm, stage 2) the Antarctic ice sheet expanded and the surrounding ice shelves became marine based and advanced on the sea floor covering wide portions of the continental shelf. The Ross Ice Shelf advanced extending in the Ross Sea embayment, even though the most advanced position of its grounding line is still matter of discussion. Radiocarbon dates of marine organisms that lived below the floating ice shelves that surrounted the marine based ice sheet supply more and more information on the grounding line position during Lgm and the following retreat phases.
The outlet glaciers that drain the ice sheet interior and the alpine glaciers fed by local névés advanced and thickened in the coastal area reaching several hundred metres above the present sea level (up to 400-500 m at Terra Nova Bay). Several reconstructions of late Wisconsin longitudinal glacier profiles are based on the distribution of glacial drifts and erratics deposited during the Lgm as well as on geomorphological evidence of glacial erosion. They document the maximum level of glacier surfaces and allow us to depict the Lgm morphology of the area.
The glacial retreat that followed the Lgm is the last big geological and environmental event that characterized the landscape evolution of the Victoria Land coastal area. Retreating ice isolated wider and wider rocky areas at the head of embayments reached by the rising sea. Penguins nested in those ice free areas and reoccupied the Victoria

Land. Abandoned penguin rookeries are common landscape features related to biological activity all over the Victoria Land coast. Ornithogenic soils from abandoned penguin nesting sites supply several radiocarbon dates that document the penguin re-colonization of the Antarctic continent. The oldest date was obtained at Cape Hickey (northern side of Mawson Glacier basin) where penguins nested since 12 ka BP. Furthermore, several localities between Ross Island and Terra Nova bay were completely deglaciated and occupied by Adélie penguin rookeries since 10 ka. Coastal deglaciation was completely accomplished about 8-9 ka BP.
Deglaciation was followed by the uplift of the coastal belt and by the retreat of local ice shelves that reached minimal position about 7-6 ka BP. Sets of Holocene raised beaches, marine pavements and marine terraces are widespread coastal features. ^{14}C dates from marine organisms and ornithogenic soils allowed the reconstruction of curves of emersion for different sectors of the Victoria Land coast. Evidence of Holocene glacier variations (i.e. «Medieval warm period» retreat and Little Ice Age advance) complete the picture of the geomorphological evolution of the coastal Victoria land areas.

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The geomorphological map of the Terra Nova Bay Area, Victoria Land, Antarctica

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The mapped area is located in Terra Nova Bay, to the south of the Italian Station. It extends from the Nansen Ice Sheet (including Cape Confusion, Vegetation Island and Inexpressible Island) to the southern side of the Campbell Glacier. The eastern limit is the coast of Ross Sea, here forming the Terra Nova Bay; the western one is the deep trough of the Browning Pass. The morphology is mainly moulded by glaciers, and rounded summits together with smoothed slopes are present. Glacial deposits are widespread. Connected with the Holocenic deglaciation is the uprise of the coastal area with a rate ranging from 2 to 5 mm per year in the last 5000 years.
In the mapped area five physiographic units can be distinguished.
Inexpressible Island – The island is about 13 km long in the NNW-SSE direction, and have a triangular shape. Its western portion have an higher altitude and rocks are largely outcropping in rounded summits. Polygons develop where a debris cover is present. A scarp divides this higher portion from the eastern lower part of the island, where a large cover of glacial drift is present. On the drift many periglacial features develop (terraces, sorted and non-sorted polygons, ice cored dirt cones). On the south a flat surface has been interpreted as the bottom of a previous cove or lagoon, now raised above the sea level. Along the present coast, around the raised sea floor and on the side to Hell's Gate raised beaches have been recognized by many researchers.
Hell's Gate Ice Shelf – The Hell's Gate Ice Shelf extends in the central part of the map, flowing from northwest to south-east into the Ross Sea. A double morainic ridge to the east and two alignments of ice-cored dirt cones to the west are present on its surface. Other complex moraines outcrop near Cape Confusion and to the east of Vegetation Island. The ice shelf is characterized by a strong uprising towards the surface, due to intense surficial ablation by the katabatic winds descending from the Antarctic Plateau; so marine ice outcrops in the coastal belt of the shelf.
Vegetation Island – Vegetation Island is a rock bluff (a real nunatak) long about 4.5 km in NNE-SSW direction, emerging between the ice flows of the Priestley and other local glaciers. Its western slope is vertical, the eastern side is something gentler. A deposit of supraglacial debris rests on the lee side of the glacial flow.
Cape Russel – The promontory of Cape Russel is a long narrow strip of ice-free rock limited on the western side by snowfields and a local glacier and on the eastern side by the sea. Here rocks are almost free from debris cover. In the northern part they form a smooth surface, with some rounded summit. In the southern portion an almost flat horizontal surface can be interpreted as a terrace (probably a raised abrasion platform). On the western side, close to the limit of the Hell's Gate Ice Shelf, raised beaches reach an altitude of about 20 m.
Northern Foothills – The upper portion of the Northern Foothills is largely covered by local glaciers and snowfields. Scattered rock outcrops form a smooth surface with rounded knobs. Its surface is strongly weathered, with varnish and tafoni. Where a debris cover is present, polygons and gelifluction terraces develope. The portion closer to the sea is more ice free and debris cover is more abundant. As a whole, the surface can be considered a plane gently sloping toward the sea. Along the coast a high cliff has been cut by marine action. To the west, the Northern Foothills are limited by a steep slope facing the Browning Pass.
The map has been drawn to give the many researchers carrying out investigations in the field near the Italian Station an easy-to-read tool to frame their observations in a geographic and geomorphological context. The base of the map is a georeferenced satellite image processed by M. Frezzotti in the Enea laboratory. On it contour lines have

been drawn by photogrammetry. From the image the reader can argue the characteristics of the ground (bare rock, debris, snowfields, ice, water,...). The symbols are grouped and classified in colour classes according to the main geomorphic processes. They were mapped using both photo- and satellite image- interpretation and prolonged field surveys carried out during antarctic expeditions since 1985.

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Antarctic geomorphological maps

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The geomorphological maps and the geomorphological sketches related to the Antarctic territory have been collected and analysed. Of 271 geomorphological cartographic documents only ten can be classified as geomorphological maps *sensu stricto* (*s.s.*). On the basis of the graphical representation adopted and of the importance given to origin of landforms, morphograpy and lithology, the geomorphological maps *s.s.* were grouped as follows:
– morphostructural small scale maps that picture the whole Antarctic continent (1 document);
– morphogenetic-morphodinamic maps that depict the most important landscape components differentiated with colours on the basis of different morphogenetic origin; active and relict landforms are also distinguished and chronological information are supplied where available (4 documents);
– morphochronological maps that emphasized with different colours the chronology of landforms and deposits represented (2 documents);
– geomorphological-morphographic maps that differentiate areas where different geomorphological processes are, or were, active; morphographic information is also supplied (3 documents).
A different group of maps regard the geomorphological thematic selected maps (6 documents). They differ from the geomorphological maps *s.s.* because they show a limited number of geomorphological themes. Those maps are clearly produced to study one particular scientific problem (*i.e.* glacial history).
Furthermore, we have considered the detailed sketches of small size that describe the geomorphology of a certain area (30 documents). These latter, defined geomorphological sketch maps, are different from geomorphological maps due to their smaller size and the absence of well-organised topographic data (generally only spot heights are indicated). Finally, 225 thematic sketches and location maps with geomorphological information have been analysed.
The structure of the Antarctic geomorphological maps is highly discordant: the discrepancies mainly lay in the definition of legends, due to a different importance given to the morphogenetic processes, the structural characteristics of investigated area and to the chronology of the events. These differences reflect the points of view of various geomorphological schools, and are also a function of scale of representation and local characteristics of the areas surveyed.
Of the ten geomorphological maps *s.s.* analysed (scale variable from 1:20,000 to 1.15,000,000), five regard East Antarctica, two West Antarctica, two the Subantarctic Island of South Georgia and one includes almost the whole continent. Excluding this last map, the others cover 17,686 km^2.
Interest in the production of geomorphological maps has recently grown testifying to the important role that the geomorphological cartography has in Antarctica, both as a method of basic research, as a method of representation and analysis of the landscape, as a support for other research, and as base documents integrated in systems of geographical information (Gis). A deeper confrontation between the researchers working on Antarctic geomorphology is therefore necessary for convenience in utilizing comparable if not compatible and integrated legends.

CARLO BARONI[1] & ALBERTO CARTON[2]

The Adamello Group (Central Alps, Italy): geomorphological map and Holocene glacier variations

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The 1:50,000 geomorphological map of the Adamello massif prepared in accordance with the guidelines for such maps elaborated by the Italian National Geological Service in 1994 is presented. It was originally drawn to the 1:10,000 scale and summarises the results of investisations carried by the writers over the last ten years (Baroni & Carton, 1987, 1990, 1991a, 1991b, 1992 and 1996, in press; Baroni & *alii*, 1993). The glaciological data collected during the surveying work have resulted in a very detailed representation of the changes that have taken place in most of the local glaciers. Exact mapping of the present glaciers and application of the accumlulation/total area ratio method have enabled their equilibrium line altitude to be compared with that for the Little Ice Age, as reonstyructed

by mapping the respective moraine ridges. The topograhical information provided for the larger glaciers is accompanied by the representation of a seriea of epiglacial forms, such as snow cornices, wind scoops, snowdrifts and ice divides.
A particular feature of the Adamello massif is the widespread cropping out of intrusive magmatic rocks belonging to the largest pluton of the Alps, now regarded as a batholith dating from the Alpine age. Their several lithotypes (Bianchi & *alii*, 1970; Callegari & Dal Piaz, 1973) belong to various more or less differentiated plutons that intruded from 42 to 30 My B.P. The main outcrops are the Monte Re di Castello, Western Adamello and Central Presanella tonalites.
The entire area is heavily imprinted by a glacial and periglacial morphogenesis associated with slope processs due to gravity and surface water runoff. Morphochronological data derived on the basis of the sedimentological characters, lichen cover, development of soils and of the dating of buried organic remains (wood, peat, soils) have been used to distinguish the Upper Pleistocene and Holocene tills and identify significant Holocene episodes. Radiometrically dated sites and their ages are also indicated. The wealth of existing illustrations, photographs and maps has enabled the evolution of many forms and deposits over the last 100-150 years to be illustrated.
A brief account of the landscape portrayed on this map includes various types of tills on the edges of the present glaciers and in the areas they have recently abandoned. These are intermingled with fluvioglacial deposits and have often been shaped into accretion and superposition moraine ridges. The slope dynamics is very active: talus cones, scree, avalanche tracks and cones, and debris flows have shaped the flanks of the valleys. Erosion forms often emphasise the structural features of the area. They are mainly the work of Pleistocene and Holocene glaciers.
The numerous radiocarbon dates have been used to determine the features of certain significant morphological evolution: Neoglacial glacier advances between 3350-3096 and 2706-2207 years B.P. have been identified, and some moraines attributable to events during the Little Ice Age have been dated.

RATNESWAR BARMAN

Geomorphological characteristics and socio-economic pattern in Lower Yulsi Basin, Assam (India)

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The Kulsi, a tributary to the Brahmaputra river, has carved out a sub-basin with distinctive fluvio-geomorphic characteristics within the master basin of the Brahmaputra. The lower part of the sub-basin in Assam, India over a Precambrian rock-basement between the Brahmaputra and Meghalaya Plateau covers an area of 1896 km^2 and supports three distinct socioeconomic groups. The differences in fluvio-geomorphic processes and forms within the basin have been well-reflected in socioeconomic character of these social groups. The lowermost floodprone part, for instance, is dominantly inhabited by the landhungry immigrant peasants, while the flood-free middle plain and the foothill region have been under the dominance of indigenous non-tribal and tribal groups respectively. The pattern of landuse, settlement and occupation of all the groups are basically determined by the physical characters like slopes, channel shifting, bank erosion, floods and waterlogging, and soil of the respective zones within the Lower Kulsi Basin.
This study attempts to relate the geomorphic parameters of different zones of the basin with certain socio-economic attributes of the population groups. The work is based partly on primary data and partly on secondary data pertaining to the basin characteristics.

KÁROLY BARTA[1] & TAMÁS TARNAI[2]

Relation between the size of non-karstic catchment area and the connecting caves' sizes in a Hungarian study area

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One of the speleologists' main problems is the determination of the cave's sizes that they wanted to explore. In our research we have tried to apply morphometrical methods to determine the expectable cave's sizes. The method can be used in allogenic karst where you can compare the non-karstic catchment areas connecting to the different sinkholes. We can apply it if only these conditions of the different catchment areas are similar: geological structure; development of the areas; relief conditions; climate.
If these conditions are similar, then the passages' sizes underlying the sinkholes depend on mainly the size of the non-karstic catchment areas because the similar climate gives the similar annual rainfall, the similar geological structure gives the similar sediment types and the catchment areas' size can determine the rate of flow and the amount of the sediment carried by the stream.
Our study area is found in the south part of Hungary, in the Mecsek Mountains. The extension of the karstic rocks is about 38 km^2 and this area is connected with an 8 km^2

large non-karstic area which gives the streams disappearing in the sinkholes. There are lots of sinkholes and springs but we know only a few explored caves.
We have measured the size of the karstic and non-karstic catchment areas, the water input to the sinkholes, the valleys' cross sections and - if it is known - the passages' sizes of the sinkhole caves. The relation between the parameters belonging to the same catchment area was very strong so we can estimate the unknown passages' sizes underlying the unexplored sinkholes.
Naturally we must be careful to apply the method because there are lots of other factors which we are unable to show but they play very important role in the cave forms, e. g. softer rock strata, tectonic faults, e.t.c. In the future we would like to expand our research to the spring caves and their catchment areas. We wanted to compare the absolute size of the catchment area, the rate of the karstic and non karstic catchment area with the caves' sizes.

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The influence of the «Terraced Lands» on the stability of the Ligurian slopes

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Since the most ancient times, the territory of Liguria has been concerned by a progressive and widely spread shaping. The mainly mountainous features of the slope, even of the steepest ones has always been inevitable. Above all, in recent times, the industrialisation of the coast line let all the complex and perfectly efficient system of water regulation, drainage and farming organisation of terraced lands run wild, causing remarkable, widespread hydrologic disarrangement and slope unsteadiness.
We think there is an urgent need of testing new research methods on the territory in order to be able to focus on the various aspects of the degradation and diffusion of this phenomenon. On this subject, the team constituted by Regione Liguria, Datasiel and Genoa University intends to bring out a morphological and structural analysis of the Ligurian terraced lands, aiming, by means of Gis technologies, at the map-making of area in danger because of the terraced structure decay.

ROBERTO BASILI, CARLO BOSI & PAOLO MESSINA

Paleo-landsurfaces and tectonics in the Upper Aterno Valley (Central Apennines)

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Remnant landsurfaces are a widespread and evident morphological feature all over the central Apennines. They are represented by low-relief erosional surfaces with a typical step-like topography. Landurfaces unconformably cut various rocks and formations (Meso-Cenozoic carbonate Units, Miocene siliciclastic Units and Plio-Quaternary continental deposits).
We hypothesize that these surfaces originated from the lateral erosion of ancient rivers and streams; so that successions of remnant erosional landsurfaces can be assimilated to fluvial terrace successions, resulting from an interaction process involving erosion, deposition, tectonic uplift and climatic changes.
Recognition and analysis of these surfaces and their relations with the Plio-Quaternary continental deposits have greatly contributed to the understanding of intermontane basins and to their geological evolution. In this work remnant landsurfaces are in particular used to investigate the elevated areas between intermontane basins in order to i) reconstruct the landscape evolution of these areas; ii) indicate the possible presence of zones affected by differential vertical movements and iii) assess the geometry and kinematics of the structural elements.
The investigated area is ca. 2000 km^2. Single patches of remnant surfaces, from a few hm^2 to a few km^2, have been identified from aerial-photo interpretation and pin-pointed on topographic maps (at the scale 1:25,000). In addition, field surveys supplied data on clastic continental deposits. Correlation between patches of remnant landsurfaces was based on the following criteria: i) spatial continuity or quasi-continuity; ii) accordance of elevation, taking into account possible original gradients; iii) equivalence of position within single local successions of remnant landsurfaces. This procedure led to the reconstruction of about twelve paleo-landsurface levels distributed between 600 m and 1900 m a.s.l., levels being separated from one another by slope from 50 (minimum) to 300 m (maximum) high.
On the basis of these observations we propose the following «model» of tectonic behaviour of the elevated areas between intermontane basins during Plio-Quaternary times. The general landscape evolution seems to be due to the interaction between fluvial dissection and faulting. The studied area would belong to a single large block having homogeneous tectonic behaviour, which was uplifted while minor portions of it (a few ten km^2) were being deformed along NW-SE trending normal faults.
In conclusion, we can say that to study remnant landsurfaces is an useful method to reconstruct the geological evolution of intermontane basins and of elevated areas separating them. For these areas it would also be possible to

identify portions with differential vertical movements. On a wider perspective, the method may be a tool to constraint geometry and kinematics of Plio-Quaternary faulting and assess general uplift rates.

SUBHASHRANJAN BASU

Effluent seepage from the ground water-table and its effect on arsenic contamination in the Deltaic West Bengal

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In a country like the Ganga Delta where the soil is alluvial and fairly porous, a considerable percentage of precipitation, depending on the nature and covering of the ground, is absorbed and forms a great underground reservoir. Ground water is not static, it always moves from places of higher head to places of lower head down the hydraulic gradient. The rate of movement of ground water between two points has a direct relationship with the head differences, the distance between the points and the permeability of the water bearing material. During the winter months of December and January when the river - levels of the Ganga Delta are lower than and intersect the water-table, the sub-soil water seeps through the banks and beds and maintains a steady river-flow. Such an effluent seepage from the unconfined ground water aquifer coupled with heavy withdrawval of sub-soil water for agricultural irrigation in this part of the country leave pore spaces within the soil-texture to be recharged annually by rainfall. But as the recession of water-table in between winter months and the summer months is to an extent of 0.75 to 3.28m, the volume necessary for recharging such a loss is easily imagined. The annual amount of run-off in this part of the Delta also quite high (about 432 mm) due to the utter lack of vegetal cover. Therefore, rain alone cannot compensate for the total loss incurred. As a result, the equilibrium in among the constituent of the sub-soil is disturbed with the consequent lowering of density and the formation of zones aeration in the underground aquifer. Iron pyrites (FeS_2) present in alluvial soil, is found to be rich in arsenic. Although pyrites is not soluble in water, it decomposes when exposed to air or in aerated water. Due to the effluent character of the sub-soil water together with the high withdrawal of groundwater for irrigation, the geo-chemical environment of the sub-soil aquifer has recently been drastically changed. As a result pyrites coming in contact with oxygen decomposes to ferrous sulphate, ferric sulphate and sulphuric acid and thus arsenic in pyrites become available to contaminate the underground water-table. Arsenic has been found in ground water in seven districts of West Bengal covering an area of 37,493 km^2 having about 34 million population. Surveys indicate that 560 villages are arsenic - affected and more than a million people are drinking arsenic contaminated water and about 200,000 people are suffering from arsenic - related diseases.

RAMON J. BATALLA

A field evaluation of bed-material transport formulae

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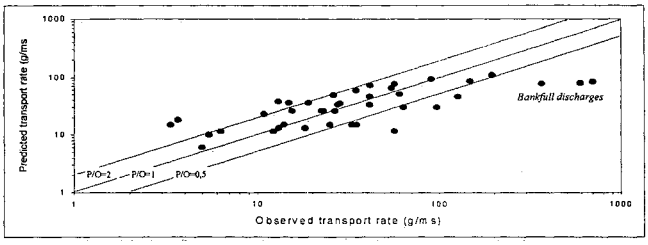
Because of difficulties in field measurements of bed-material discharge, a large number of transport formulae have been developed for a wide range of sediment sizes and hydraulic conditions, most of them derived from flume experimental data under steady flow conditions, rather than from natural flow and transport observations. Several studies (e.g. White & *alii*, 1975; Andrews 1981) showed that the best equations predicting bed-material discharges, within a range of one-half to twice the observed values, lay around 70% of the observations; but little is known, for instance, about the performance of bed-material load formulae in poorly sorted river-beds. This study presents a test of bed-material transport formulae based on field observations in the sandy gravel-bed of the perennial Arbœcies river (NE Spain). Bed-material load under a wide range of discharges was sampled weekly as well as during flood events in 1991 and 1992. River bed-sediment is mainly poorly sorted sand and gravel (d_{50} 2.2 mm, d_{95} 71mm, sorting coefficient 7 from $s_g=0.5[(d_{84}/d_{50})+(d_{50}/d_{16})]$). Bedload and suspended load were collected by means of Helley-Smith and US DH48 samplers respectively, and added to obtain the total bed-material flux. The Arbœcies data showed a marked scatter of bed-material discharges, reflecting the high variability of bed load and suspended sediment concentrations. Mean bedload is 38 gr m^{-1} s^{-1} (submerged weight), ranging from 1 gr m^{-1} s^{-1} at low discharges to 280 gr m^{-1} s^{-1} at bankfull. Mean suspended sediment concentration is 191 mg l^{-1}, from 1 mg l^{-1} at low flows to almost 3 g l^{-1} during floods.

Bed-material discharges were used to test four bed-material and one bedload transport formulae. The data base on sediment flux obtained in the Arbœcies streambed shows that some formulae are reasonably capable of predicting bed material transport; the percentage of observations in which the discrepancy ratio between observed and computed values has a value between one-half and two times the field data reached more than 65% for some of the tested equations. Nevertheless, the degree of agreement between observed and predicted values varied greatly: 25% (van Rijn), 38% (Brownlie), 52% (Meyer-Peter & Müller), 65% (Engelund & Hansen), and 68% (Ackers & White). The wide range of hydraulic conditions from which the data was obtained and the poor sorting of the bed sediment affected the performance of the van Rijn (1984) and Brown-

lie (1981) equations. The adjustment between observed transport rates and values predicted by the Engelund & Hansen (1967) formula appears to be unaffected by the poorly sorted bed material of the Arbœcies River. The Meyer-Peter & Müller (1948) model predicted bedload transport in the Arbœcies River with reasonable accuracy and no bias for transport values under low and intermediate flow conditions. The best agreement with measured values was obtained using the Ackers & White (1973) model, a reflection of its original design for poorly sorted sediment (figure below). In particular, for the range of sediment transport 10-100 gr m^{-1} s^{-1} the equation showed an excellent agreement with observed values, laying eighty six percent of observations within the discrepancy ratio 0.5 and 2. However, it appears to be inappropriate to phases of transport associated with or close to bankfull discharges in this river.



Bed-material load in the Arbœcies river in comparison with predicted values based on Ackers & White (1973)

As it has been suggested in previous studies, wherever bed-material discharge equations give a reasonable estimation of the actual discharge, are preferable to field measurements because of the uncertainty, expense, and time consuming involved in the latter. However, most of them perform still poorly and, therefore, more field data on sediment transport are required to improve predictions on bed-material fluxes in river beds of various hydraulic and sediment-type characteristics.

MARIA BAUMGART-KOTARBA

Neogene and Quaternary fault-bounded Orava Basin and new hypotesis of the Western Carpathians tectonic evolution

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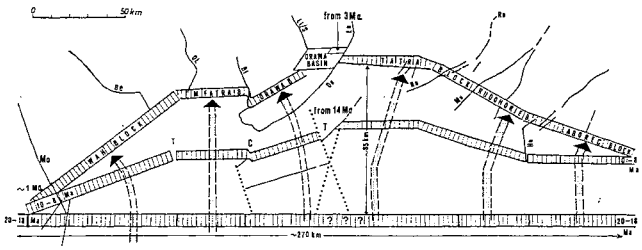
The intramontane Orava Basin (24x16 km) is situated at the boundary of the Inner and Outer Carpathians, in the zone of the change of orientation of the dominant structures: the SW-NE (Silesian) orientation is replaced here by W-E (Tatra) one. The Orava Basin is a tectonic depression formed due to subsidence and filled with the Upper Badenian throught Pontian deposits. The present boundaries of the basin are mostly controlled by the extent of less resistant Neogene fluvial, mainly floot-plain (backswamps) series up to 950 m thick. The erosional history was associated with general uplift, probably initiated in Late Pliocene time. During the Quaternary the western part of the Orava Basin was uplifted and system of six levels of cut-and-fill terraces was formed. The NE part, was controlled by young subsidence, and Wróblówka graben filled with 112 m thick Quaternary fluvial deposits was formed.

Different hypotheses of the Neogene origin of the Orava Basin were proposed. The role of horizontal strike-slip movements resulting in formation of a pull-apart basin was considered by Pospisil (1990, 1993), Bac-Moszaszwili (1993), and Baumgart-Kotarba (1993). Geophysical interpretation by Pomianowski (1995) documents well faults controlling the Orava Basin. The presence of oblique faults points synsedimentary character of this depression related to structural pattern of the Magura Nappe.

My hypothesis is that the Orava Basin would have been formed under extensional regime which existed between the Orava Block, rotating by 40-42° toward NW and the NE migrating Tatra Block. The principal oblique-slip fault is the sinistral fault bordering the southern Choc, which continues along the Western Tatra margin and then through the Inner Carpathian Paleogene flysch, along Domanski Wierch molasse and finally along Lepietnica river valley through Outer Carpathians flysch. This line was named «Prosecno dislocation system» by Nemcok (1993) and according to Baumgart-Kotarba (1981,1983) lineament of western marigin of the Tatra Mts very well visible on satellite image.

I suppose that the Orava Basin became open due to block-type movement being common for the Inner and Outer Carpathians. During folding and thrusting of the Outer West Carpathians, when the whole orogen was migrating toward the North (Oszczypko & Tomas 1985, Kovacs & *alii*, 1989) individual blocks were formed due to friction exerted by the crystalline substratum. The Bohemian Massif hampered the westernmost part of the Carpathians, which caused the NW rotation of the Male Karpaty and Trencin-Zilina segment of the Western Carpathians (43° since the Eggenburgian and 37° since the Karpathian) (Kovacs & *alii*, 1989). The Orava Block was rotated between stopped from the west Mala Fatra Block and migrated farther to the North Tatra Block.



Hypothetical model of the formation of the Western Carpathians arc during three time spans. Hachures show Klippen Belt, while arrows mark assumed direction of the movements of the distinguished blocks. The model shows openning of the Orawa Basin due to tension (T) and formation of the Zazriva sigmoid related to rotation of Orava Block (C - compression). Main fault with abbrevation of names (example Do -Le Domanski Wierch-Lepietnica, Ru - Ruzbachy, Mu - Muraň,Ho - Hornad fault).

ROLAND BAUMHAUER[1] & PETER FELIX-HENNINGSEN[2]

Late Pleistocene and Holocene palaeoenvironmental records of Ténéré, Erg of Ténéré and Erg of Fachi-Bilma (Central Sahara): new implications from palaeolimnological and palaeopedological data

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Palaeoecological studies of late Pleistocene and Holocene lake and swamp deposits and palaeosoils of central Sahara enable the reconstruction of the palaeoenvironmental development of the vast Ténére sand plain, Erg of Fachi-Bilma and Erg of Ténére region, NE-Niger, for the first time. The environmental changes are deduced from geomorphology, sedimentology and biological remains as well as of palaeopedological and prehistoric evidence.
Comparing the lacustrine sediments, three successive types of waterbodies with different conditions could be distinguished. At the end of Late Pleistocene and in Early Holocene large shallow freshwater lakes with rather stable hydrological conditions. Topographical factors, geomorphology and biological remains (e.g. *Lates niloticus, Hippopotamus amphibius, Crocodylus niloticus*) suggest from 11.5 ka BP a wide-spread lake-land country with permanent lakes changing size, level and water balance in space and time. The chronological framework shows a rapid change of the environmental conditions at 6,5-6 ka BP: The desiccation from shallow permanent freshwater lakes next to ephemeral ponds with saline/alkaline superficial dilute/stratified waters and final to a swamp environment. A scattering of neolithic artifacts on the surface of the lake sediments confirms that the lakes had lost much of their original size by the time of the neolithic settlement. The analytical results of the wide-spread palaeosoils reflect the palaeolimnological approach. The palaeosoils, with 60 to 100 cm of preserved thickness, are classified as Chromi-Cambic or Cambic-Arenosols. The soil horizons are stabilized by pedogenic cementation and have been affected by bioturbation. In the shore region of the palaeolakes the terrestrial palaeosoils grade into hydromorphic Gleyic Arenosols. The former shorelines are marked by fringes of stem-shaped to masssive accumulations of bog-iron that was precipitated in the uppermost Go-horizons around the roots and stems of a shallow-water vegetation.
The results demonstrate that the palaeolakes of the vast lowland areas of central Sahara have reacted differently to the groundwater fed lakes in endorheic depressions in front of cuestas.The ecological status obtained, suggest a more direct influence of the major climatic tendencies superimposed on local topographic conditions and changes in geomorphology (e.g. dune activity) only. The palaeopedological approach shows a rather close correlation between the degree of rubefication as well as physical, chemical, and mineralogical properties of the palaeosoils and the geographical position. The climatically determined gradient of decreasing weathering intensity from southwest to northeast has been modified only by local differences of the original mineral spectrum and by the influx of aeolian dust. Based on the lacustrine sediments, faunal remains and palaeopedological evidence, the annual precipitation rate is estimated at least at 400 mm at the end of late Pleistocene and at the beginning of Early Holocene, combined with an interaction of monsoonal precipitation and atlantic/mediterranean cyclons. In the course of Early Holocene and in Mid-Holocene this interaction was very reduced and the character of precipitation became more frequently violent, indicating a stronger saisonality of climate as well as a reduction of the annual precipitation rate (150-250 mm), with a more and more stronger gradient from southwest to northeast.

MICHAEL BECHT & CLEMENS GEITNER

Fluvial dynamics in high alpine regions of the Eastern Alps during the Holocene

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For more than thirty years the history of the variations of the timberline have been investigated by pollen analysis of cores from alpine bogs. The mineral layers in the profiles caused by of floods of small creeks have not been investigated in greater detail. To get more informations not only about the history of glaciation but also about the variations of fluvial dynamics in high alpine regions it is necessary to investigate sedimentation basins in small catchment areas at the timberline. Fine or coarse grained sediments or organic layers are the result of climatic changes or human impact in this sensitive environment. The well known history of glacier retreat in the past hundred years gives us the chance to compare it with the deeper sediments to get a better understanding of the sedimentation conditions during earlier times in the Holocene.
The study area is situated in a small lateral valley of the Ötztal in the Stubaier Alps. Two sedimentation basins in small lateral valleys were formed by the glacier during the Late Pleistocene, whereas present glaciation is limited to the valley heads. One of the basins at an altitude of 2120 m a.s.l is damned by an Egesen morain, the other at an altitude of 2300 m a.s.l by a roche moutonnée and a talus cone. The present timber line lies at about 2100-2200 m a.s.l.
Investigations of present-day fluvial dynamics show that sedimentation into these basins only occurs during high floods accompanying heavy snow melt events in early summer. The snow accumulation before the melting in 1995

was above average and caused very high water levels in the investigated basins. The amount of sedimentation could be measured. In contrast in 1996, after very low winter precipitation no sedimentation occurred. The water level rises only little after rain showers in summer because of the very high infiltration rate but it may be possible that in the case of a coincidence of snow melt and rain the flood increases. The corings up to a depth of more then twelve meter show periods with more organic layers and other periods with mineral sediments predominating. But there are also periods with a quick change of conditions. The basis of the corings has not been dated by ^{14}C or OSI. up to now so that we have to estimate the time of the beginning of sedimentation. The oldest absolute date (^{14}C) is on an organic layer at a depth of about 9 meters with an age of 5,750 ± 400 BP. The existence *Pinus cembra* remains points to the fact that at this time the timberline lay at this altitude or higher. An estimated age for the beginning of sedimentation in the basin based on extrapolation of the sedimentation rate above gives a result of 6,500-7,000 BP. This agrees with an age given by Heuberger for the end moraine near the border of the basin. It is possible that under the coarse sediments there are other layers which cannot be recovered with the used equipment.
About 4,500 BP one of the basins was damned by debris flow activity on the talus cone. So a temporary lake was formed, which has left evidence in the form of fine stratified sediments with low organic content. The sedimentation rate was high. After the Atlantic stage climatic changes may have caused more periglacial morphodynamics in the catchment area of the basins.
In the Little Ice Age the sediments were markedly coarser than during the preceding centuries, although the streams had no direct connection to the glaciers but perlocated in the debris of the *gletschervorfeld* areas. This could indicate that the fluvial sedimentation into the basins was not only due to the glacial streams but also to the surrounding slopes.
All in all the sediments suggest a relationship between climatic changes which are reflected in fluctuations of the timberline, and changes in sedimentation dynamics. While the area has been used as pasture for the last 2,000-3,000 years, no evidence has been found for a possible human impact on fluvial dynamics so far.

HEINRICH R. BECKEDAHL & MAGANDARAN MOODLEY

Road induced accelerated soil erosion forms: their classification and potential significance

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Roads and the associated embankments result in local modifications of the surface roughness and infiltration characteristics of the immediate area. This is particularly relevant, but not exclusive to, unarmoured roads. The road surface proper is compacted and cambered, enhancing these effects. Consequently, runoff is concentrated as potentially erosive, confined flow. The injudicious siting of cut embankments, road culverts and the poor maintenance of road gutters frequently result in accelerated soil erosion forms. These range from collapsed embankments to gullied road verges, to piped and gullied hillslopes.
The present work argues in favour of a fourfold morphogenetic classification of these accelerated erosion forms. Through the discussion of selected case studies, it is shown that these forms develop at rates varying from 4.3 t/a to 65 t/a. The question of reclaiming erosion damage versus initial preventative measures is explored using cost-benefit analysis.
The research suggests that much of the off site damage could have been avoided with a significant cost saving, had local geomorphic processes received due consideration at the time of construction.

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Azimuthal analysis of stream orientations to define regional tectonic lines

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In the last decade many researchers have focused their attention on the definition of the role played by tectonics, and particularly neotectonics, in the geomorphological evolution of areas located in different parts of the world. Many attempts have been carried out also in Italy with the aim of gaining more knowledge about the relationships between morphology and tectonics. In particular, the examination of the tectonic control on drainage network geometry has led to the formulation and improvement of quantitative methods for studying the azimuthal distribution of stream channels, which can help efficaciously the analysis of the field morphological evidence for tectonics in the definition of the structural arrangement and history of a given area. The researches so far performed have shown that tectonics control the drainage network patterns in a way which differs with varying stream order; that is, stream channels of lower orders, which are likely to have joined the net in a later stage of its development, have resulted to be controlled mainly by tectonic lines active in very recent times. Moreover the hypothesis has

been formulated that the activity of strike-slip faults can lead, eventually, to the rotation of preferential stream directions.
This study has a twofold aim: to improve the knowledge of the structural arrangement of some Italian areas affected by tectonics active in recent or historical times, and to aid the individuation of possible strike-slip faults of regional importance, through the careful examination of the drainage network patterns. To this end a methodology has been defined to infer the existence of strike-slip faults on the basis of the quantitative characteristics of surface drainage and to verify whether the activity of such faults resulted in areal variations or rotations of the preferential stream orientations (or domains).
In the first phase of this study a sample area has been chosen; it is located in Latium (Central Italy) and is crossed by a left NW-SE trending strike-slip fault, known in the specific literature as «Val Roveto Fault», for which the results of field survey and the related mesostructural data are available. The quantitative characterisation of the drainage network of this sample area has been carried out separately for the two sectors divided by the tectonic discontinuity; moreover within each sector both the whole drainage network and the different stream orders have been considered and analysed in quantitative terms. The results of this first phase of the research have pointed out that some significant modifications of the preferential stream orientations occur close to the strike-slip fault.
To test the applicability of the proposed method, a second sample area has been considered; it is located in Tuscany (Central Italy) and is characterised by the existence of an hypothetical strike-slip tectonic element which is more properly considered by the Authors as a «belt of deformation and discontinuity» rather then as a linear element. To better define the location of this hypothetical tectonic element, various azimuthal spectra of the channels of each stream order have been previously elaborated and analysed; such spectra have been automatically obtained through suitable software and have been realised according to azimuthal «transepts» randomly crossing the study area. This analysis has allowed to evidence the stream channel preferential orientations; in this way sharp deviations from the channel main directions and domain rotations have been singled out, which may be the surface effects of important discontinuity lines.
The results obtained for both the considered sample areas provide hints from the methodological point of view. In fact it has been possible quantitatively evaluate which of the linear and areal variations of the drainage network main geometric characters may individuate the possible strike-slip motion of tectonic lines of uncertain interpretation. Moreover the proposed methodology has turned out to be suitable to single out and locate tectonic lines of regional importance within areas lacking of geological and tectonic information. The developed methodology may provide useful also for preliminary evaluations of geological structures over wide areas by satellite image analysis.

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Un piémont détritique à silicifications différenciées: les Hamadas tertiaires de Boudenib (Sud-Est Maroc)

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Le système de piémont atlasique du Sud-Est marocain, d'âge tertiaire, est constitué dans le secteur de Boudenib de deux séquences distinctes. La Hamada de Boudenib forme la séquence inférieure et se caractérise par d'importants encro tements carbonatés, riches en dolomite et attapulgite. La séquence supérieure de la Hamada du Guir marque une reprise de l'érosion et le dépôt de matériaux relativement peu altérés. Les deux séquences sont affectées par deux grands types de silicifications qui nont pas la m me signification.
Dans la Hamada de Boudenib (Eocène), les silicifications affectent l'unité inférieure : Boudenib I (Eocène inférieur) ainsi que les grès crétacés sous-jacents, et jalonnent une surface d'érosion reconnaissable dans tout le piémont. Ces silicifications sont précoces, puisque remaniées dans les dépôts ultérieurs. Les illuviations d'opale et les accumulations granulaires intercalées entre les concrétionnements successifs de silice attestent d'environnements pédologiques. La silicification plus forte vers la partie supérieure des coupes, ainsi que l'association fréquente des faciès silicifiés avec des niveaux bioturbés et altérés sont également à rapporter à des dispositions pédologiques. Ces silicifications se développent pendant une période de stabilité tectonique et s'installent dans un paysage de glacis et sous des climats chauds à saisons alternées. Leur reconnaissance à l'échelle régionale constitue un repère lithostratigraphique précieux.
Dans la Hamada du Guir (Néogène), les silicifications sont présentes à tous les niveaux de la séquence: grès, conglomérats, marnes et calcaires lacustres, mais toujours sous forme d'«accidents siliceux» circonscrits depuis des veines millimetriques jusqu'à des amas métriques. L'étude micrographique de ces silicifications montre clairement que celles-ci sont tardives, post-sédimentaires. L'essentiel de la silice est constitué par des dépôts dans des vides de dissolution et des épigénies en bordure de ces vides. Ces dépôts des les vides montrent une zonation remarquable des différentes phases de cristallisation de la silice, allant de l'opale vers des quartz automorphes, et témoignent de la circulation de solutions nourricières. L'absence de géotropisme dans ces dépôts indique un régime hydraulique noyé, d'écoulement de nappe. La charge en silice des eaux est acquise par l'altération de minéraux silicatés lors de l'écoulement des nappes. Ces dernières sont conditionnées par des modelés d'entaille qui forment les exutoires des nappes : les vallées. La superposition de plusieurs niveaux de silicification indique des variations dans

les niveaux phréatiques à différentes étapes de l'évolution du paysage plio-quaternaire, et n'ont donc pas une connotation climatique, aride, comme dans les travaux plus anciens.

MOHAMED TAHAR BENAZZOUZ

Aeolian morphogenesis and desertification in the Ziban Range, Algeria

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Through the research methods on desertification the geomorphological techniques proved to be well adapted to the knowledge and the comprehension of desertification processes on the northern margins of algerian sahara. The study of aeolian morphogenesis focused on the Ziban Range allows the evidence of an aeolian system which supplies and maintains the desertification as a natural phenomenon. The Hodna-Ziban aeolian system is disposed excactly on the north-west flux axe while main reliefs are orientated south-west to north-east and are perpendicular to the prevailing winds . The cartography of this aeolian system sol impact shows the existence of forms and formations relevant to the aeolian morphogenesis .
This explains just south of Biskra, the abrupt changement orientation of oued Djeddi which adapts a new direction north-west to south-east, the presence of dunes field orientated north-west to south-east, northern slopes are supported wind-blown sand veneers, and marks of corrasion on the tops of reliefs, all these indicators confirm the activity of aeolian morphogenesis which entrains sand and carries it over at least 250 km to the Grand Erg Oriental.
The aeolian morphogenesis here is more efficacious because the presence of both paleosebkha and active sebkha which stood in a straight line along the corridor Hodna-Melrhir. So, role of endoreism will be determinant here because the store of aeolian sands which is produced by some active sebkha as chott el Hodna or sebkha Selga This Hodna-Ziban aeolian system develop on the soil some aeolian corridors by which can transit sands to the south-east towards chott Melrhir and the Grand Erg Oriental. This natural aeolian transit is often accentuated by anthropic actions. So, the irreversible appearance of desertification are often located exactly in these aeolian corridors because the recent agriculture devlopment near Tolga oasis and in sebkha Selga where wind-blown accumulation is very high and threaten seriously oasis.
Finally, it appears that in the Ziban Range, aeolian morphogenesis contribute effectively to desertification but can't be considered exclusively as a natural phenomenon.

AJIT KUMAR BERA

Hidro-Geomorphological studies for agricultural planning in West Bengal, India

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An attempt has been made herein to deal with the Hydro-Geomorphology concerning agricultural planning in West Bengal. Hydro-Geomorphology deals with the hydrological attributes and geomorphological attributes on the earth surface. Agriculture is the art of raising plant life in soil on the earth surface. Man's agricultural activities mainly depends on the Hydro-Geomorphological condition i.e. water, climate (hydrological attributes), relief, drainage and soil (geomorphological attributes), etc.
The area under study is mainly confined to West Bengal, India. On the globe the position of West Bengal extends from 21°38' North to 27°13' North latitudes and 85°45' East to 89°50' East longitudes. The total geographical area of West Bengal is 87675.91 km^2 and the total population of the state is 67.982.732 persons as per 1991 census. Whereas 63.05 per cent land uses for agriculture and 17.54 per cent is agricultural labourer out of 28.26 per cent of the total worker in the State. In the State, where 65 per cent people depends on agricultural and neerly 50 per cent of the State's income derived from it. The State earns more than 23 per cent foreign exchange through the export of different agricultural commodities.
The paper is mainly based on the findings of the fieldwork through correlation with the published works on this particular branch of the subject. The study treats of the classification of land in proper perspective and its future. Finally, an attempt has been made to throw some light on the brighter possibllities regarding food and job for local people with the help of modern technology and management.

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Geomorphological investigations on gully erosion in the Rift Valley and Northern Highlands of Ethiopia

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Gully erosion phenomena are very common in Ethiopia. They affect large areas with different morphological, pedological and climatic characteristics. The amount of soil loss due to gullying has become a very serious problem in the

recent decades as it was associated to remarkable depletion of cultivated land.
Field investigations on gully morphology and their genetic processes were carried out in two study areas of Ethiopia, representative of different geological, geomorphological and other environmental conditions. They are: a) the Lakes Region in the Rift Valley north of Shashamene (elevation between 1,700 and 2,000 m a.s.l.; annual rainfall ranging from 700 to 1,100 mm; gully occurrence mainly on colluvial foot-slopes at the base of fault scarps, alluvial and lacustrine deposits); b) Adi Kolen and Mai Maikden, south and north of Mekele respectively, Tigray (sedimentary rocks, Antalo limestone and Agula shales; annual rainfall around 500-800 mm; mainly vertisols; in both areas gullies originated by piping processes are very common. These gullies develop on both footslopes and flat swampy or overbank deposits.
Three main types of gullies were identified on the basis of their morphological characteristics. They are: 1) embryo gullies, which generally develop on gentle slopes (gradient less than 0.05-0.1) and whose cross-section area increases from an upstream minimum to a maximum, at approximately their mid length, and decreases again to a minimum at their downstream edge; 2) headwater gullies, formed by deep erosion processes typically migrating upslope. These gullies make up the main headwater sediment sources of larger river systems; 3) bank collapsed gullies. They are gullies whose almost vertical banks may have partially collapsed filling, locally entirely, the incised channel. Multiple cycles of filling and stream incision were also observed.
In order to investigate the main causes originating the different types of gullies, data on geomorphology, land use, soil characteristics and hydraulic geometry were collected in the field. From the analysis of field and climatic data hypotheses on gully formation in the study area were derived. The temporal evolution of the gullies in the study areas and the main factors originating them are illustrated and discussed in this presentation.

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Geomorphological and sedimentary records of Holocene climatics changes and human impact in the Highlands of Northern Ethiopia

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The highlands of Welo and Tigray (northern Ethiopia), at elevations generally exceeding 2.000-2.500 m a.s.l., with maximum elevations above 4.000 m a.s.l., may be considered one of the tropical areas most affected by soil erosion and land desertification. The climatic characteristics of this region (with 15 °C to 25 °C annual temperatures and 500 to over 1.200 mm annual rainfall, mostly concentrated in summer months) are compatible with a *Juniperus* and *Podocarpus* forest, and by mixed deciduous and *Juniperus* woodland (with subordinate savannah). By contrast, arboreal vegetation is lacking at present, except for a few trees (*Juniperus*, *Olea* and *Ficus*), generally clustering around churches, monastaries and in less accessible sites.
Since the second half of II millennium B.C., the area has sustained the impact of human activities which reached their maximum development during the kingdom of Aksum (II century B.C.-800 A.D.) and, subsequently. underwent a sudden decrease, probably as a consequence of the kingdom's decline.
This paper discusses the results of geomorphologic-stratigraphic investigations carried out on Holocene deposits in the highlands of Welo and Tigray (northern Ethiopia). Radiocarbon datings of peaty deposits and buried soils allowed to establish that during Early-Middle Holocene (at least between 8,300 ± 100 yr B.P. and 3,880 ± 70 yr B.P.) more humid climatic conditions favored soil formation and forest development in the area. Later, generalized slope erosion caused the burial of the soils under thick layers of colluvial and alluvial sediments. This may be related to a progressive reduction of vegetation cover due to the onset of drier climatic conditions even though, the finding of artifacts and prehistoric settlements in the area also suggest some influence of human impact.
A more recent phase of soil formation, possibly connected with a minor shifting of climate towards wetter conditions, is testified by the dating of buried soils in Tigray (1,250 ± 60 yr B.P.; 970 ± 60 yr B.P.). Subsequently, widespread slope degradation, likely related to human activity, followed. The impact of human pressure on the environment has continued till the present times (specially during the last decades), being responsible for the present barren landscape.

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The relationship between strain and morphology on a solifluction lobe, Finse, southern Norway

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This paper discusses the relationship between surface strain and morphology on a solifluction lobe, localized at

Finse (60°35'N, 7°30'E, 1,350 m a.s.l.), southern Norway. The solifluction lobe is about 50 m long, 20 m wide and has a frontal riser of about 2 m. The lobe is situated in front of a semiperennial snowbank. Threaded bolts were drilled into stones along the central flow line of the solifluction lobe. Ball joint markers were inserted into the bolts and aligned vertical with the aid of a circle bubble. The positions of these markers were repeatedly surveyed with theodolite/Electronic Distance Meter from two concrete pillars on bedrock. Standard position errors are close to one millimeter.

The measured displacement along the central flow line varied by an order of magnitude. The displacement was largest (about 10 cm/year) in a sector immidiately downslope of the snowbank. In this sector, the solifluction lobe is slightly concave in cross section. Further down towards the lobe front, the displacement was lower. Here, the lobe has a convex cross section. Sorted and nonsorted stripes are directed in towards the central flowline in the upper part of the lobe and to some extent outwards on the lower part of the slope. This reflects the flow pattern.

The surface strain along the central flow line resembles that of a glacier, and the glaciological concepts of extending flow ($du/dx>0$, u = velocity, x is distance in flow direction) and compressive flow ($du/dx<0$) are therefore adopted to describe the flow of the solifluction lobe. Extending flow implies a downward velocity component, which explains the cross sectional concave upper part of the slope. The downward flowline of a single soil particle is explained by the debris supply from nivational processes and from the velocity component towards the central flow line. The convex cross section surface of the lower part of the solifluction lobe could be caused by a movement component directed upwards relative to the surface. A small velocity component outwards relative to the central flow line would displace the upper parts of the soil sideways, thus bringing the deeper part of the soil to the surface. The debris is also nonisotropic, and could therefore be compressed.

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Sedimentation and sediment delivery: a flume study

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The estimation of the sediment delivery to streams, which is crucial if one wants to estimate the off-site effects of soil erosion, requires information on both erosion and deposition. Although there is a vast number of studies on erosion processes at various spatial and temporal scales, detailed sedimentation studies are almost non-existent. Consequently, current deposition and sediment delivery routines in erosion models remain largely untested.

Experiments were carried out to study deposition in detail. Homogeneous mixtures of water and silty soil were brought in a 2,5 m long flume with a constant slope of 2% where deposition occurred. Each experiment was conducted using a constant discharge and sediment concentration. For the different experiments the discharge ranged between 150 and 650 l/h and sediment concentration between 50 and 200 g/l. The amount and the grain size of the sediment leaving the flume were monitored in function of time. After each experiment, the amount and the grain size of the sediment deposited in the flume were analysed every 20 cm downslope.

The experimental results showed, as expected, that sedimentation is a highly selective process so that the exported sediment is always enriched in clay and fine silt. However, other observations were less obvious:

– Although the sediment mass depositing in the flume increased the water surface slope during the course of the experiments, the sediment delivery ratio as well as the grain size distribution of the exported sediment remained essentially constant.

– Sediment concentration at the inlet did not have a significant effect on sediment delivery or the grain size composition of the exported sediment. On the other hand, these variables were strongly dependent on discharge.

The experimental results were then confronted with the deposition theories incorporated in different erosion-deposition models (Eurosem, Wepp and the Rose/Hairsine Model). In Eurosem and Wepp net deposition is occurring as the transport capacity is exceeded. The Rose-Hairsine model sees net deposition as the difference between the continuous processes of deposition and reentrainment. None of these models predicts correctly the observation that the sediment delivery ratio is independent of the input sediment concentration. However, the Rose/Hairsine model generally agrees better with the experimental data than the transport excess routines of Wepp and Eurosem.

SUDIP KUMAR BHATTACHARYA

A constructive approach on landslides through susceptibility zoning and case study in the Rakti basin of Eastern Himalaya

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The Rakli River basin over the hills of Darjeeling district in Eastern Himalaya faces severe landslide hazards in the rainy season every year. The problem becomes so grave

that it not only geopardises the cultural and economic set up but also claims lives and properties in the Basin.
Landslide treatments, in the basin area, are seen to be taken up by the construetion engineers and geo-technical experts almost every year from Govt. level. But sorry to say that only constructional works on the slide affected spots and filling procedures of sinking areas have beome totally unsuccessful to heal up the problems. Rather, treated areas become prone to more severe slides and subsidences in the preceeding years. It happens beeause their treatments are targeted to the rectification of individual spots, without verifying the deep-rooted causes which practically enhances landslide susceptibility as well as slide and subsidence occurrence.
Therefore, this paper attempts to determine the various susceptible zones of slope failure through intensive investigation of different natural and anthropogenic causes. Moreover a detailed case study of a very ideal slide cum subsidence in the basin has been carried out to realise the exact nature and causes behind the occurrences.
The methodology for such purpose has been based on intensive field survey, topographical map and aerial photo analysis on various factors like relief, drainage, bedrock, regolith and soil, legacies from the past and anthropogenic factors by means of a 'check list' in numerous field sites of the basin.
Thus, four categories of landslide susceptible zones have been determined and it is identified from the case study that the extraneous or human induced causes are the triggering factors for slides and subsidences over the basin area.
Finally, the appropriate remedial measures have been prescribed.for the different slide susceptible zones and slide cum subsidence affected areas to arrest this menace over the basin under study.

KUM KUM BHATTACHARYYA

Human perception and adjustment in the riverine sand bars: a case study of the Lower Damodar river, India

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Control structures are common features of the economically important tropical rivers. The Lower Damodar river, a subsystem of the Ganga river is no exception to this. The river has been controlled by means of embankments, canals, weir, barrage and dam. As a consequence, a chain of sandbars have emerged within the river bed below the control structures and most of them subsequently have been settled by the refugees from the then East Pakistan.
The community of the migrants was forced to live in such isolated riverine sandbars due to specific sociopolitical factors. These sand bars were perceived as unproductive by the local agrarian community. The refugee community has a distinct position in the social space. Due to their specificity in the social space, the perception of resource potentialities of the barren sandbars are distinctively different from that of the local people.
Though flood frequencies have been reduced in the post dam period yet sandbars get inundated atleast partially whenever excess water is released from the control points. The refugees have accepted this flood-risk and have taken some pragmatic measures in their own landuse system, which is flexible and adjusted to the floodprone micro-environment. At present every available space of sandbars is being used here objectively and rationally. As the human perception and appraisal of environment have been changed so the concept of resource evaluation has been widened. Thus the sandbars between the Panchet reservoir and Palla village, so long a land of no use have become a valuable resource base for the migrated people. Some important findings are noted below:
1. By controlling the river during the monsoon period, flood frequencies have been reduced and stabilization of sandbars has taken place.
2. Sandbars are growing through anthropogenic influences.
3. The migrated people due to their distinct position in the social space are more rational towards hazard assessment and resource appraisal.
4. The controlled sector between the Panchet reservoir and Palla village is becoming less hazardous and more resourceful with the mitigation of annual flood discharge.
The paper is a critical review of the perception and application of the geomorphic knowledge about the hazard reduction and resource evaluation of the riverine sandbars by the refugees to fortify their physical space in the riverbed.

AUGUSTO BIANCOTTI & MICHELE MOTTA

Morphotectonic evolution of the Ligurian Alps and their forelands

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The Ligurian Alps form a belt of nappes. Their Ligurian side skirts the sea, whereas on the Po Valley side they are hounded by the Quaternary deposits of the Cuneo plain and the Langhe, the name of a hilly area where Oligo-Miocene continental slope deposits have buried the Lower Oligocene mountainous morphology.
Examination of the literature and fresh geomorphological and morphotectonic evidence enables an account to be given of the main stages in the evolution of this interesting area, which lies between the main arch of the Alps and the Apennines.

On the Po Valley side, the evolution of the river net that formed on a Plio-Pleistocene pediment was determined by the particular structural context: owing to the presence in central Piedmont of the outer fingers of the rising Apennines, two distinct areas offered routes for the drainage of southern Piedmont. The Turin corridor took advantage of the structural trough between the Alps and the Apennines, and was the drainage path followed by all the Alpine watercourses starting from the present Bormida di Millesimo and Bormida di Spigno during the Lower Pleistocene, while the Alessandria area, a depression in the Apennines between the Monferrato district and the Ligurian section of the Apennines, formed the outlet for the smaller streams running down the easternmost sector of the Langhe pediment, The Turin route was initially favoured by its better structural position, but gradually deteriorated throughout the Pleistocene due to the progressive obstruction of the Turin rock bar between the tectonically uplifting Turin Hills and the initially fluvial and then fluvioglacial fan of the Dora Riparia coated with enormous moraines by each glaciation, and hence in steep progradation despite its erosion by the Po. During the Upper Pleistocene - Lower Holocene, this evolution culminated in the changes in the Piedmontese drainage pattern known in the literature as the «capture of the Tanaro». The subsequent erosion phase gave the present Langhe their cuesta shape, though in their southern section the almost total wearing away of the Oligocene marine deposits has resulted in partial exhumation of the Oligocene morphology. Along the Ligurian-Adriatic watershed, on the other hand, the head of the Pleistocene watercourses, once tributaries of the Alessandrine plain, were altered by the development of a net with a rectangular pattern determined by fault systems that were also the cause of the progressive tectonic subsidence of the Ligurian side, and hence of the northward displacement of the watershed itself, with the gradual shearing of the heads of the Padane rivers to the east of the Cadibona Pass, in keeping with the characteristic morphotectonic style of the Ligurian section of the Apennines.

In the Alpine area, the most significant event during the Pleistocene was the transition from the ancient WNW drainage pattern to the present net, whose main river (the Tanaro) runs northwards along a structurally and morphologically low zone that probably formed during the Lower Pleistocene through reactivation of direct faults already present in the Middle Oligocene. The Alpine area was also affected by the elevation in relief energy associated with the capture of the Tanaro, resulting in a marked increase in erosion, except where karstification transformed fluvially modelled areas into poljes or causses.

On the Ligurian side, too, the paths of valleys that had formed along the ancien pediments were different in the Lower Pleistocene to those they have today. In the Finale area, where their evolution can be reconstructed with a good degree of approximation, there are interesting signs of competition with the karstification process: initially the rivers ran round the major karsts, which formed causses, whereas later they were captured by underground complexes within the caussess and ended up by forming narrow, boxed-in valleys, some of which were shaped in the Lower Pleistocene and then abandoned, and have been preserved until the present as relicts. During the Quaternary, the fluvial morphogenesis of the whole of the Ligurian side has experienced periods, which probably correspond to positive eustatic oscillations, when the valleys became much wider with flat floors linked to hillside terraces, alternating with periods, such as the present, in which the recommencement of relative uplifting is the cause of a deep incision in the river net, with the shaping of a rather harsh landscape.

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PIER FRANCESCO GRANGIÈ [3] & MARIA CRISTINA SALVATORE [1]

Remote sensing, photogrammetric monitoring and digital cartography for regional management of landslides

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Landslides and other slope erosion forms are singled out and located accurately and in a short time using image interpretation techniques. The use of small scale aerial photographs allows to get very good results because it is also possible to have the photogrammetric mapping of both the interpretation data and the topography of slopes deeply modified by landslides.

Active phenomena, being most dangerous or of greater scientific interest, may be monitored by means of multidata photography and aerial photogrammetry or, if a retrenchment of futher expenses is required, by terrestrial photogrammetry. Today this one makes use of new computer equipments, as digital metric or semimetric cameras, and software working in personal computers for data plotting.

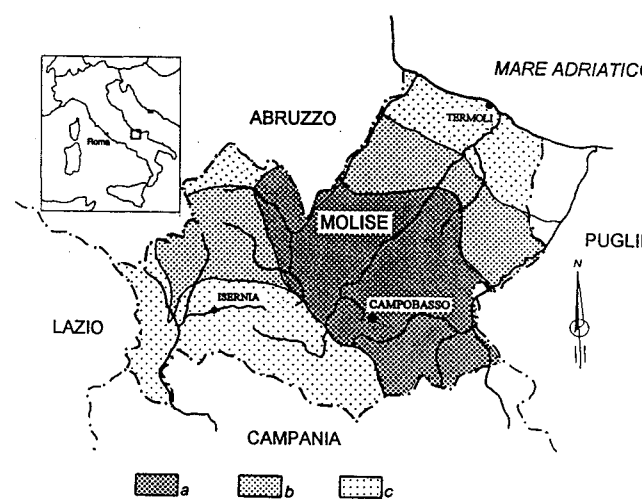

FIG. 1 - The investigated area and density of landslides: a) high; b) medium; c) low.

This software makes photographic record as well as orientation of photographs for coordinate calculation easier. Also mapping makes use of computer equipments for digital map output, while geomorphological data processing, toghether with all thematic data heplful for regional management inside Gis, is facilitated just by the format (vector or raster) of monitorated data.
Authors produce the first results coming from the application of cited systems. The aim is to create a sound support to the management of areas affected by strong landslides hazards like the region Molise (Central Italy) covering 4,400 km^2. The first application stage has been carried out using panchromatic aerial photographs (scale 1:70,000) having a high ground resolution (about 60 cm under average contrast condition). Photogeological investigation covering the whole regional area allowed to locate, analize and map (at a scale 1:50,000) more then 600 landslides, mostly still active and negatively influencing man's presence. Phenomena are distributed with a high density (see figure) over all areas where clayey-sandy and variegated clays outcrop, and in general where vertical or horizontal facies changes and highly tectonized outcrops occur. These landslides are poorly widespread in areas with smoother morphology, towards the Adriatic Sea, and on clearly lithoid calcareous rocks. Phenomena show a medium distribution on arenaceous, marly and calcarenitic rocks. For some present landslides, for which a recent morpho-evolutive stage has been recognized, comparing then with previous aerial photographs, monitoring by means of aerial and terrestrial digital photogrammetric mapping as been started. First data, as they are georeferenced, represent the first map of the data base required for the management of landslides of Molise inside Gis to a complete advantage of a prompt and quick updating, and necessary for an integration also with data of different typology.

ALESSANDRO BIASINI[1], CLAUDIO CAPUTO[1],
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First geomorphological data of the Mount Murchison Quadrangle (Victoria Land, Antarctica), mapped at 1:250,000 scale by aerial photographs and satellite images

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Within the research project «Glaciology and Paleoclimate» of the Italian National Antarctic Research Programme (Pnra) for several years various studies are being carried on with the aim of characterizing the geomorphology of Victoria Land and in particular for the study of glacial processes and of the climate and environmental history of our planet. An important contribution to the knowledge of these regions and to the reconstruction of climatic changes comes from investigations on reliefs and glacial covers, as well as from the compilation of thematic maps, above all if one considers that mapping of these regions is very poor. In this context, some research groups of the Pnra are carrying on, since several years, a wide programme of researches directed towards the drawing of thematic maps (particularly geomorphological maps) being both synthetic and detailed. Among these the drawing of a series of geomorphological maps of Victoria Land at a scale 1:250,000 is programmed, the result of the cooperation of several researchers. Till now the geomorphological map of the Mount Melbourne Quadrangle has been compiled.
This poster shows the first morphological data of the Mount Murchison Quadrangle (fig. 1), which have been obtained mainly from the interpretation of the Trimetrogon Antarctica stereoscopic aerial photographs taken by the US Navy during the Fifties and Sixties, and, subordinately, from the interpretation of satellite imagery and field checks for some areas. Data have been mapped on a Landsat satellite image which had been processed at the Enea-Casaccia laboratories by M. Frezzotti; the geometrical correction and the georeference of the image have been made by means of ground control points which were acquired by L. Vittuari of the Disart (University of Bologna) by using Gps receivers during the XII Antarctic Italian Expedition.
The mapped area covers about 15,000 km^2 between 73°S and 74° S and 162° EGW and 166°33' EGW. Large glacial valleys holding very big glaciers highlight and define the main mountainous domains. The Priestley and Campbell glaciers delimitate the northern sector of the Deep Freeze Range, a large mountainous domain running NNW-SSE; the summit of these reliefs is a sort of plateau reaching its maximum elevation with Mount Hewson (3720 m), while the northeastern part of these reliefs shows a typical alpine morphology with valley glaciers, cirques and horn; some other sectors are characterized by glacial deposits and large supraglacial debris covers. More to the north follow the tabular reliefs of the Mesa Range (peculiarly shaped structural reliefs), bordered to the east by the Rennick Glacier, at whose feet frequent supraglacial debris often show complex dynamics. Between the Campbell and the Aviator glaciers extend the Southern Cross Mountains almost completely covered by snow and ice except for some isolated and small rock outcrops. To the east follow the Mountaineer Range from which stand out the twin peaks of Mount Murchison (3501 m): this range show an alpine-like morphology being well developed and enlivened by several local glaciers. Volcanic edifices may be recognized in the northernmost parts of this area (f.e. Mount Overlord).
In the map geomorphological symbols are grouped according to the main processes: glacial, periglacial, aeolian, marine, structural, weathering and due to gravity; glacier features, hydrography and lithology are also mapped. Morphographic and lithological sketch maps have been also produced. Data coming from direct surveys and from

multispectral and multitemporal image analysis will be added to these first data obtained by photointerpretation in order to complete the map.

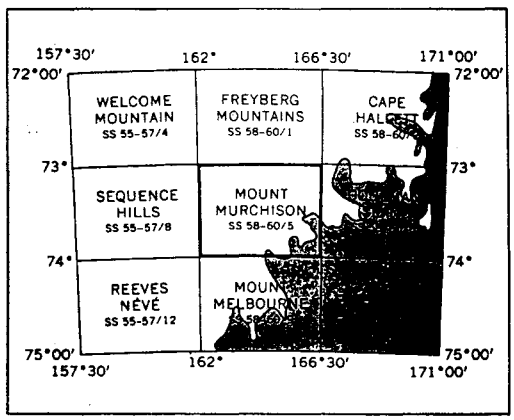

FIG. 1 – Location map of the mapped area

ALESSANDRO BIASINI[1], MIRCO MENEGHEL[2] & MARIA CRISTINA SALVATORE[1]

Geomorphological map of the Andersson Ridge area, Victoria Land (Antarctica)

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The investigated area is located in the southern portion of the Eisenhower Range (Victoria Land) eastward of the Italian Station of Terra Nova Bay. A geomorphological map of a 75 km^2 area including Andersson Ridge and the so called Backwater Glacier (Chinn & *alii*, 1989) has been compiled at a scale 1:25,000 (fig. 1). Investigations were carried out by interpretation of different photographic coverages taken on November 1960 by the U.S. Navy and on November 1993 by the US Geological Survey together with the New Zealand Department of Survey and Land Information. The photointerpreted data have been checked and integrated by field surveys carried out during the IX Italian Expedition. The morphology of the extensive ice-free area of Andersson Ridge appears moulded by glaciers and rounded ridges together with small cwms, basins rock, small local glaciers and debris covered glacier are present too. The glacial deposits are represented by the Younger Drift (Late Wisconsin) distinguished by Denton & Hughes (1981), here informally named Terra Nova Drift (Orombelli & *alii*, 1991).

The geomorphological map of the Andersson Ridge area has been produced using a previously tested method (Biasini & Salvatore 1993b; Salvatore, 1995), based on a digital stereoscopic plotter (Digital Video Plotter) which records the plano-altimetric coordinates from stereoscopic aerial photographs. To do this, it was necessary to acquire new control point to provide the coordinates for georeferencing the three dimensional models. The Gps surveys were carried out with the helpful collaboration of L. Vittuari (Disart, University of Bologna) during the IX Italian Expedition (1993/94) using two Trimble 4000 SSE Gps receivers in «rapid-static positioning» mode providing coordinates with centimetre accuracy. All Gps data have been post-processed and referred to the World Geodetic System 84 (Wgs 84).

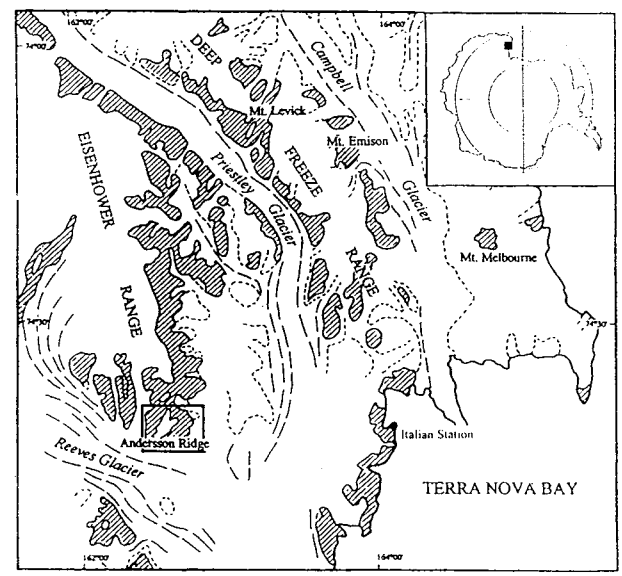

FIG. 1 - The investigated area.

The use of analytical plotter and the methodology used have enabled the creation of a georeferenced data base for a Geographic Information System; a software named Geodress, still in an experimental stage purposely done for geomorphological cartography, was utilized for specific editing.

Computerized data offer a number of advantages among which the main one is to support the creation of cartographic maps with a data base for further studies and analyses. These data and informations could be easily integrated with others and placed on a network for exchange between researchers. In the map geomorphological symbols are grouped according to the main processes: glacial, periglacial, aeolian, weathering and due to gravity; glacier features, hydrography and lithology are also mapped. To complete the map contour lines with 50 m interval have been built by the use of the digital stereo plotter.

SABINA BIGI[1], ERNESTO CENTAMORE[1], SIRIO CICCACCI[2], LEANDRO D'ALESSANDRO[1], FRANCESCO DRAMIS[3], PIERO FARABOLLINI[4], BERNARDINO GENTILI[4], STEFANIA NISIO[1] & GILBERTO PAMBIANCHI[4]

Quaternary evolution and morphotectonics of the Marche-Abruzzi peri-Adriatic belt

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The study area, located between the Apennine range (Gran Sasso Massif, Laga Mts. and Sibillini Mts.), to the west, and the Adriatic sea, to the east, provides geomorphological and geological evidence from which it is possible to understand the relief building processes that affected the Italian peninsula since Middle Pleistocene.
During Messinian-Lower Pliocene, the area consisted of a foredeep sedimentary basin migrating eastward within a thrust system; on its external side, starting from Middle Pliocene, a subsiding piggy back basin was located. At the same time, the inner Apennine area was affected by progressive uplifting as proved by sequences of erosional surfaces on the eastern side of the range and by minor unconformities within the Plio-Pleistocene marine deposits, which show a general monocline setting dipping to northeast.
Starting from the end of Lower Pleistocene, a rapid regional uplift, with amplitude increasing westward, caused the emergence of the area. Therefore, late Lower Pleistocene marine deposits were raised up to 494 m a.s.l. at Ripatransone (Marche) and 576 m a.s.l. on the divide between the Foro and Moro river basins (Abruzzi) with uplift rates around 0.8-1.0 mm/yr; in the same areas postrasgressive Pliocene deposits are located at elevations of 672 m a.s.l (S. Giovanni, Tenna River basin, Marche) and 1103 m a.s. l. (Mt. Ascensione, Marche).
After the end of Lower Pleistocene, areal erosion processes, probably favored by sub-arid climatic conditions, generated an erosional surface across the whole area, from the Apennine range to the Adriatic coast; this surface truncates Sicilian marine deposits and it is overlain by Middle Pleistocene coastal deposits (Crotonian). Also the erosional surface underwent uplifting and tilting towards the Adriatic coast, while rivers cut deep valleys. The valley incision was associated to terracing favored the climatic changes that affected the area during Middle Pleistocene-Holocene.
This framework was also complicated by the building of compressive structures along the coast (whose activity is proved by earthquake hypocentres distribution), and by the differential uplift of transverse blocks whose bounding faults reactivated previous tectonic dislocations. Somewhere (as in the case of the «Fermano» sector) inversion of vertical movement also occurred.

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Geomorphological mapping in Tigray (Ethiopia)

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A research project on slope degradation processes, including geomorphological survey and mapping, has been carried out in the Highlands of Tigray (Northern Ethiopia), a region strongly affected by soil erosion and desertification (Hunting Technical Service, 1976). On the basis of airphoto interpretation and field survey, morphological maps at medium (1:100.000) and large (1:25.000) scales have been produced.
In the medium scale map, which represents a large belt of the Highlands west of Mekele, the land surface is divided into a number of homogeneous geomorphological units, characterized by different bedrock lithology and structure, overburden materials and slope geometry. The morphodynamic evolution of these units is shown by means of an «ad hoc» predisposed legend.
The large scale map illustrates in detail landforms, surficial deposits and morphogenetic processes affecting slopes and thalwegs in the Adi Goudum area, a vast catchment south of Mekele. The legend derives from the one proposed by the Italian Group on «Physical Geography and Geomorphology» (Gruppo Nazionale Geografia Fisica e Geomorfologia, 1994), specially oriented to illustrate the distribution and incidence of present geomorphological processes.
The use of these maps may be particularly useful for land-rehabilitation and planning projects in the view of the socio-economic development of the region.

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Morphologic study of the Sanabria Lake (Spain)

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Active glaciers are nowadays found in Spain only in very restricted areas. These occur in the Pyrenees, at around 3,000 m above sea level. There are vestiges of Quaternary glaciers, outside the hights of active glaciation, in the Pyrenees, the Cantabrian mountain chain, the Galician massif, the León mountains, the Iberian and Central ranges and, in the South, in Sierra Nevada.
The main effect of glacial morphogenesis, occurred during the Quaternary, was overexcavation. In many overexcavated areas, the disappearance of the glacier resulted in the formation of lakes further downstream, dammed by hard rocky thresholds or by the glacier-caused moraines. A combination of the two phenomena was also possible. The lakes originate in valleys, crossed by the glacier tongue, or in cirques after ice has disappeared.
As regards the Quaternary glaciation of the León mountains, located in the South-West of the Cantabrian mountain chain, between the Galician massif and the Douro sub-plateau, the large «plateau» glacier of Sierra Segundera may be highlighted. This glacier branched out into numerous lobes, one of which gave rise to the Sanabria lake. Other lagoons, like the Cárdena, stand out among other smaller ones, resulting from Quaternary glaciation.
This study deals with the glyptogenetic characteristics of excavation in the above mentioned lakes, particularly the Sanabria Lake and useful parameters are given for further morphologic and engeneering research.

CARLO BISCI[1], FRANCESCO DRAMIS[2] & MARCO MATALONI[1]

Test of the potential usefulness of digital shaded-relief maps to morphotectonic analysis: an application in the Southern Marche Region (Central Italy)

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A detailed geomorphological analysis of automatically generated digital shadow-relief maps has been carried out for the southern half of the Marche Region (Adriatic side of Central Italy), mainly aiming at the recognition of previously undetected lineaments. The whole work can be divided into three successive phases:

1) acquisition, informatization, check and elaboration of the digital maps;
2) geomorphological analysis of the maps;
3) field check and characterization of some of the detected lineaments.

All the laboratory procedures have been carried out using a Geographic Information System (Ilwis®), running on a normal pc.
The survey has been based upon grey-scale shadow-relief maps deriving from the application of specially designed digital filters to a high-fidelity (pixel = 30 m) Digital Elevation Model. The latter has been obtained checking, editing and rasterising the regional topographic map (1:10,000) of the whole study area, and then interpolating the resulting raster contour map.
Information layers regarding tectonics, lithology, slope instability and macroseismal events have been recorded too in the georeferenced data base, in order to make it easyer to individuate (and possibly classify) the lineaments; data on the above themes have been obtained basing upon public domain data (i.e. already published tematic maps).
The shadow-relief maps, created simulating different virtual light source positions, have been accurately examined, tracing over them all the detected lineaments. To make it easyer to individuate the lineaments, the shadow-relief maps have been digitally processed in different ways, trying to enhance them.
The ancillary information have been used in different ways: the lineaments corresponding to lithological contacts have been disregarded, the lineaments already mapped in the geological maps have been classified separately, the alignments of mass movements have been checked for further morpho-structural evidences in the shadow-relief maps, the spatial distribution of hypocenters of earthquakes has been compared with the network of lineaments etc.
At the end of the computer-based analysis, a large number of previously non-detected lineaments resulted, often forming swarms. Some of the lineaments (i.e. the longest or most significative ones), have been checked in the field by means of detailed geological and geomorphological survey, aiming to find evidences of tectonic dsiturbance and, possibly, to collect kinematical data. In most cases, the acquisition of ground truth allowed to identify the presence faults (mainly normal and transcurrent ones, sometimes showing reactivations), and therefore to significantly improve the knowledge on the tectonics of the study area. Particularly interesting is the previously unknown fault system oriented ca. N 105° E, which, notwithstanding its discontinuity (it is interrupted and sometimes laterally dislocated by the faults controlling the main river valleys), crosses the whole study area from the Apenninic belt to the Adriatic coast.
Standing the fully satisfactory results of the research, analogous investigations are in progress for the northern half of the Marche region and it has been scheduled both to improve the capabilities of the computer based analyses (adopting more adequate HW and SW) and to expand the study to wider areas, also outside Italy.

PEDRO BLANCO SEGUNDO, JOSÉ R. HERNÀNDEZ SANTANA, ANTONIO MAGÀZ GARCÌA & JORGE L. DIAZ DIAZ

Basic principles for the classification of the recent exogenous processes of the Cuban relief

Instituto de Geografia Tropical,
Ministerio de Ciencia, Tecnologìa y Medio Ambiente, Cuba

New classification criteria of the recent exogenous dinamics of the Cuban territory relief sustained on the expeditionary geomorphologic research for the elaboration of the «Recent Exogenous Processes» map of the Nuevo Atlas Nacional de Cuba (Nanc) are presented. The carried out classification has four hierarchic levels: l) Zonal type of the process, which is the fluvial one for Cuba; 2) Category of the process, which according to its direction can be denudation accumulation and weathering; 3) Mechanism of the exogenous modeling, that is connected to the genesis of the process (fundamental type or level of classification) which can be erosive, denudative, karstic, etc, and 4) Intensity of the process, given by the degree which the earth surface is transformed. The general geologic and geomorphologic characteristics of the relief, are the basis for the determination of the category of the process and the mechanism of the exogenous modeling. The degree of intensity was qualitatively determined by the condition of the plant cover, land use of soil, angle of the slope, genetic type and the annnal mean precipitation. The present classification synthesizes the main criteria and ideas of the exogenous dinamic researchers in Cuba.

JOHN BOARDMAN[1] & DAVID FAVIS-MORTLOCK[2]

Frequency and magnitude in soil erosion-some effects of spatial scale

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Soil erosion by water results from both rainfall and runoff. Because of the important role of the land's surface, frequency-magnitude distributions of erosion events differ markedly from those for rainfall and runoff. This difference is due in part to temporal changes in vegetation cover and soil properties. It is also related to variation in the relative importance of erosional processes with rainfall amount and intensity. Examples are the increase in the contribution of splash with increased rainfall intensity, and the shift in the balance between rill and gully erosion with changed rainfall intensity (Poesen & *alii*, 1996). Also the importance of these processes does not necessarily vary smoothly across the whole range of rainfall magnitudes: there appear to be broad thresholds separating the domains in which each dominates. Frequency-magnitude analysis of rainfall or runoff is therefore a poor predictor of erosion.
Knowledge of frequency-magnitude relationships for erosion events is hindered by a lack of long-term studies incorporating high magnitude events (Favis-Mortlock & Boardman, this volume). Even for shorter periods of observation, knowledge of the frequency-magnitude distributions of erosion events at the field and catchment scale is limited, since the majority of existing time series of erosion rates are derived from small plots. In particular, we lack knowledge of the effects of spatial scale on frequency-magnitude distributions. Moving from hillslope plots to small catchments, increased heterogeneity of vegetation cover may become important. For example, while it is clear that on the agricultural UK South Downs most erosion occurs as the result of a few storms, these are only effective when and where there is low crop cover. While storms of >1000 year return period have little erosive effect in summer, storms of 25 year return period may give rise to erosion rates >200 m^3ha^{-1} on individual fields with little crop cover in the autumn period.
A second effect of increased scale is increased opportunity for storage. Work done by erosional runoff in the agricultural landscape is difficult to quantify because of the possibility of long-term sediment storage. Trimble (1983) shows that eroded sediment may be eventually released from storage sites on slopes and flood plains. A central issue here is therefore the degree of connectivity between landscape elements; this varies through time and in relation to the magnitude of runoff events. Experimental plots fail to address these scale issues.
This study presents an analysis of erosional frequency-magnitude relationships for sites in the South Downs and other localities at a range of scales.

JAN C. BOELHOUWERS

Periglacial slope deposits in the hex river mountains, Western Cape, South Africa

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Coarse debris deposits are of widespread occurrence in the Western Cape mountains of South Africa. Although no hard evidence exists, the origin of the material, which occurs down to sea level, has generally been related to Late Quaternary phases of cryoclastic weathering. The processes of deposition of the slope materials and the environmental conditions under which they took place remain equally debatable. While various types of slope processes have been suggested for the lower slope deposits, block-

streams related to periglacial solifluction have been described for sites at altitudes above 1,500 m a.s.l.
This paper provides a brief overview of the range of deposits encountered in the Western Cape mountains, while more detailed morphological and sedimentological descriptions are presented for the periglacial slope deposits at Matroosberg (2,249 m a.s.l.). Near the summit, extensively shattered bedrock is found closely related to several broad stone-banked terraces, over two hundred metres long, up to 40 m wide and with openwork boulder fronts up to 8 m high. Clast sorting and orientation are described. With an increase in slope angles at 1,900 m a.s.l. the slope cover grades into broad stripes of alternating coarse and less coarse, sorted material parallel to the maximum gradient. Widths of the zones of coarse material increase from 5 m to over 20 m over a distance of more than 50 m in downslope direction. Here they merge into openwork block deposits several tens of metres long and wide.
The assemblage of relict periglacial landforms described for this area closely resemble the lobate stone-banked terraces studied by Benedict (1970, 1976) in the Colorado Front Range. As these landiorms appear to be associated with the most severe climatic conditions during the Late Quaternary in these mountains, their paleoclimatic significance is evaluated.

FEDERICO BOENZI, MASSIMO CALDARA
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The morphostructural characters of the substrate of the «Tavoliere di Puglia» (Southern Italy)

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The «Tavoliere di Puglia», is the second Italian plain for extension. It coincides with the part of the Adriatic Foredeep which is delimited by the Apennine Chain and Apulian Foreland, more precisely corresponds to the area surrounded by the Daunia Mounts, Gargano Promontory and Murge Hills. The geological history of this area could be summarized as follows:
– sedimentation of the Mesozoic-Paleogenic carbonate platform;
– fragmentation of the Apulian plate with the consequent formation of the foredeep beginning from Miocene;
– filling of this subsident trough during the Plio-Pleistocene (Bradanic cycle);
– regional rising with glacioeustatic fluctuation of sealevel followed by an important phase of mesopleistocenic-holocenic terraces.
The aim of this study is to reconstruct the top of the carbonatic substratum and to individuate the main morpho-tectonic structures. For this purpose the geological outcrops of the mesozoic mudstone of the perimurgian and perigarganic areas have been used together with the stratigraphy of the oil wells on the border of the Apennine Chain and the unpublished information given by the holes for water searching drilled in the plain.
The first information are summarized into a countourn map and shows that the Tavoliere can be divided into three zones.
The Southern zone, between the Murge and Cervaro Stream, corresponds to a graben delimited by two important tectonic lineations. The graben, SW-NE orientated, is complicated with minor trasversal structures dipping forwards the Apennine Chain.
The Central zone is perfectly contained between the Dauno Subapennine and the Gargano Promontory. It corresponds to a big semigraben which has apennine alignment dipping SW complicated with a series of host and graben.
The Northern zone is divided from the central one by the Torre Mileto-Diga di Occhito Fault. It corresponds to a semigraben dipping into the Adriatic Sea with secondary E-W and NE-SW structures and also N-S corresponding to the Fortore Fault.
These structure have been hidden in the surface by mesopleistocenic-holocenic deposits; their presence, however, conditions the course of the most important rivers in the Tavoliere. A good example can be given by the rivers Fortore, Cervaro and Ofanto which have an antiapenninic orientation and the Candelaro River flowing close to the Gargano Massif with a direction parallel to the Apennine Chain.

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The Quaternary terracing phases of the «Tavoliere di Puglia» (Southern Italy)

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The «Tavoliere di Puglia», is the widest plain of Italy second only to the plain of the Po river. It corresponds to the area limited to the West by the Mounts of the Daunia (Apennine Chain), to the South by the Murge Highland (Apulian Foreland) and to the North and East by the Adriatic sea and it surrounds the southern border of the Gargano Massif. From a structural point of view, the Tavoliere was a part of the subsident trough, that was formed, starting from the Lower Pliocene until Lower Pleistocene, and was filled by the sediments of the Bradanic Cycle. The regressive part of this cycle consists of the «Argille subappennine», «Sabbie di Monte Marano» and «Conglomerato di Irsina» Formations.
After the basin filling, some terracing phases linked both to glacio-eustatic and discontinuous uplifting phenomena

took place: various phases are characterized by the deposition of transgressive marine sediments unconformably over deposits of the Plio-Pleistocene cycle, in particular over the «Argille subappennine» Formation.
The aim of this study has been to reconstruct the terracing phase using both the buried abrasion platforms present at the top of the bradanic deposits and superficial morphologies. For this purpose the stratigraphies of some thousands of wells drilled by Boards and Companies specialized in water drillings have been analysed and in many cases perforations of calibration have been realized. The results of this regional preliminary study show that the Tavoliere is divided into three different zones.
The Southern zone, between the Ofanto River and Cervaro Stream, corresponds to a plane delimited by two important tectonic lineations. This surface slopes down softly towards the Adriatic sea, and shows evidence of the phases of the sea mesopleistocenic-holocenic terraces. In the whole it is possible to recognize eight marine terraced surfaces put between 350 and 5 meters. Differently, a succession of nine buried flat surfaces was recognized on the top of the Plio-Pleistocenic Cycle, starting from 260 m a.s.l. to-40 m b.s.l.. These surfaces delimited by evident slope can be interpretated as abrasion platforms. Stratigraphical analyses suggest that on these platforms there are marine deposits: the deposits located at a higher level are formed by a single sedimentary cycle, instead of the lower ones which are composed of two or three sedimentary cycles, superimposed upon the other.
The Central zone is perfectly contained between the Dauno Subapennine and the Gargano Promontory. From the morphological point of view the central sector is characterized by two districts. The former is western, situated near the mountains of the Subapennine, between 500 and 100 meters, the latter is eastern, and it is between 100 meters and the present coastal plain. The characteristic of the zone is given by the streams that join the Candelaro Stream. These have deeply cut the highest area of the central Tavoliere, and consequently they have isolated and divided the marine terraces into flat ridges boarded with a series of fluvial terraces. This situation made difficult the recognition and the correlation of the marine phase terraced.
In spite of that, sixteen fragmentary buried flat surfaces were recognized cut into the «Argille subappennine» Formation, starting from 430 m a.s.l.. Above the first seven platforms there are no evidences of marine sediments, these have been recognized owing to the fauna starting from the eighth platform. The deposits of the eastern sector are formed by various superimposed sedimentary cycle up to four.
The Northern zone is divided from the central one by the Torre Mileto-Diga di Occhito Fault. This sector is characterized by a young hydrographic grid, still in a phase of evident regressive cut, which does not flow into the Manfredonia Gulf but into the Adriatic Sea, west of the Gargano Promontory. Besides, in recent times, the marine streams have ridistribuited the sediments brought by the Fortore River eastwards, forming the long coastal bar and the consequent Lake of Lesina. Traces of the quaternary sea level fluctuations are present only near the coast, where the sediments reach the highest thickness in theTavoliere, equal to 138 m.

SERGEY I. BOLYSOV

The mapping of biogenic continental relief

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The biogenic relief is one of the least studied genetic complexes of the continental relief yet. The principles of its mapping are not worked out nearly. There are rare maps of some biogenic forms (for example: organic coasts, individual relic reefs, some bog complexes) or of local areas with the high density of bioforms of relief. But usually biogenic relief is reflected in general geomorphological maps as one of many different genetic complexes on the occasions of its dominating importance (as bog complexes) or presence of large biogenic forms (as relic reefs). We adduce proposed principles of mapping of biogenic relief in different scales in this article as a result of drawing the maps of the world continental biogenic relief and of the relief of some key parcels in the Center of the Russian plain.
The maps of biogenic relief are the typical example of typological geomorphological maps. Legend of my map of biogenic relief (scale 1:70,000,000) reflects the zonality of biogenic relief formation. The biogenic relief has bright outline of geographical zonality more than some other genetic complex. So the image of geographical zones of the world (the adapted version of the Riabchikov's & *alii* map, 1988, was used) serves as the coloured base of our map. The main biogenic complexes and the versions of indirect biogenic influence upon the relief formation are reflected in two columns in the table legend for the map. So the participation of organisms in the relief formation is minimum in arctic and antarctic cold deserts and is come to the biogenic weathering in the main. The bog relief formation in addition to bioweathering is developed in tundra broadly. As these processes and zoogenic complexes formed by beavers or a great number of zoogenic and phytogenic micro- and nanoforms, root-denudation, tree gorges and others play important role in the temporate belt forests. The vegetation is of great importance in the deserts of tropical and middle latitude as the factor of the structure of difference of aeolian forms, also the zoogenic micro- and nanoforms play important role. The termitariums are the bright forms of the relief in savannes. The presence of organic humus acids is the main factor of intensive development of «tropical» karst in subequatorial and equatorial climate. The «cattle-terraces», forms of root-denudation and some others are typical for microrelief of mountains.
The second ground of symbols of the legend is the combination of different areas of the most widespread forms or

of the largest biogenic ones (their areas are reflected with the shading of different kinds and colours). There are the areas of bog complexes of relief (marshes in coasts, mole-courses, ant-hills, marmot-hills, suslik-hills, steppe-marmot-hills, mima-relief, termitariums, beavers' complexes, root-denudation; the areas of «tropical» karst (in connection with the role of vegetation in this process), the organic (reef, mangrove, reed) coasts (Kaplin & *alii*, 1991) and the areas of relic reef complexes in the continents in the map. Literature data about the biogenic continental relief is generalized in this map, also our own observations in some natural zones are used.

As to mapping of biogenic relief on a large scale, it's proposed to use qualitative background (colour or shading) for large forms (relic reefs, beavers' dams and reservoirs) or unscaled symbols for outstanding ones (as termitariums), as well as for leading processes of biogenic relief formation (areas of peat accumulation and bog tussocky microrelief formation). The use of the dot method is optimum for mapping of micro- and nanorelief to my mind. Naturally the drawing such detailed maps on large scale is possible as a result of painstaking observation of biogenic relief in regions only (we conduct such kind of observations in Moscow, Kaluga and Kostroma regions in the Russian plain). I think the mapping of biogenic relief is necessary for study of mutual connections between the relief and organisms in the ecosystems of different classes.

ALDINO BONDESAN

A glaciological map of a small ice shelf (Hell's Gate Ice Shelf, Terra Nova Bay, Antarctica)

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The Hell's Gate Ice Shelf (Hgis) is a small ice shelf located to the south of the Italian Antarctic Station «Terra Nova Bay». Its total area is more than 70 km^2, extending about 17 km north to south and having a maximum width of about 10 km. It is nourished from the north by the Priestley Glacier and by the ice flow from Browning Glacier; to the west it is in connection with the Nansen Ice Sheet. The Hgis is bounded by the northern Foothills to the east, Vegetation Island to the north, Inexpressible Island and Nansen Ice Sheet to the west and the Ross Sea to the south.

Intense surficial ablation due to the katabatic winds descending from the Antarctic Plateau and blowing with great intensity and frequency across the ice shelf is responsible of the strong uprise of the ice and of the replacement with marine ice at the bottom, expecially at the front. Because of its peculiarities Hgis has been a field of research for glaciologists, geophysicists and metheorologists since the first Italian antarctic expeditions (1984/85).

The map, which is descriptive in many aspects, is designed as a basis for future interpretation of the dynamical behaviour of the ice shelf. It is based on the field research carried out during the IX, X and XI Italian Antarctic Expedition, also as part of the Italo-Belgian joint glaciological research program. Data from former studies by Italian and Belgian researchers also greatly contributed to the making of this map. The only available map of this region was the U.S. Geological Survey 1:250,000 sheet «Mt. Melbourne». Also images from satellite and aerial photographs are available. The cartographic basis that was adopted for the glaciological map of Hgis is a mosaic derived from the black and white aerial photographs of the «Tma 6-11-85» flight and the «Hell's Gate 8-11-93» flight (approximate scale 1:25,000). The Gps geodetic measurements performed in 1993 year (10 points) allowed the geometric georeferencing of topographical and morphological features in the area.

The map combines the photointerpretation of aerial photographs (1956-57, 1985, 1993) with field survey. The great detail of the high-quality aerial images and the opportunity that we had to study and check the various glacial features directly in the field, under different seasonal conditions, allowed us to identify properly the different glacial subsets and covers. Problematic cases were eventually investigated through ice corings and field studies of the ice textural characteristics.

The data covered by the map can be organized in the following groups:

a) snow and firn; b) glacier ice; c) marine ice; d) sea ice; e) lake ice; f) cones; g) ice cliff h) hydrography (bédières and melt water lakes); g) glacial movements and the related surficial forms (pressure ridges, ice bulges and domes); h) main foliations; i) main crevasses and cracks in fast ice; l) ice foot, fast ice margin and the hummocked ice; m) marine specimens; n) aeolian forms and processes (snowdrifts, snowbarchans, sastrugi, wind scoops, snow deflation and corrosion). Some supplementary and important information are also added, including geochronological dating (with age, method and material), ice drillings performed (with depth), geophysical surveys (with used method), stable isotope analyses, ice depth, snow accumulation and ablation, Gps measurements, mean annual temperature, wind direction and velocity. This work has been carried out in the framework of the Italian Antarctic Research programme, core project 2a.1: «Glaciology and Paleoclimate».

MARCO BONDESAN[1], PAOLO RUSSO[1] & MARCO GATTI[2]

Map of the relief and vertical movements of the Po Plain

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Together with the Geomorphological Map of the Po Plain at a scale of 1:25,000, the Map of the relief and vertical movements of the Po Plain has been produced at the same scale. Both maps were coordinated by Prof. G. Castiglioni (Department of Geography of the University of Padua) and the authors from 10 Universities and other scientific institutions in northern Italy.
Apart from showing the altimetry of the Po Plain by means of depicting the contour lines, this second map presents a synthesis of the ground movements which have been recorded since 1897. These movements are not only due to neotectonics and natural subsidence but above all to phenomena of artificial subsidence. The latter were mainly caused by the drainage of water for agricultural, industrial and civil uses, the extraction of water containing methane, the hydraulic reclamation carried out between 1860 and 1970, and the artificial control of the ground water.
The impact of this subsidence is very marked; in fact it has been the main cause of the presence of vast depressions in the part of the plain which lies closest to the sea, impeding the runoff of surface water, and in particular modifying the slopes of the canals for the drainage of rain water, thus compromising the functionality of numerous pumping stations present in this area and impeding the distribution of the irrigation water. In addition the subsidence raises the height of the ground water in the cultivated fields and provokes the infiltration of sea water into the ground water. On the coast it causes the beaches to retreat and increases the danger of flooding.
The study of the vertical movements of the ground was based on the data resulting from the levelling surveys carried out by the Istituto Geografico Militare and the Direzione del Catasto. A first insert of the map shows the subsidence for the period between 1897 and 1957 (Arca & Beretta, 1985). It then shows the data for the following decades, up to 1990: the latter study, which is largely unpublished, was carried out by M. Bondesan, P. Russo & M. Gatti in the ambit of the work for the Geomorphological Map of the Po Plain, and involved the storage and processing of the data obtained during various levelling campaigns in an Altimetric Information System. The available data mainly concern the eastern part of the plain, which is also that which is most affected by both natural and artificial subsidence. Among the results of this analysis, the map shows the graphics of the vertical movements recorded for each levelling line and an insert at a scale of 1:500,000 in which the velocity of the movement recorded with the most recent measurements is compared with the greatest velocities of the subsidence recorded in the previous periods.
Comparing the data for the 1970s with the most recent data, the phenomenon turns out to be markedly reduced in the whole of the region of Veneto, in the eastern part of the province of Ferrara and in the coastal strip in Romagna. On the other hand there has been an increase at Modena, around Forlì, to the south of Ferrara, between Ferrara and Ravenna, at Ravenna and, above all, in Bologna and its province (where it now exceeds 10 cm/year). In general the greatest subsidence occurs in areas which have been recently industrialised and can be interpreted as being the result of excessive drainage of ground water.
A synoptic analysis of the movements recorded in the internal network allows some general considerations to be made on the influence of the geology on the vertical movement of the ground; in particular it highlights a frequent coincidence between rapid velocities of subsidence, including artificial subsidence, and greater thicknesses of loose Quaternary and Pliocene sediments.

PAOLO BONI, LAMBERTO LAURETI, CLAUDIA OTTONE, LUISA PELLEGRINI & ROBERTO ROSSETTI

Morphotectonic influences on the drainage pattern in the Northwestern part of the Apennines (Northern Italy)

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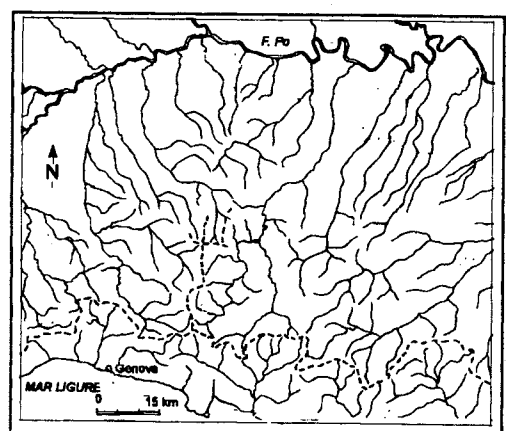
Discussing on geographical features of the Northwestern part of the Apennines between Orba and Taro rivers (Boni & *alii,* 1996), we showed strong differences between the two sides of the Genoa meridian. Westward of this line, the mountain range has a SW-NE orientation and it is narrow and low (respectively under 10 km and 1,000 m) while eastward the chain has a NW-SE direction and it is wider and higher (over 30 km and 2,500 m). In this part, we founded more interesting situations as: 1) a meridian axis (Antola axis) quite near the western border likely linked to the major orogenic movements; 2) some evidences of paleosurfaces and 3) strong changes in the drainage system, undoubtedly connected with neotectonic events.
Now, discussing on hydrographic pattern and their evolution, we considered the relationships between hydrography and tectonics.



Geographical outlines of the considered area

Referring to a topographic basis 1:100,000, firstly we ranked each river basin and secondly we rectified the whole pattern starting from the third order branches. From previous studies and documents we derived any information both on the general and local structures (faults and fractures, fold axis, thrust planes). Starting from these data, we redrawn a structural map at same scale of the hydrographic pattern and afterward we rectified all the structural traces for a comparison with the rectified rivers. Revising the results, we noticed the existence of some structural directions, like 135° (Apennine direction) and 0° N, related to the main orogenic events, and others caused by Quaternary settling movements that are typical of a specific area but generally included in the sector 55°÷135°. The frequency analysis of the directions, both for the fluvial and structural system, showed not only that there are some associations demonstrating the superposition of the major and minor structural systems, but this analysis highlighted also that sometime the river direction looks independent from the local structure. The third order rivers (following Stralher, 1958) show the 115°N azimuth as prevailing and the 10° as subordinated while for those of the fourth order the two main azimuths are respectively 140° and 50°. The azimuths of the fifth rank rivers are respectively 90° and 10°, while the number of the sixth order ones is too little to carry out any usefull conclusions.

Analyzing the flow direction of the more important streams and rivers, we found the presence of a large number of deviations often isoriented for more water courses in the same area or showing an evident alignment in a lengthened band or widespread in the whole area without any evident linkage. This kind of anomalies of the river pattern (globally defined by us as «torsion») includes both tectonic influences and morphogenetic processes. Linked to the tectonic structure are the changes in the regional dipping and rejuvenation by faulting, while examples of morphogenesis are the capture phenomena. Very interesting is the noticed presence (Boni & *alii,* 1996) of two subparallels divides eastward of Genoa meridian: the Apennine one (Tyrrhenian-Adriatic Sea divide) and an higher internal divide. A neotectonic assessment of the Ligurian maritime border is more likely the responsible of this situation but the sequences of these events caused progressively a southward and downward shifting with respect to the ancient divide (the higher one). We pointed out that the area around the older watershed shows clearly the existence of a wide paleosurface gently dipping toward the Po-river plain and that the major streams flow northwards also today, crossing and carving the internal divide. This means that the sinking speed of the old southern rim was be lower that erosion power of the streams. Considering the river elbow, we clearly identify some regional situations like, for instance, those on the steep northern slope in the NW Apennine side where we observed that more streams show a strong flowing change from north to west. We founded also evidences of capture elbow both for regressive erosion (sometime forced by neotectonic events) and for overflow in more parts of the examined region.

ASHOK KUMAR BORA

Floods of Assam (India): a geomorphological analysis

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In Assam, flood is almost a regular phenomena. Historically the people of the state are well acquainted with it and sponteneously they have acquired the art of living with it to a considerable extent. But in the recent past due to a variety of newly emerged causes, in addition to the generally recognised ones, floods in both the Brahmaputra and the Barak valleys of Assam sometimes attained such a magnitude that they appeared to be greatly hazarduous to a major section of the floodplain dwellers. Therefore, this still unresolved problem calls for persistent study and research towards economically viable and ecologically permissible solution irrespective of disciplinary jurisdictions. This paper is a modest attempt to expose the fluvio-geomorphic characteristics of flood in the state with special attention to its main causes and probable remedies from geomorphological viewpoint.

UTTARA BOSE

Geological evidences of subsidence in Boston area

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Inside the Boston harbour, there were actually three long and narrow peninsulas: Boston, South Boston and Charlestown, joined to the mainland by low «necks» submerged at high tide. The mud flats and swamps surrounding these peninsulas were eventually filled up and improved for urban expansion. There are at least five point of evidences to prove the eustatic changes of sea level along the Massachussets coast during the present post glacial period. At the climax of Wisconsin glaciation the sea level was 300 feel lower in Boslon area than it is today. During the same time, the 1and mass faced «super-elevation», as evidenced by many plant species on the islands nearby. The shoreline of Boston also faced isostatic upliftment following the recession of Wisconsin ice sheets. There are also various evidences of recent submergence of shore line in Boston area. The greatest evidence of subsidence in Boston in recent times is the presence of the Amer-Indian fishweir partially embedded over the glacial blue clay. The vast tifal marshes and flats adjoining Boston peninsulas were further of the subsidence of shore line in Boston. The glacial hills (like Beacon Hill) on Boston peninsula were cut down to fill up the bays, coves and tidal flats to facilitate the processes of urban expansion during the 19th and early 20th centuries.

MARGOT BÖSE

Glacial landforms in Taiwan

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Situated at the edge of the western Pacific, between the Philippine plate and Eurasia, the island of Taiwan is about 377 km long and 142 km broad at its widest point. A young, tilted fault-block range occupies the central part of Taiwan. The mountains are very steep and exhibit signs of strong neotectonic activity. About 20 massifs have higher elevations than 3,000 m, the highest mountain being Yu Shan (3,952 m), located on the tropic of Cancer.

In 1935 Panzer reported evidence of Pleistocene glaciation, glacially modified valley heads and a possible lateral moraine, from the two massifs of Yu Shan (Niitakama) and Hsueh Shan (Tsugitakayama). He attributed this moraine to the penultimate glacial stage because its shape did not resemble alpine moraines of the last glacial: a debatable conclusion, since weathering and erosion processes in monsoonal Taiwan differ from those in the Alps. Annual precipitation in the Yu Shan area ranges between ~2,500 and ~4,500 mm. Further observations on possible glacial landforms in Nanhu Ta Shan (Nankotaizan) are found in Tanaka & Kano (1934) and are also discussed by Panzer.

Owing to the island's steep relief, the resulting short valleys draining to sea level, and to neotectonic activity, intense fluvial erosion and many earthflows are the dominant processes in the Taiwanese mountains. Hence, relict glacial landforms may be expected only in protected positions in the midst of the mountains, unaffected by strong headward erosion. Current palaeoclimatic studies by Taiwanese researchers mainly concentrate on vegetation changes at lower and medium elevations and have revealed pronounced temperature and precipitation changes during the last glacial. To supplement this work, research on the elevation zone above 2,600 m and on glacial deposits in selected valleys is necessary. Suitable study areas were selected from maps constructed from air photographs of Hsueh Shan, Yu Shan, and Nanhu Ta Shan. Areas of weak recent denudation, possible deposition areas at high altitudes, putative glacial landforms, and the long profiles of valleys were mapped. These results and preliminary field observations have clearly shown the former presence of short valley glaciers in the highest mountain regions of Taiwan.

Measurements at Yu Shan (3,858 m), the only climate station in the high mountains of Taiwan, record frequent frost changes during winter seasons. Frost weathering is causing the formation of talus ramparts and initial nivation forms, especially above the tree line (~3,500-3,200 m).

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TAÏEB BOUMEAZA[1], ANDRÉ PISSART[2] & F. VITA[3]

Evolution du cours inferieur de la Moulouya au cours du Quaternaire (Maroc nord-oriental): propositions nouvelles

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La vallée de la Moulouya constitue la principale artère et le plus important bassin versant du Maroc méditerranéen. Sur son cours inférieur méditerranéen, il n'existe que des formations fluviales d'âge holocène. L'emboitement des formations differenciées est très rare à inexistant. Pourtant, durant le quaternaire, des vestiges de dépôts fluviaux ont marqué la totalité de ses affluents .

Les formations fluviales qui batissent les terrasses sont limoneuses à limono-argileuses stratifiées sans charge grossière. Leur évolution s'est produite en forme de dépôts de crues et liée à l'eustatisme marin au cours de la dernière transgression. L'eustatisme, s'est fait sentir à l'intérieur sur un parcour de 25 km, néamoins, la néotéctonique récente a joué un rôle dans la position actuelle de ces niveaux alluviaux. Des datations ont été pratiquées à partir des coquilles d'Hélix et ont donné un âge relatif de 10.950 ± 450 ans BP pour les niveaux inférieurs et 3.150 ± 200 ans BP., pour les niveaux supérieurs. Toutefois, ce niveau supérieur paraissait raviner une topographie de creusement antérieure à sa mise en place, ce qui peut tre interprété comme une petite phase de régression qui s'est déroulée il y'a plus de 4.000 ans BP (datation à l'appuit) permettant à la Moulouya de pratiquer un creusement dans les dépôts antérieurs, avant que le niveau marin ne revienne et favorise l'accumulation des niveaux situés au sommet et qui sont datés de 3150 ± 200 BP. Le cailloutis d'oued est fossilisé depuis le littoral jusqu'à 28 km vers l'intérieur par des dépôts fins limoneux. A partir de là il apparait plus élevé que le lit mineur de prèsque 3 à 8 m. Cette denivelletion est liée surtout à un décalage d'ordre tectonique puisqu'il est identique partout où il apparait .

Hormis ces dépôts holocènes, les formations anciennes sont absentes, et non jamais pu résister au ravinnement et à l'érosion de la Moulouya. Toutefois, les formations holocènes fossilisent des colluvions limono-argileux roses, qu'on rapporte au Soltanien (Würm). Celle-ci sont fossilisées par le cailloutis d'oued.

LOUIS BOYER[1], SAMUEL FIERZ[2] & MICHEL MONBARON[2]

Geomorphological heritage evaluation in karstic terrains

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Having been confronted with the problem of geomorphological heritage evaluation in the context of their applied research project, the authors have elaborated an evaluation process based on the principles of systemic approach and multicriteria analysis. They establish a series of markers in the aim of formalising both observation and evaluation of morphological sites and/or objects, but wish to conserve a wide range of manoeuvre. One of these markers is a list of evaluation criteria which are revealed in this poster. It is based on the synthesis of recent publications and field work. The different criteria are tested and illustrated by a few examples from the karstic region of the Franches Montagnes in the Swiss Jura Montains.

CLÁUDIA BRANDÃO[1] & MARCELO FRAGOSO[2]

Rainfall controls of soil erosion in Alentejo (Portugal)

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In the southern part of Portugal, from mediterranean climate type, rainfall have a strong seasonality, high interannual and spatial variability, falling in a reduced number of events from variable duration, few of them of high intensities. Soil degradation in Alentejo is a major problem studied for more than 30 years at differents scales, but with an emphasis to experimental plot scale at the Mertola-Vale Formoso station, and to catchement scale, with an estimation of sedimentation rate in reservoirs. Traditionally with an extensive agricultural land use for winter cereals and grazing, Alentejo presents each year an extensive area of bare soils (ploughed crop fields and fallows) potentially submitted to severe water erosion injuries. Many portuguese studies, mainly from agronomy and hydrology engineering, attempted to predict rainfall erosion losses, in particular using the Wischmeier universal soil loss equation or more synthetic technics, but it is difficult to express the rainfall regime in a single index number. Field determination of soil erodibility also is not yet available at regional scale. Hence, it is not easy to identify thresholds at which significant and extensive water erosion commence and doubt arises against the usefulness of an application of a so-called «representative» erosivity index at regional scale without study first the characteristics of the rainfall events in Alentejo.

The objective of our research is to analyse the characters of the rainfall in Alentejo, as a soil erosion control, from differents points of view, from monthly scale to single events and from regional scale to local. It concerns the seasonality, spatial and temporal variability; the study of chronological succession of events through the year; the identification of the distribution patterns of rainfall events; the frequency, duration, intensity of the events; the evaluation of peak intensities of several duration... The overall objective is to produce relevant informations for a correct interpretation of the results of experimental measures of soil erosion, runoff and sediment yields in Alentejo. The research pretends also to be a contribution for the assessment of the role of storm events in the actual morphogenesis dynamics and in erosion risk in the southem part of Portugal.

The poster presents relevant documentation (maps, diagrams, tables) and text on:

a) the interannual variability and the tendency of the precipitation regime, seasonal amounts, time concentration, and maximum annual intensity in Alentejo since 1931, using the precipitation data of more than 60 stations;

b) the time-intensity patterns of rainfall using the hyetographs recorded at Évora, a central climatological station in Alentejo, since 1951, for events with amounts $\geq$ 25.4 mm (more than 270 events) and for mean intensities $\geq$ 5 mm/h (60 events). An event is defined here as a period of rainfall (continuous or intermittent) separated from the last one and to the next by a six hours period without rainfall. The results are compared with those obtained at Lisbon and Faro stations;

c) a graphic classification of the hyetographs in four patterns of precipitation time distribution for Évora;

d) a genetic classification of the hyetographs to identify the main synoptic and mesoscale conditions of rainfall events which control the spatial variability of amounts and intensity, and thus the erosion risk;

e) an evaluation of the total kinetic energy of the different patterns of rainfall;

f) the confrontation of the results of the different patterns of rainfall obtained in c), d) and e) with experimental measures of bare soil erosion at plot scale and at rainfall event scale (Mértola-Vale Formoso and Almocreva).

Finally, Some conclusions are made about the validity of the methodology for predicting the magnitude/frequency thresholds and time/space distribution of rainfall erosivity in Alentejo in relation to meteorological conditions, and for assessing the rhythm of soil degradation in Alentejo.

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New morphostratigraphic and paleoenvironmental data for the quaternary deposits of the Polcevera plain (Liguria, Northern Italy)

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The present paper is aimed at refining the results of a previous geomorphologic survey carried out throughout the lower reach of the Polcevera Valley. Among the numerous features recognised, those concerning the occurrence of different orders of planation surfaces, the higher being at 225 m a.s.l., are of great concern to depict the paleoenvironmental evolution of the area.
It has been inferred that such planation surfaces record recurrent stages of landscape remodelling in response to the dominant Plio-Quaternary distensive tectonics, responsible for rising the coastline reach while sinking the continental margin. The effects of tectonics on the morphology declined during Late-Pleistocene/Holocene and since then both regressive erosion and glacial-eustatic movements gained importance for slope modelling and coastal plain formation.
The results of geomorphologic, sedimentologic and paleobotanical analyses carried out on materials from further soundings located at 2 km far from the right bank of the present Polcevera River outlet have been coupled with radiocarbon dating in order to establish a chronological framework of the evolution of the area trough the Holocene.
The soundings revealed the occurrence of 40 m thick alluvial sediments, emplaced on schistose bedrock, and made up by alternate levels of coarse and fine sediments. Two sandy-silt levels enriched in vegetal remains were found at about 12/14 and 26/30 m deep in core. Radiocarbon dating for the organic debris from 13,30 and 26,25 m deep in core provided the ages of 6,600 ± 50 and 8,340 ± 50 yr BP, respectively.
The pollen content in the two dated levels is highly variable. Pollen spectra, so far determined only for the deepest level, pointed out the occurrence of *Abies, Quercus decid., Tilia, Fraxinus, Ulmus* and *Alnus*. The found taxa compares fairly well with those reported for the mouth area of Bisagno Stream, located eastern wards the study area, as well as with those, spread throughout the nearby Apennine area, that are referred to the Holocene climate optimum (viz., Atlantic period, 8,000/4,000 yr BP).
With regard to the evolution pattern of the fluvial-coastal plain of Polcevera River, it has been found that the most relevant sediment levels are those recording two main sea level stationings during the last post-glacial transgression. However, because of the relevant thickness of alluvial deposits, it is reasonable that subsidence also played a major role in determining the present morphology.

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Analysis and correlation of geomorphological variables in environmental studies using a Gis

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Several methods of spatial correlation of geological and geomorphological elements were compared in order to obtain a tool useful in geoscience analysis. This study was carried out in some small river basins of the Genoa area in Central Liguria region, considering several data resumed by the Gis of the Comune of Genoa, such as lithology, distribution and characteristics of drift deposits and landslide bodies, acclivity derived by the Digital Terrain Model and others.
This analysis could provide spatial variations of the correlation among the considered elements (deviation from the values calculated with the linear regression). The considered spatial variations were represented by plotting equal deviation lines. It was found that the analysis and the validation of geoscience information could be significantly improved by the accurate examination of the isolines distribution, eventually pointing out significative gaps in the knowledge of the environment, incorrect data or not accurate sampling techniques. Finally, new correlation among both the considered and other new parameters could be suggested by the analysis.

COSTICĂ I. BRÂNDUŞ & ADRIAN I. GROZAVU

Effets de l'utilisation irrationelle des terrains dans le Plateau de la Moldavie (Roumanie)

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Située dans l'est de la Roumanie entre les valées des rivières Siret et Prut, la région annalysée se superpose sur la partie occidentale de la Platforme Est-Européenne.
Elle presente un relief collinaire dans la partie nord-est et des plateaux structurals dans les parties ouest, centrale est sud, formé sur un complexe lithologique argileux – marneux et sableux – grézeux, d'âge Sarmatiènne et structure monoclinale.
Comme suite d'une prélucration agricole irrationelle (en espèce, labourage paralel à la ligne de la plus grande pente), dans les conditions d'une grande densité de la fragmentation du relief et d'un litho-facies prédominant friable

en alternance d'un litho-facies imperméable, des grandes surfaces arables sont affectées par érosion aréolaire et torentièlle et par des glissements de terrain. Ainsi, de la surface arable totale de 1.574.098 ha, 916.757 ha sont affectées par l'érosion aréolaire et torentièlle et 62.000 ha par des glissements de terrain en defférents stages d'évolution.

ALEXADRE O. BRINKEN

Geomorphology of seacosts and global changing of climate

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Widespread opinion about increasing of greenhouse-effect because of intensification of human activity should cause higher water level of the ocean. This is the modern point of view.
But observations carried out during the last ten years on many seacosts - Peruvian coast of the Pacific ocean, Hindustanian coast of the Arabian sea, Coromandel coast of the Indian ocean, Dutch coast of the North sea, Finnish and Russian coast of the Baltic sea, Adzharian coast of the Black sea and some others - don't prove such a conclusion. They could prove long stability of a state or clearly show a recession of a seacost (Madras fortress is divided from the sea 300-meter beach which had appeared after 17th century).
These phenomenons don't show flood of seacoast and don't prove increasing Greenhouse-effect either. The conclusions can be different if the theory of increasing of the earth size is accepted.

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Sedimentation in the Yarra Estuary, South-Eastern Australia: geomorphology and management

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Sedimentation is a major management issue in estuaries throughout the world, particularly in situations where the maintenance of a navigable waterway is a management imperative. The Yarra estuary is no exception. It falls into two management regions: 1) the downstream end of the estuary which has been developed as part of the Port of Melbourne; and 2) the middle and upstream parts of the estuary which are managed for a range of uses including power boating (tourist ferries and private boats), canoeing, rowing, angling, passive recreation, and flood drainage. This paper focuses on the Yarra estuary upstream of the port.
The study area had been substantially modified since European settlement. At the time of European settlement, rock bars near the downstream end limited the intrusion of tidal flows. The removal of the rock bars in the late nineteenth century shifted the head of the estuary some 15 km upstream. Other modifications have included channel widening, straightening, bank lining, and levee bank development. The tidal regime has also been affected by port development further downstream. Catchment development, including flow regulation, has affected hydrologic regime and sediment loads. These changes have had major impacts on physical processes in the study area.
Historically, dredging has been carried out to remove unwanted sediment deposits from the Yarra estuary, although this approach has recently been queried on environmental and financial grounds. A geomorphological investigation was carried out to assist in answering management questions such as:
– are there any feasible alternatives to dredging, such as reducing sediment production at source or manipulating patterns of deposition within the estuary?
– what would happen in the absence of any further management intervention in the sedimentation processes (including dredging)?
Data were obtained using a range of methods including coring and probing of the river bed to examine the character and distribution of the sediment deposits, dating of the sediments on the basis of artefacts and pollen, and analysis of historical documentary data such as bathymetric surveys and dredging records to determine deposition rates. The study also drew upon the results of recent geomorphological investigations of the Yarra River further upstream. Some key findings are outlined below.
The sediments recently deposited in the estuary are dominated by muds and, to a lesser extent, sand. The sources of the muds are diffuse, and include surface wash-off as well as in-stream sources throughout the catchment. The major sources of the sands are likely to be in parts of the catchment close to the estuary. Catchment management will not solve the problems of sedimentation in the short term, but in the longer term is likely to be a useful part of an overall management strategy, particularly in terms of limiting the influx of pollutants bound to sediments.
A relationship was apparent between channel width and deposition, the widest reaches displaying the highest deposition rates. Other aspects of the pattern of deposition, such as the development of point bar, alternate bar, and concave-bench deposits, were predictable on the basis of geomorphic principles. We concluded that dredging is necessary where management requirements are in conflict with natural sedimentation processes, such as where over-wide reaches need to be maintained (e.g., for rowing or ferry turn-around sites), or where deep water access is required at boat landings situated on the inside banks of bends.
Hydraulic geometry analysis of the Yarra catchment and

historical channel dimensions of the Yarra in the study area both indicated that an «equilibrium» width for this part of the Yarra River, if it were non-tidal, would be around 40 m. This is considerably less than the present channel width in the widened parts, which is between 60 and 100 m. If no further dredging were to take place, it could be expected that sedimentation will continue to infill the estuary until the equilibrium non-tidal dimensions are attained.

VADIM. V. BRONGULEYEV & MICHAEL P. ZHIDKOV

Hipsometry of the Russian plain

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The Russian plain corresponds to The East European platform without Baltic shield and north-west part of the platform beyond the boundary of the former USSR. Altitudes of land surface and shelf (above –40 m) were taken from the 1:2,500,000 map with area distortion less than 2-4% at the periphery of the plain. By the grid 1cm x 1cm 8242 values were obtained, which makes up area more than 5,000,000 sq.km. Mean altitude of Russian plain is 118 m, without values for the shelf –124 m. Median is 130 m, modal interval –115-135 m, standart deviation –99 m.

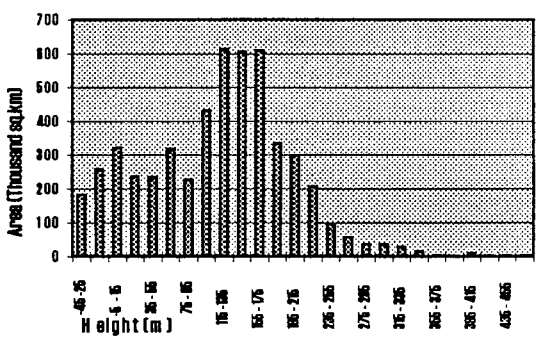

FIG. 1

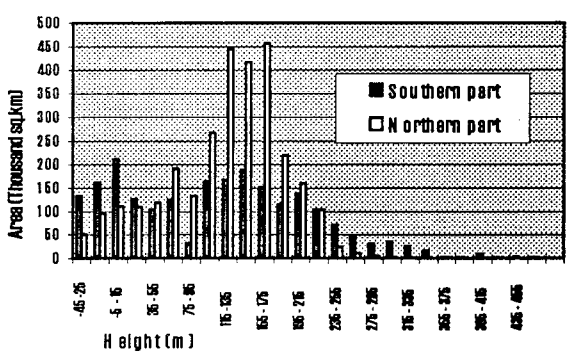

FIG. 2

Frequency histogram for the whole territory converted to area versus 20 m intervals plot has one broad and two narrow maximums (fig. 1). The broad (main) maximum lies within the 115-175 m interval and occupies 40% of the land territory. It may correspond to widespread planation surface of late miocene age. Heights of the different parts of the latter vary within these limits. One of the narrow maximums (–5-15 m) is obviously related to Pricaspian lowland and partly to recent sea coasts and shallow water. Another one in the interval 55-75 m may correspond to plains of N-Q marine accumulation located near the platform margins or to the level of accumulation in some periglacial basins. The histogram shows the absence of positive asymmetry which would be typical for mature or ancient relief at the descending stage of development. Thence, neotectonic uplift the most part of Russian plain was subjected to is still far from compensation by denudation processes.

Besides the whole massive of data two parts of the Russian plain were analised: the northern part (average altitude 130 m, st.dev. 57 m) that has undergone the pleistocene glaciations and the southern one (average altitude 117 m, st.dev. 98 m) which lies out of the glaciation limits (fig. 2). The difference is indicative of the much more intensive and contrasting neotectonic movements in the south and of the planating role of glaciers in the north. Some maximums on both histograms may as well be correlated with certain planation surfaces of the Russian plain. The descending right «tails» of histogram in fig.1 for heights more than 175 m and especially for northern part of the plain (see fig. 2) shows that miocene planation surface may be considered as the denudational base level for some highlands of the Russian plain.

Distribution of altitudes is also compared to N-Q tectonic movements, basement surface and Moho depths within the same territory. Some common features and differences of the histograms are discussed.

ANDREW P. BROOKS

Riparian vegetation as a control on the channel geometry and evolution of a natural river, Thurra River, East Gippsland, Australia

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There is increasing acceptance amongst fluvial geomorphologists in Australia that alluvial rivers have, in varying degrees, been fundamentally transformed as a result of European land-use throughout the last two centuries. What is less clear, although there has been much speculation, are the precise mechanisms responsible for the

changes and the proportional contribution of each altered variable to the overall changes.

Appropriate strategies to combat contemporary river management problems rely on a sound understanding of how channel and catchment disturbance altered the balance between the numerous variables controlling alluvial river behaviour. This is particularly pertinent when considering that lagged responses to initial European disturbance are still evident today.

The majority of research on alluvial rivers in Australia has been concentrated within disturbed rivers – not surprisingly, given that virtually all rivers are disturbed to some extent. However, the insight that can be gained into pre-European river behaviour, and by extension contemporary behaviour from these studies is limited, in that pre-European (or baseline) river condition must necessarily be extrapolated. When assessing the degree of post disturbance change using the extrapolated baseline there is considerable room for error.

In this study, an attempt has been made to gain direct insight into the pre-European condition of an alluvial river, and the balance of controls on the behaviour of this river. The Thurra River is a largely undisturbed alluvial river in East Gippsland, Victoria. Whilst it is only a small system (400 km^2) it represents one of the last remaining alluvial rivers in eastern Australia having intact riparian vegetation from the headwaters to the basin outlet. Investigation of abandoned channels and floodplain sedimentology suggest that contemporary river behaviour is consistent with that throughout the 2nd half of the Holocene, at least, and probably longer (dates still to come). The presence of bank and floodplain vegetation almost entirely undisturbed by Europeans throughout the whole catchment, presents a unique opportunity to specifically investigate the control of native vegetation on channel morphology and its longer term control on the evolution of this river.

The study firstly looked at the variability in channel morphology throughout the catchment, and then within certain reaches. A modelling approach was adopted in selected reaches, utilising the model developed by Millar (1994), to quantify the contribution of riparian vegetation to bank strength, and hence to channel morphology. Having quantified the gross contribution to bank strength, the specific characteristics of the vegetation were investigated at various sites within the modelling reaches.

Whilst the focus of this study is on the extent and nature of vegetation control on bank strength, the modelling approach necessitated that this be put in the context of all other controlling variables (ie. discharge; bank material; bedload transport; flow resistance associated with planform, the vegetation itself, and woody debris; valley slope; water surface slope etc.). In this way a potential baseline is established from which the likely ranges of variables can be determined. In addition to the insight into «natural» or pre-European river behaviour gained from the modelling approach, this study also makes an important contribution in documenting and mapping this now rare window into our geomorphic and ecologic past.

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Apatite fission track analysis and its role in reconstructing the morphotectonic evolution of continents

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To understand how the topography of continents evolves over geological timescales, we need information on the spatial and temporal variation of the relevant near-surface processes over these timescales. Understanding the development of the sub-aerial topography, and its relationship to the offshore basins at the continental margins, is also essential for fully understanding the tectonics of the continental break-up process. However, quantifying the timing and extent of post break-up denudation and the topographic history of continental margins and cratonic interior regions has proved to be a difficult task, not least because the significant amounts of post break-up denudation that typically accompanies and follows margin formation effectively removes any stratigraphic record for this phase of the margins' history.

Apatite fission track analysis is a well-established thermochronological system that is sensitive to temperatures < ~130°C for timescales of 1-100 Ma. As temperature in the Earth generally increases with depth, denudation in response to both erosional and tectonic processes leads to cooling of rocks as they approach the surface. For < 5km of denudation the temperature range of interest will typically be < 200°C, and so this technique is particularly well suited to the study of long-term continental denudation.

A suite of fission track samples can be used to determine detailed thermal history information for temperatures less than ~130°C. This range is typical of the temperatures expected within the upper 4-5 km of the continental crust. To convert the thermal history information into estimates of denudation an estimate of the palaeogeothermal gradient is required. This information can be obtained from a series of selected samples, such as profiles of samples over a range of topographic elevations or a series of samples from deep bore holes (such as those typically drilled by hydrocarbon exploration programs). The temperature information derived from the fission track data is then simply combined with spatial information (vertical offset between samples) to obtain an estimate of the palaeogeothermal gradient. The combined temperature and palaeogeothermal gradient information can then be used to derive quantitative estimates of the timing, amount and rate of denudation.

In any particular region detailed thermal histories can be determined for each sample locality. These thermal histories can then be used to estimate the palaeotemperature for each sample site at any chosen time. Where suffcient

data are available maps of palaeotemperature estimates for any time interval can be derived by interpolating between the point estimates. These palaeotemperature maps can then be converted into maps of the depth of denudation that has occurred over the chosen time interval. Finally, these denudation maps can be used to reconstruct palaeotopographic maps by replacing the denuded section onto the present topography, allowing for isostasy. If a series of maps are prepared at suitable consecutive time intervals they can then be combined to give an animated image of the various parameters. These animations, or "movies", are an excellent medium for investigating processes that vary both spatially and temporally.
Each of the steps incorporates additional estimates of various parameters and requires new assumptions to be made, all of which introduce extra uncertainties in the final maps. Despite these limitations, with sufficient data and due care in interpreting the model results, this methodology provides an extremely powerful tool for quantifying long-term denudation rates on a continental scale. Large data sets suitable for applying this methodology now exist for several regions. An example from southern Africa will be discussed and demonstrated. A particularly useful aspect of the technique will be discussed with reference to South Africa, where volume estimates of the amount of rock eroded at any time can be compared with volumes of sediment deposited within the adjacent offshore sedimentary basins over the same time interval. An important outcome of this study is the recognition that the cratonic interior region of southern Africa was deeply eroded in places during the mid Cretaceous. These data raise some important questions about the long-term morphotectonic stability of cratonic regions.

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Late Holocene fluvial response ro climate and land use change in Central Italy

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This paper presents the first results of a regional study of valley fill sediments from Central Italy. Four contiguous basins were selected in an area (Etruria) with relatively homogenous geology and excellent records of vegetation/climate and land use information. The vegetation and climate data is derived from pollen and palaeohydrological studies of the numerous crater lakes in the region and the land use information from several archaeological surveys of the area. The valley infills vary more from basin to basin than within each basin but in all basins there is a change from the deposition of channel-gravels and coarse-sands to channel and overbank sands and silts within the sequence. A variety of dating methods have been used including, radiocarbon, palaeomagnetic, pottery and optically stimulated luminescence (Osl). Osl is particularly useful as it allows the dating of sediments directly rather than inclusions which can pre- or post-date deposition. The dated sequences illustrate major palaeohydrological change between the Roman and Medieval periods with a the common occurrence of a major upper unit of post Late Medieval/Renaissance age.
The role of climate and land use change is evaluated and it is argued that whilst the trigger for accelerated sedimentation was an increase in storms of high intensity it was also dependant upon land use variations which conditioned the form of fluvial response varying from increased lateral migration with gravel deposition in areas of lower intensity arable land use to rapid floodplain aggradation by sands and silt in high areas of high intensity arable land use.

DENYS BRUNDSEN[1] & ROGER MOORE[2]

Engineering geomorphology of the coast: lessons from West Dorset

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A central aim of the paper is to describe the general context in which an applied geomorphological investigation for a management project will be set. It attempts to show how the decision which have to be made at the start of a project may be affected in different ways by the coastline, the aims of the project, the historical legacies of altered dynamic behaviour and structures and the public and administrative attitudes to change. These are particularly acute in the area studied, the Dorset Coast of the UK, because it is one of the most heavily protected Heritage coasts in the world. Modern attitudes to coastal management in Great Britain are summarised in the light of recent studies by the Department of the Environment and the Ministry of Agriculture, Fisheries and Food.
The Dorset coast in South West England, UK, has a magnificent array of geomorphological features including Chesil Beach, the Stonebarrow and Black Ven landslides, Lulworth Cove and Durdle Door. There is an interesting history of coastal use which has greatly influenced the sediment flux and cliff erosion systems. The structures involved are now old and there are a number of schemes in progress to reconstruct the coastal defence systems. This is an ideal setting in which to discuss problems of contemporary coastal management in a Heritage Coast area and to compare the alternatives available as well the general principles of landscape design which might be employed.
The central question posed by the paper is whether the key engineering designs can be based on the geomorphological design of new landforms.

THOMAS BUFFIN-BÉLANGER, ANDRÉ G. ROY
& MYLÈNE LEVASSEUR

Quantification and visualization of the effects of protruding pebble clusters on the turbulent structure of a depth-limited flow

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In gravel-bed rivers, flow turbulence is characterized by the presence of large scale structures depicted as intermittent low and high speed fluid wedges. Protruding pebble clusters interact with these structures and modify the flow field. The nature and implications of the interactions between wedges of low and high speed fluid and the recirculating flow pattern and vortices associated with a cluster are yet to be investigated. What are the effects of pebble clusters on the extent and maintenance of wedges? Does the presence of wedges introduce a more dynamic turbulent response to the protruding clusters? It is necessary to understand these questions as they relate to the flow structure and to the sediment transport dynamics at the reach scale. This research aims at characterizing the spatial and temporal scales of turbulent flow structures resulting from the presence of protruding clusters. We use both detailed quantification and visualization of the turbulent flow field. Quantifications were performed by sampling streamwise and vertical velocity components upstream and downstream of a pebble cluster along a six meter transect in a straight gravel-bed reach. An array of three electromagnetic current meters (sampling rate 20 Hz, time constant 0.05s) was deployed to obtain a dense grid of velocity measurements (225 pts/m^2). In order to visualize the flow structure, milky-white fluid was injected using a plastic tube ending either in the lee or on the stoss side of the cluster. Velocity measurements were also taken during flow visualization. Flow quantification and visualization revealed five characteristic flow regions related to the presence of the cluster. Integrated into a dynamic model, these regions are: the accelerating flow region on top of the cluster, the recirculating and shedding flow regions in the proximal downstream side of the cluster, and the reattaching and resurging flow regions in the distal downstream side of the cluster (fig. 1). From flow quantification and visualization, it appears that high-magnitude shedding-events are related to the presence of high and low speed fluid wedges of the incoming flow. Furthermore, there is a feedback process between the intense shedding motion and high-magnitude sweeping-events in the resurging flow region. This process may generate large scale flow structures in the form of wedges propagating downstream. Pebble clusters may therefore be instrumental in structuring the large scale turbulent motion above a gravel-bed river. This research presents conclusive quantification and visualization of flow processes needed to assess the origin of ejections and large scale turbulent structures in a depth-limited flow in gravel-bed rivers.

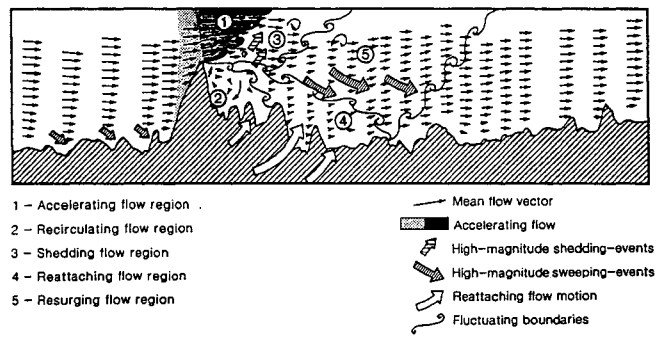

FIG. 1 - Dynamic flow regions related to the effect of a pebble cluster on the turbulent structure of a depth-limited flow over a gravel-bed.

JOHN M. BUFFINGTON, DAVID R. MONTGOMERY
& H.M. GREENBERG

Geomorphic controls on salmonid spawning grounds

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Channel characteristics such as temperature, depth, velocity, percent fines and intra-gravel flow affect selection of spawning sites, but perhaps the most important characteristic is the physical size of the gravel in which an adult salmonid can excavate a redd. While the size of salmonid spawning gravels varies between species, salmonids generally prefer spawning gravels with median grain sizes of about 10-40 mm. Geomorphic controls on bed surface grain size, and thus spawning gravels, are examined here using a bankfull-threshold model. The model is based on the observation that many gravel-bedded rivers exhibit a near-bankfull threshold for significant bedload transport (Buffington, 1995). Consequently, the critical grain mobilizing shear stress (τ_{c50s}) can be defined as the bankfull shear stress ($\tau_0=\rho ghS$), which when inserted in the Shields equation allows prediction of median surface grain size (D_{50s}) from bankfull depth (h) and slope (S)

$$D_{50s} = \tau_{c50s} / \tau^*_{c50s}(\rho_s-\rho)g \text{ Å } 20.2\ hS \qquad (1)$$

where the dimensionless critical shear stress is τ^*_{c50s}Å0.03 (Buffington & Montgomery, in press) and the fluid and sediment densities are, respectively, ρ=1000 and ρ_s=2650 kg/m^3. This bankfull-threshold model predicts the median surface grain size of a wide, low-sediment-supply, plane-bed channel characterized by grain resistance only, and thus provides a theoretical reference point from which to examine textural response to sediment supply and hydraulic roughness other than grain resistance (Buffington, 1995). Within the bankfull-threshold framework, surface grain sizes systematically fine away from the model prediction in response to increasing sediment supply and hydrau-

lic roughness [i.e., bedforms, large woody debris (Lwd), etc.]. Empirically determined ranges of textural response to sediment supply and hydraulic roughness allow examination of the geomorphic controls on salmonid spawning grounds.

We find that the availability of preferred spawning gravel sizes can be significantly enhanced by textural response to sediment supply and hydraulic roughness. For example, in fully armored plane-bed channels (i.e., channels not exhibiting textural fining), spawning gravels only occur for bankfull shear stresses ranging from about 5-20 Pa. However, as a result of textural fining caused by bedform and Lwd roughness, spawning gravels have the potential to occur in a variety of different channel types and over a greater range of bankfull shear stresses (5-300 Pa). Although the extent of salmonid spawning habitat can expand through increases in either hydraulic roughness or sediment supply, the latter may induce higher embryo mortality, offsetting any potential gains in spawning habitat extent. Increased sediment supply can cause bed mobility at stages less than bankfull, and thus more frequent scour and a higher probability of egg excavation. Furthermore, increased sediment loading may lead to greater interstitial filling of bed material, resulting in reduced intra-gravel oxygen flow to buried salmonid embryos.

Geomorphic controls on spawning grounds can be rapidly assessed using empirical findings of the bankfull-threshold model coupled with predictions of shear stress and channel type determined from digital elevation models (Dems). For example, we examined the effect of bedform and Lwd roughness on salmonid spawning habitat using a Dem of the Finney Creek watershed of western Washington, USA. We restricted our analysis to channels with slopes ^{2}0.04, typical of plane-bed and pool-riffle streams used by salmonids. These channels were further divided into three types of potential spawning channels based on bankfull shear stress ranges associated with spawning gravels in plane-bed (5-20 Pa), self-formed pool-riffle (>20-80 Pa), and Lwd-forced pool-riffle channels (>80-300 Pa); a fourth shear stress category (>300 Pa) was designated unusable for spawning. Our analysis indicates that plane-bed channels with suitable spawning gravels comprise, at most, only 2% of the stream length with slopes 0.04. However, an additional 42% of this stream length can be opened to spawning if characterized by a self-formed pool-riffle morphology and consequent textural fining caused by bedform roughness. Another 52% can be opened if characterized by a Lwd-forced pool-riffle morphology and textural fining resulting from the combined effects of bedform and Lwd roughness.

Land management practices of splash damming, riparian clearcutting and «stream cleaning» have decreased the amount of Lwd in many channels throughout North America. Our results suggest that consequent textural coarsening in response to Lwd loss may have decreased salmonid spawning habitat availability and may be a factor in historic declines of fish populations and shifts in species type. Wood loss can further compound impacts on fish populations by decreasing pool frequency and area, and thus the availability of potential rearing habitat.

ELZBIETA BUKOWSKA-JANIA[1], MARIAN PULINA[2] & JACEK JANIA[2]

Calcium carbonate in deposits of the last scandinavian glaciation and contemporary chemical denudation in Western Pomerania (NW Poland)

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The studied area is located in the marginal zone of the Pomeranian Phase of the Vistulian (Weischel) Glaciation (16,500 yr BP). Relatively high content of $CaCO_3$ has been noted in moranic and fluvioglacial deposits (5-15% by volume). Exposed on the surface youngest deposits are separated from the bedrock by more than 100 m thick older Quaternary glacial sediments. Moreover, exposures of carbonate rock are not watched below the Quaternary series beneath the studied area and hundreds kilometres upstream of the last ice sheet. Problem of origin of $CaCO_3$ in glacial and fluvioglacial sediment is considered basing upon results of studies of the actually glaciarized areas in Spitsbergen. A model cryochemical enrichment in these deposits in the calcium carbonate is applied.

Quaternary deposits are a source of calcium carbonate for contemporary dissolution by waters from precipitation, ground waters and flowing waters. The majority of river and lake waters in the area has got relatively high mineralisation (up to 300 mg/ l) and there hydrochemical type is HCO^-_3 - Ca^{2+} - Mg^{2+} (SO_4^{2-}). Some of springs has even higher minaralisation (more than 350 mg/l). Hydrochemical studies combined with the hydrological data of two medium size catchments (Pilawa - 342 sq km and Plytnica 170 sq km) indicate intensive, chemical denudation of the area built by last glacial deposits. The dissolved denudation ratio varies between 7.4 up to 21.5 $m^3/km^2/yr$ in particular subcatchments. Calcium carbonates are deposited in lakes as qythia and lake-marl. Discussion in the paper concerns modern balance of chemical denudation and attempt to estimate amount of $CaCO_3$ which has been being removed since the ice sheet left this area. Results show importance of $CaCO_3$ content and its active migration in the post glacial environment of the northern Poland.

BENGT CALLES & LENA KULANDER

Erosive rains in Lesotho

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Lesotho is justly regarded as one of the countries in the world that has suffered most from soil erosion caused by surface runoff of water. As part of a study on the effects of soil erosion and efficiency of conservation measures, the frequency of erosive rains was investigated. Erosive rains were defined as having a higher intensity than 25 mm/h based on 30-minute intensities. This measure conforms in principle with the conventional definition of erosive rains as being EI_{30} >25 mm/h, e.g. total impact energy based on the sum of rain drop energies during the most intensive 30 minutes of a rain.

Are precipitation conditions unusually harsh in Lesotho or are other factors likely to be responsible for the present status of a severely eroded landscape? The recurrence interval of rains exceeding the threshold value gives valuable information on the natural climatic conditions for erosional processes and enhanced erosion as a result of man's activities and is also a measure well suited for erosion hazard assessment.

Background information on precipitation was available as daily rainfall amounts at three sites covering the period from 1880 to present. The information on rainfall intensities is scarce and scattered in time. Apart from 3 major sites shorter time series of recorded intensities at 4 four sites were used. The two types of data sets give an areal coverage of Lesotho's lowland and foothill regions which are the principal agricultural regions of the country and where soil erosion is a problem of social and economic importance.

In order to overcome the lack of long series of intensity observations, the relationship between storm amount and intensity was determined for the 7 sites. Mean relation-ships using linear least square fit of regression lines through the data sets were determined. A second step in the analyses consisted of determination of the relationship between total daily rainfall amount and amount in individual storms during the same day. Combining these two procedures made it possible to transform long series of daily amounts into series of maximum 30-minute intensities.

The partial duration technique was applied to determine the recurrence interval for rains of varying intensity. The results show that the spatial variation over the studied area in Lesotho is small. The average number of rains each year exceeding 25 mm/h ranges from 2.2 to 1,5 during the wet season and from 0.4 to 0.3 events each year during the dry season. No major difference is apparent if the long series on daily amounts and the shorter intensity series are compared. A comparison of the computed recurrence intervals with information from other regions in Africa and Europe shows that the computed frequencies are not extremely high. Hence it is likely that rainfall conditions cannot be regarded as the only or major cause for the present situation. The relatively scarcity of erosive event makes it justified to doubt if the term erosive rains is a suitable measure for estimating soil erosion. More emphasis should be put at understanding and modelling the entire physical processes on erosional processes resulting from antecedent conditions and overland flow of water.

MARC CALVET

Rythmes et vitesses d'évolution morphogénétique dans un orogène alpin. Le cas des Pyrénées orientales franco-espagnoles

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La pertinence des modèles d'évolution géomorphologique sur le long terme suppose leur confrontation avec des données quantifiées, bilans globaux de matière, taux de surrection et d'ablation, de façon à saisir à la fois rythmes et vitesse d'évolution morphogénétique. L'approche se doit d'être multiscalaire, pour espérer dépasser le hiatus qui sépare dynamique des formes de celle des processus et atteindre à une véritable géomorphologie dynamique globale. Le tronçon oriental des Pyrénées propose à la fois des fossés à remplissages corrélatifs néogènes et des surfaces d'érosion culminantes, qui fournissent des repères chronologiques et géométriques de grande valeur pour toute approche quantifiée. L'orogenèse y apparait comme un phénomène brutal et très saccadé, en plusieurs épisodes dont seuls les derniers, de plus en plus généralisés et rapides depuis le Miocène supérieur, sont responsables du volume montagneux actuel. On démontre que l'arasion de la chaîne a été totale entre la fin de la tectogenèse pyrénéenne vers 35 Ma. et l'Aquitanien. À l'échelle d'un bloc comme le Canigou, les conglomérats du Conflent prouvent la naissance d'une montagne vers 19 Ma., l'ablation d'au moins 1 à 2 km de gneiss oeillés puis l'arasion totale de ce horst de 2000 m et large de 20 km, au Miocène moyen, en 6 à 8 Ma. seulement. La confrontation de ces données, brièveté et caractère saccadé des phases de surrection, rapidité de l'arasion dans le contexte bio-climatique du Paléogène supérieur et du Néogène, redonne quelque crédibilité au modèle cyclique davisien: il s'applique non seulement aux domaines de socle, où on a tendance à le cantonner, mais aussi à certains orogènes récents, au moins ceux de type intracontinental.

ERIK L.H. CAMMERAAT

A hierarchical approach to the geomorphological development of hillslope and catchment geomorphology: two contrasting examples from a semi-arid and a humid temperate region

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In the last 5 years a new approach is being developed to explain hillslope and catchment evolution from a systems dynamic point of view, incorporating a hierarchical approach. This approach to geomorphological evolution is focusing on the spatio-temporal domains of relevant processes as well as the linkage between processes and process related patterns. Furthermore, it will be clear that erosion and water fluxes are strongly related to biological controls such as vegetation cover and pattern, and soil biological activity. Between these three components water, soil and vegetation/soil fauna feedback mechanisms exist, which control eco-geomorphic processes. The approach followed here is originally adapted from ecological system dynamics approaches and is applied to understand the geomorphological evolution for different types of geo-ecosystems.

In this presentation a demonstration is given using this approach for two areas, with very different climatological characteristics, and which results in a very different set of processes and geo-ecosystem properties, driving geomorphological evolution. One site is located in semi-arid south-eastern Spain (in the Guadalent'n basin), and the second demonstrates the application for a basin in temperate humid Luxembourg. The processes and patterns in the semi-arid area are driven by water limitation, and competition for water whereas in the humid temperate areas process-pattern relationships are directed by a surplus in water.

This hierarchical approach is underlined by data which have been collected and which are relevant for the different spatio-temporal domains studied. They include monitoring of temporal and spatial variation of fine scale properties such as soil structure and soil biological activity. At all scales of interest monitoring of runoff and sediment yield and through- and pipeflow were determined using both experimental techniques and spatially nested designs of field measurements.

For both areas the importance and linkage of fine scale processes (soil aggregation, soil structural changes, soil faunal activity), operating on a scale of the square meter, to a broader scale is demonstrated, and their specific implication for hillslope scale processes and patterns is indicated. On this broader scale, both in space en time, other processes are active (flow concentration and hillslope runoff, erosion features, vegetation patterns) and are partially directed by finer scale processes. The influence of the intermediate scale level on the basin scale is demonstrated and can explain the geomorphological evolution of the catchment. Also the influence of frequency magnitude relationships for precipitation will be discussed as these, and other perturbations have an important effect on the evolution of the landscape.

It was found for the semi-arid sites that the patchiness of the vegetation or vegetation structure, which reflects many important fine and intermediate scale processes and properties, determines the hydrological conditions under which flow concentration and consequently erosion takes place. These processes are strongly influenced by biological feedbacks in the system. For the humid temperate area, it was concluded that runoff generating areas were strongly related to the (micro-)topography, which was maintained by clear feed-back mechanisms controlled by the effect of soil biological activity on soil structure and preferential flow paths of water. It can be concluded that, under semi-natural conditions, and under conditions recovering from perturbations in the geo-ecosystem, the hierarchical approach as presented here, can be used to explain hillslope and basin geomorphological evolution.

NICOLETTA CANNONE[1], MAURO GUGLIELMIN[2], & AUGUSTO PIROLA[1]

Alpine vegetation in the periglacial environment and the effect of a different Holocenic glacial evolution (M. Foscagno area, Upper Valtellina, Italy)

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The aim of this work is the analysis of alpine and snow-patch vegetation in an area interested by periglacial phenomena and, partially, by old glacial episodes to verify if there is an influence of these phenomena on the composition and the characteristics of vegetation and in which way this influences are expressed. The study area is Monte Foscagno, Upper Valtellina, Italy. In particular, were studied two opposite slopes of Monte Foscagno: the glacial cirque La Foppa and, on the other side, the valley named La Vallaccia. In the glacial cirque La Foppa is possible to observe tardiglacial moraines, many rock glacier, of which has been described the rock glacier named La Foppa I, poligonal soils, striped soils and boulder stream. La Vallaccia is characterized by periglacial forms of which the most important is a rock glacier with complex degree of activity that results one of the widest rock glacier of Lombardy. The upper part of La Vallaccia has been interested by recent glacial episodes: in fact, here there are many late Holocenic moraines, probably of the Little Ice Age.

The vegetation of the two study areas has been analized by phytosociological *relevés*: in La Foppa has been carried out 131 phytosociological *relevés*, of which 108 on the active rock glacier La Foppa I; in La Vallaccia has been carried out 171 phytosociological *relevés*, of which the first fourty in the upper part of the valley, on late Holocenic forms. Both mosses and lichenic flora have been analyzed.
For both the two study areas' flora has been analyzed Raunkiaer's life forms by which results in La Vallaccia a great dominance of *Hemicryptophyta*, particulary *Hemicryptophyta scaposa*, on *Chamaephyta* with a *Hemicryptophyta/Chamaephyta* ratio of 2,67. In La Foppa area, the dominance of *Hemicryptophyta* is confirmed, but the H/C ratio is greater: 4,98 considering all the study area; 4,33 referred to the rock glacier La Foppa I area and 5,71 for the other glacial and periglacial forms.
The corological spectra of the species has been analized: there is a dominance of Orophyte species on Circumboreal, Alpine-Endemic and Artic-Alpine species, but with different ratios in the considered areas.
Has been carried out the calculation of the ecological indices for all the species present, according to Landolt, concerning some soil characteristics. For all the study area has been carried out the calculation of floristic richness, of biodiversity and has been made the Principal Components Analysis and the phytosociological classification of the *relevés*. From the analysis carried out, the influence on vegetation of present periglacial phenomena results significant for both the study areas; it is possible to observe some differences of the characteristic of vegetation in the two areas, in particular from the analysis of vegetation of the upper part of La Vallaccia.

MAURO CARDINALI[1], ALBERTO CARRARA[2], FAUSTO GUZZETTI[1] & PAOLA REICHENBACH[1]

A predictive model of landslide occurrence, Upper Tiber Basin, Central Italy

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The diffusion of new technological tools, such as hyperspectral sensors, high-speed workstations, digital photogrammetric systems and Gis, has made it possible the application of quantitative techniques and models in assessing and forecasting natural hazards, among which landsliding appears to play a central role.
Today, many instability causal factors, mostly morphological and geological in nature, can be cost-effectively acquired, stored and analysed in digital form. In particular, by processing elevation data and its derivatives new morphometric parameters can be readily generated over wide regions, and used as predictors of landslide occurrence. Despite the potential of such technological advancements, landslide hazard mapping remains a complex, ill-formalised operation. The identification of past and present landslide depositional/erosional areas, which constitutes the first step for forecasting future slope-failures, is still a highly subjective task. Likewise, many basic instability determinants cannot be acquired and mapped with adequate accuracy. Many of the methods for handling instability factors and evaluating hazard levels are questionable. The type of terrain-unit selected to partition the region under investigation (*i.e.*: unique-condition unit, slope-unit, topographic unit, etc.), exerts a relevant influence on the reliability and feasibility of the hazard model developed. Models, based on different types of terrain-units or statistical approaches, yield responses that may be statistically comparable but dissimilar in terms of applicability in lad-use planning. In addition, when different landslide types occur over a region, each type requires the development of a specific model.
In spite of such conceptual and operational drawbacks, the experience gained from the application of predictive multivariate models in small pilot drainage basins led to initiating a long-term, major project which attempts to produce a predictive model of landslide occurrence in the upper section of the Tiber river (central Italy), an area over 4100 km^2 in size.
The task involved the generation of a high-fidelity (25x25 m) grid Dtm, totalling 6.5 million heights; starting from this elevation model, the basin was then partitioned into 20,000 slope-units, each one characterised by 24, automatically derived, morphometric attributes featuring slopes and channels. Through an extensive interpretation of 1:33,000 scale aerial photographs and field checks, over 8500 landslide deposits were identified, classified and mapped at a 1:25,000 scale. Existing lithological, structural, hydrological, and land-use data were acquired, revised, reinterpreted and integrated with new data collected in the field or through aerial photo-interpretation. In particular, bedding attitude was mapped identifying areas of constant attitude with respect to the local slope. A catalogue of bibliographical information on slope failures was completed for the period 1918-1990 through the systematic review of newspapers, interview of expert witnesses and inspection of technical reports. All the above data are currently digitised and stored into a vector Gis which will eventually constitute one of world largest databases of high-resolution spatial data for assessing and controlling slope-instability.
At present, a weighted stepwise discriminant function was applied in order to discriminate landslide-free and landslide-bearing slope-units pertaining to the uppermost section of the Tiber basin (over 1100 km^2 in size). Of the 40 variables entered the function, those reflecting slope morphometry and attitude of bedding proved to be the most powerful in successfully classifying stable and unstable terrain-units.
Such results indicate that the Gis-based, statistical approach, although no lacking conceptual and operational limitations, is the most suitable and cost-effective method for evaluating landslide occurrence and hazard on a regional scale.

MAURO CARDINALI, FAUSTO GUZZETTI
& PAOLA REICHENBACH

Map of sites historically affected by landslides and floods in Italy: the Avi Project

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The Avi project, an acronym for *Aree Vulnerate Italiane*, was commissioned by the Department of Civil Protection to the National Group for Hydrogeological Disasters Prevention (Gndci), to compile an inventory of information on areas historically affected by landslides and floods in Italy, for the period 1918-1990. Seventeen research teams worked for one year, between 1991 and 1992, on the project. Each team collected, organised, and summarised the information on mass movements within one or two Regions and on floods within several hydrographic basins, covering approximately the same territory. The investigation was guided by a framework based on two levels. The first level aimed at the widespread collection of information through interviews, review of newspapers and the analysis of technical and scientific reports and papers. The second level aimed at synthesizing the information at the regional scale, and at refining the knowledge of a limited number of particularly important events. A total of twenty-two journals were systematically searched and 350,000 newspaper issues were screened. About 150 expert witnesses were interviewed and more than 1400 published and unpublished technical and scientific reports were reviewed. The main results of the inventory and of its preliminary analysis consist of:

– an archive of more than 30,000 newspaper articles from 22 different journals;

– a digital archive with information on 11,455 landslides and 5358 flooding events. The database, first developed for a personal computer, will soon be available through the Internet;

– a set of Regional Reports providing a preliminary estimate of the occurrence of geo-hydrological catastrophes as well as a list of sites historically affected by mass-movements or inundations. The reports were distributed to local, regional and national Civil Protection Authorities;

– a synoptic map, at 1:1,200,000 scale, showing the spatial distribution of sites affected by landslides or floods in Italy. Separate maps and graphs portray, for each of the 20 Italian Regions: the type of damage caused by landslides and inundations; the location of sites recurrently inundated; and the number and frequency of inundated sites. The synoptic document demonstrates that, in the time-span of the inventory (72 years), all of the 92 Italian Provinces experienced at least once a landslide or a flood. In the most recent years, from 1991 to 1995, about half (44) of all Provinces were affected by catastrophes that caused more than 100 casualties. Direct and indirect damage was not ascertained but it can be provisionally estimated in the order of several thousand million dollars.

In spite of the limitations due to the complexity of the Italian territory, the different awareness of the impact of geo-hydrological catastrophes on the land, the Avi inventory represents the most comprehensive, nation-wide archiving of geo-hydrological disasters ever prepared in Italy, and one of the few available in the world.

Research efforts are aimed at: updating the inventory; testing the reliability and completeness of the archive; and analysing the available historical information to help evaluating geo-hydrological hazard and its temporal and spatial occurrence at the national scale. Archive update is currently performed by two research teams that are systematically searching 40 newspapers for the period 1991-1995. An attempt to evaluate the spatial reliability of the Avi inventory, by comparing the distribution of historical landslide events with the spatial distribution of more than 20,000 slope-failures mapped by photo-interpretation in the Umbria and Marche Regions of Central Italy, showed that the density of historical events falling directly on landslide deposits or within a distance of 500 meters is twice the density of the events that lay at a greater distance. In other words, 70% of historical landslide events in the Umbria and Marche Regions lay on, or within a distance of 500 m to the nearest mapped landslide.

As a preliminary assessment of geo-hydrological hazard the distribution of historical information was ascertained and mapped at the regional scale. For 975 municipalities in 16 Provinces of Central Italy, the relative abundance of historical catastrophes was mapped. On average, for each municipality 5 catastrophes are reported, but few municipalities experienced more than 50 events. More recently, an experiment carried out in the Tiber River basin to relate the occurrence of catastrophic events (landslides and floods) with the hydrological characteristics of the triggering meteorological events allowed the definition of regional warning thresholds based on historical data. More than 500 potentially hazardous meteorological events were identified based on the analysis of river discharge at several gauging stations. For each event, hydrological characteristics (namely, mean daily discharge, estimated flood volume, event intensity and duration) were compared with the occurrence of historical landslides or floods. Graphing the relationship between the hydrological characteristics of the meteorological events and the occurrence of historical hydrological catastrophes, functional thresholds for the occurrence of damaging phenomena were obtained.

CLAUDIO A. CARIGNANO & MARCELA A. CIOCCALE

Landscapes antiquity of the Central Sierras Pampeanas (Argentina): geomorphic evolution since the Gondwanas times

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This paper discusses the significance of relict landforms eroded on Precambrian, Paleozoic and Mesozoic rocks of the Sierras Pampeanas (Argentina), within the framework of the Gondwana evolution. The Pampean belt belongs to a complex collage of cratonic blocks, brought together along the southwestern Gondwanaland margin in late Precambrian to early Paleozoic times. The geomorphological evolution of the Central Sierras Pampeanas is analized within the geological framework of southern portion of South America during Mesozoic and Cenozoic times. This masif permanently underwent subaereal denudation since at least Triassic times.

The erosion surfaces which have successively levelled the relief are identified by using geomorphological, geometrical and sedimentological criteria. The reconstructed morphogenetic evolution proceeded as follows.

During Jurassic times a long period of tectonic quiescence and predominantly humid tropical climate enabled the progressive elaboration of a broad surface. The ocurrence of corestones, bornhardts, rocking stones and deep weathering profiles are interpreted as residual forms of that surface.

The late Jurassic-early Cretaceous transition was marked by continental rifting and the surface degradation under arid and semiarid climates.

During the mid-Cretaceous a second surface was generated; some remnants are preserved on weathered basalts. Later, that surface was eroded during the upper Cretaceous.

From uppermost Cretaceous to Lower Eocene times a third planation surface was developed under humid climate. It was further worn during the Eocene-Oligocene.

A fourth planation surface developed during the Miocene. Thick and mature calcretes remain as evidence of a long time stability.

Due to the faulting and Pampean uplifting during the last 10 Ma almost all surfaces were broken and tilted. Two late Cenozoic minor planation surfaces were also identified.

The Sierras Pampeanas planation surfaces are correlated with the Eastern Brasil ones.

LUIGI CAROBENE, MARCO FIRPO, MAURO PICCAZZO & MARINO VETUSCHI ZUCCOLINI

Raised Quaternary coastal features along the Ligurian Sea passive margin from Genova to Savona (Italy)

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The morphology and deposits linked to the action of the sea during the Quaternary period in Liguria have been the object of study since the last century, by Issel (1883) and then Rovereto (1923). These studies, like those of other later Authors, provided detailed, well localized descriptions. There are also more recent studies, but they lack adequate cartographic support. Our objective was thus to present the results of surveys and morphological studies carried out by us in recent years along the coast between Genova and Savona, on a 1:25,000 scale Map showing forms created by uplifting.

The coastal tract we chose is particularly interesting as it formed being part of a passive continental margin with a prevalent uplift of this sector during the Pliocene and Quaternary periods. The mapped forms are thus evidence of ancient sea-levels stand due to the interaction of uplift and eustacy. The objects mapped are the forms and deposits of marine origin which we see today as relics, where erosion may have removed all or part of the original deposits and where sedimentation, on the other hand, may be masking the original morphology. These factors have made both interpretation and representation difficult; furthermore, the lack of datable deposits is an obstacle to correlation.

The legend used to explain the information about the forms and any marine and/or continental cover due to stands and fluctuations of the sea level is deliberately limited to descriptive elements. The symbols define the extent of the terraced surfaces and morphological limits, elements that are closely connected with the environmental conditions of formation and with subsequent remodeling. In particular, the nomenclature of the relic forms includes the inner margin and outer edge symbols of the terraced surfaces, which represent the key moments in the marine morphogenetic phase. The symbols describe the various forms corresponding to the more or less preserved relics of terraces of various size observable along the ridges descending seaward.

The marked presence of tracts of sub-horizontal ridges obliged us to develop a criterion for the mapping of relic forms that are heavily degraded but still recognizable as terraced surfaces. Interpretation of these forms also took into account lithology and geological setting, which is very complex in this area.

Separately we also mapped low gradient terraced surfaces caused by marine and continental deposits covering and masking marine abrasion platforms. In some cases evidence of these can be found on scarp slopes close to the current shoreline. Lastly, we also marked recent small sized coastal plains delimited by the foot of the valley sides. They sometimes present one or more orders of fluvial terraces. The simplified topography (thalwegs, contour lines, elevations) also includes recurrent altimetric culminations linked to the more evident forms. The Map is thus a basic tool for making morpho-stratigraphic correlations and evaluations of tectonic movements and the uplifting of the zone in the Quaternary period. Examination of the Map shows there was a high degree of erosion after the formation of the terraced surfaces, thus giving the area its present morphological aspect.

MANDY CAROLISSEN

Investigating bedload movement in the Jonkershoek catchment, in the Western Cape, South Africa

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Bedload movement was monitored on a long-term and short-term basis in two streams, namely Bosboukloof and Langrivier, in the Jonkershoek catchment in the south-western Cape. Bosboukloof is afforested with *Pinus radiata*, has a low slope of 29° and area of 200.9 ha, while Langrivier is a natural catchment, consisting of several fynbos species, has a steeper slope of 49° and an area of 245,8 ha. The long-term bed load movement for both catchments highlights the spatial and temporal variability of bedload movement. The high sediment peaks for Bosboukloof were a result of extrinsic factors, namely clearfelling and bushfires. Short-term bedload movement with the aid of tracer particles was monitored during the wet season (June - August) of 1995. Langrivier yielded greater sediment movement than Bosboukloof, with a maximum displacement of 11.75 m. The particle sizes of Bosboukloof consisted mainly of sand sizes, while in Langrivier, particle sizes ranged from sands to boulders. The banks and river beds were the main sources of sediment for the catchments.

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Derivation of high-quality Dtms from contour lines and digital photogrammetry

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In the recent years, digital terrain models (Dtms) and their derivatives have found application in many investigations appertaining to the realm of applied and theoretical geomorphology. Meanwhile, in several countries governmental organisations are increasingly involved in the production of high-resolution digital ground models over large areas.
Grid (raster) and Tin formats, which are the two basic structures for electronically storing and handling elevation data, are derived either from digitised contour lines of existing maps, or directly from aerial photographs.
The first is still the most common approach followed by public institutions in order to produce large elevation databases within Gis projects. By exploiting automatic scanner/vectoring technology, contours can be cost-effectively digitised and used as source data for Dtms. The extent to which these contours reflect the real ground morphology will greatly vary depending on many factors that cannot be readily assessed. By generating Dtms from such contours, all source errors are transferred to the elevation model which will also incorporate the errors related to the operation of contour interpolation (grid Dtms) or space tasselation (Tin Dtms).
The second approach consists in the direct derivation of the Dtm from analytical plotting of stereo aerial photographs; however, the costs involved are unaffordable when dealing with large regions.
An alternative direct method is recently becoming available on the market: the automated processing of stereo aerial data through digital image correlation techniques (Krzystek & Ackermann, 1995). However, in spite of the recent technological advancements, the quality and accuracy of Dtms obtained by this technique do not appear fully documented as yet.
Within the framework of an investigation on Dtm generation and application (Bitelli & *alii*, 1996), an attempt was made to investigate the quality and accuracy of Dtms derived from both contour lines and image matching techniques.
For a morphologically complex sample area located in Calabria (southern Italy), grid-based digital terrain models were derived from both digitised contour lines and digital photogrammetry. The first was obtained by interpolating with a high-quality algorithm scanned and vectored contours of existing topographic sheets. The second was extracted from scanned aerial photographs using softcopy photogrammetric technology. By comparing each Dtm with a third terrain model generated by traditional analytical plotting, advantages and pitfalls of each approach were highlighted. They can be summarised as follows.
Owing to the current technology, contour-derived Dtms can be produced for wide areas at effective cost, but they are affected by unpredictable widespread errors which are due to both inaccuracy of input contour lines and inefficiency of the interpolating algorithm. Digital image correlation-derived Dtms faithfully reflect the actual relief of most of the ground surface; however, the whole process is still costly and, most importantly, it may leads to very large local errors where slopes are steep, ground mantled by thick forest and aerial photographs masked by shadows.

MAURO CASADEI & ENZO FARABEGOLI

Estimation of the effects of slope map computing on landslide hazard zonation. A case history in the Northern Apennines

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The geomorphological setting of the Northern Apennines features a widespread distribution of landslides, most evident within badland-type terrains. The evaluation of slope angle plays a relevant role in the process of landslide ha-

zard evaluation, especially for shallow mass wasting processes. Three methods for the automatic production of slope maps were compared:
1. rectangular grid scheme (detail ≤ 30 m);
2. triangular irregular network (Tin);
3. «clinometric» method, based on contour elevation data.
In order to evaluate the influence of the chosen computing model on geomorphological and hydrological considerations, a few sample catchments from the Romagnan Apennines were analyzed at 1:5000 scale. The slope maps were produced at a different level of detail, taking into account the digitized contour elevation lines with 10 m, 25 m and 50 m heigth spacing and thereafter reconstructing the associated Dtms. Each slope map theme was separately overlaid on the landslides and land use themes, and the contingency tables were eventually analyzed. The results displayed the following points:
1. the regular grid approach produces an artificially homogeneous slope distribution;
2. the Tin method is more suitable to represent the irregular hillslope geometry, but it still tends to overestimate the number (and the area) of «flat» triangles, which generally fall within concave/convex areas, the most critical ones;
3. the clinometric approach allows to point out the main thresholds for shallow landslides triggering.
4. the use of 25m heigth spacing contour elevation data represents a good trade-off between accuracy and economical costs.
The analysis confirms the need to strive towards a unified framework for producing digital terrain representation, which nonetheless cannot still be solved by means of the current Dtms, which are not satisfying for technical needs.

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Monitoring of streambank instability processes

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Bank erosion processes represent the most important mechanism in determining planform changes in alluvial rivers. Pore pressure plays a fundamental role in the stability of streambanks. In this study two main pore pressure effects are investigated: 1) increases in apparent cohesion by negative pore pressures due to suction effects in partly saturated material; 2) response of the phreatic surface and pore pressure in the zone subject to instability during storms. In order to investigate these aspects, a series of transducers have been installed in a bank of the Sieve River, Tuscany. The river bank is composed of two main layers: a lower one, 1.7 m thick, of embricated gravel with interstitial sand and an upper one, 2.5 m thick, of silt and sand. The lower layer is subject to undercutting by the stream flow and the upper one is affected by slope failures. Four tensiometer-piezometers are set inside the upper layer at increasing depths from the top of the bank. Pore pressure is measured in continuous, during low-stage periods and during floods, as well as rainfall, discharge and water height data are collected.
Negative pore pressure within the sandy-sily level gives an apparent cohesion to the bank material during low-stage periods allowing the bank to exceed the friction angle. Values of negative pore pressure range from 2 to more than 80kPa. Apparent cohesion estimated by Bst test was about 2kPa in April 1994. The apparent cohesion can completely disappear during floods if the material becomes completely saturated; during the drawdown of the flood a bank failure is very likely to occur.
Data relative to some storms occurred during 1996 allow us to assess the values of the drop in suction and the lag time of the tensiometers responses with respect to the rainfall and the peak discharge. Fluvial entrainment at the basal area is also monitored by: a) repeated cross-profiling; b) erosion pins; c) marked pebbles and painted portions of the basal packed gravel.

NICOLA CASAGLI & LEONARDO ERMINI

Geomorphic analysis of landslide dams in the Northern Apennine

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Within the National Group for Hydrogeological Disaster Prevention a research project is active on the study of landslides that cause the partial or complete blockage or rivers or streams. This interest is connected with the high risk conditions often associated with these phenomena and with the need to set up a method for forecasting the possible evolution of these phenomena. In this note the results of a regional inventory of about sixty landslide dams is presented. These case histories, selected in the Northern Appennine in Tuscany and Emilia-Romagna, allow to implement a methodology for forecasting the possibility of blockage of streams threatened by landslide and for evaluate qualitatively the stability of landslide dams already formed. The research program is organised in the following main phases:
1. collection of bibliographic materials and historic information;
2. cartographic and air-photo analysis for the determination of the main geomorphic parameters of the landslides, the streams and their watershed, the blockages and the lakes;

3. field survey for the control and the integration of the collected data on each case history;
4. data processing aimed to the set up of a forecasting model based on data that can be obtained with simple geomorphic and lithological analyses.

Regarding the possibility of blockage of streams threatened by landslide, the most meaningful parameters result to be:
1. the blockage index given by the ratio of the logarithm of the volume of the potential dam and the logarithm of the watershed surface area at the point of blockage;
2. the constriction index given by the logarithm of the ratio between the landslide velocity and the valley width;
3. the grain size and the texture of the dam material.

As far as the stability of landslide dams is concerned, the most meaningful parameters result to be:
1. the above mentioned blockage index;
2. the shape index given by the ratio between the total width of the landslide dam (measured along the dammed stream) and its height;
3. the grain size and the texture of the dam material.
4. the bottom slope angle of the stream.

The following step is the integration of the different parameters using the interaction matrices of Leopold-Hudson. It has been possible to evaluate semi-quantitatively the mutual interactions amongst the parameters. The influence of each of them on the system can be expressed by coefficients using a cause-effect diagram. Different weights are assigned to different classes within each parameters by means of the analysis of the case histories. The sum of products of the weights times the coefficients gives a final synthetic index both for the blockage possibility and for the dam stability. These indices can be used for forecasting the evolution of future events. The results obtained show a good correlation between the model and the observed case histories.

GIOVANNI BATTISTA CASTIGLIONI

Geomorphology of the Po Plain

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Geomorphologists who are engaged in the study of a plain region cannot avoid paying particular attention to the sensitivity of the physical and territorial system confronted with the pressure of human presence. What once appeared as a flat, uniform, stable «terra firma» which could be manipulated according to the specific society's needs, now clearly shows its environmental fragility, its vulnerability and remarkable diversity from place to place depending on its historical evolution and on present-day prevalently semi-natural processes. The thread of the argument which follows can be summarized in these terms: «the answer of geomorphic processes to environmental variations». This is the title of a national research project coordinated by the colleague Paolo R. Federici of Pisa University on whose direction we plan to continue our research.

Except for the noteworthy work of few authors and geomorphologic studies on specific aspects carried out in the past, it should be noted that Italian geomorphologists' attention for the plains developed relatively late if compared with the attention traditionally paid to montainous and hilly areas. The early progress of the Po plain's subsoil geologic and hydrogeologic studies should be put in relation with the research for gas, oil and water resources. Progresses obtained on the geomorphologic knowledge of the Po plain will be presented here and proposed for further dicussion and research.

On principle, this geomorphologic region should be considered as a whole including both the part which is called today the Pianura Padano-Veneta and the part of the platform submerged in the Adriatic sea up to the Mesoadriatic Depression. The relationship with the closeby ranges of mountains can be regarded as exemplary from the morphotectonic aspect and for the forms of sedimentary evolution and erosional phenomena; the plain should be considered in fact part of the Apennine's Foredeep.

The asymmetry of the two Po plain sectors, located respectively to the north and to the south of the River Po, is exemplary as well. The distiction between high and low plain, not only in terms of altitude, is also exemplary. Such distinction, characterized by the diversity of fluvial sediments and hydrogeologic and hydrographic conditions, is here represented by the aspects of surface morphology and genetic processes marking the two belts and the transition from one belt to the other. The connections between the alpine glaciation areas and the fluvioglacial and fluvial sedimentation area are also exemplary for a discussion about the nature of the Italian «sandurs», and about the terracing processes affecting not only the piedmont zone but also many sections of the low plain. On the above mentioned aspects the specific research results of several authors are discussed here.

The Holocene plain shows a typical basin and ridge feature, with several examples of river changes due to avulsion; it presents a large area not only near the coastline but also inland especially on the right side of the River Po and in a few sectors close to piedmont bands, where young alluvial fans alternate with the older ones; moroever, «Holocene valleys», carved into terraces with meander belt features, belong to it. The delta and lagoon areas were most affected by recent changes caused both by natural processes and by artificial interventions on the coastline and river beds. The effects of subsidence, of changes in fluvial discharge and load, of coastal erosion and sedimentation are well evidenced in the new cartographic representations which provide also a detailed picture of the large amount of lands below the sea level. Questions arise on particular themes. For example: which geomorphological correlation does exist between the sectors of the Pleistocene plains in the land and their possible continuation in the part submerged by the sea buried under Holocene sediments of different thickness? Which modifications and deformations can be attributed to the effects of continuing tectonic movements, on the basis of geomorphologic evidences?

GIOVANNI BATTISTA CASTIGLIONI

The Geomorphological Map of the Po Plain 1:250,000

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The 2nd International Conference on Geomorphology in Frankfurt (1989) offered the opportunity to inform about the progress made by many Italian research-workers in surveying the geomorphology of the Po and Veneto Plain, one of the most important physiographic regions of Italy. Now we present the finished work, consisting of: (i) the Geomorphological Map proper; (ii) a second map («Map of relief and vertical movements of Po Plain»). Both are edited in three sheets, on the same scale (1:250,000). The authors come from ten universities and other scientific institutions in northern Italy.

The Geomorphological Map provides a detailed classification of landforms based on morphogenetic criteria, and includes information on surface sediments and morphography. Both fluvial and glaciofluvial forms are particularly evident and highlight the complex evolution of the entire hydrographic system. Special attention is also paid to the forms of the coastal belt with its deltas and lagoons. As is well known, the physical landscape has been profoundly influenced by human activity; these are indicated on the map both by special symbols for man-made forms and by other information on the recent tendency of rivers and the coastline to change.

Both maps show contours according to the latest detailed altimetric surveys published by regional cartographic offices. The second map is basically one of contours; the particular situation of the coastal and deltaic belt, in which more than 2,300 sq. km. of the plain are below sea level, is emphasized. Details are mapped by zero-contour and by +2 and –2 m contour lines; the eastern part of the Po Plain is severely affected by subsidence. The second important theme developed in this map, thank to new processing carried out by the colleagues of the University of Ferrara, includes subsidence velocities along many high precision levelling lines, and the comparison of measurements taken at various periods until 1990.

FILIPPO CATANI & RICCARDO FANTI

On the fractal character of landscape in Central Italy

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The present work takes into account the utilization of fractal geometry concepts in the field of geomorphometric analysis. Many authors have recently faced this problem, coming to the conclusion that self-similar characteristics may be useful either when they turn out to be correlated with the classical morphometric parameters, or in the opposite case. In fact, in the first hypothesis the fractal dimension might be easier to compute with respect to the other variables or even it could prove to be a more intuitive statistic and one that has a much wider potential. In the second one, instead, fractal dimension might communicate some new meaning that can be explained and utilized opportunely. In the analysis of landforms, the fractal dimension D summarize the space-filling nature of the topographic surface, varying from 2.0 to 3.0 with the increase of roughness and with the change from a state in which the differences in elevations exhibit positive spatial autocorrelation to one in which they show negative spatial autocorrelation. The variation of this parameter has been frequently related to the nature of processes which have been acting on the area under study.

In order to verify if these considerations can be applied also in some typical Italian landscapes, in this work we tried to adopt the same approach on some test areas in Tuscany and Lazio. In a preliminary phase the chosen methodology required the realization of digital terrain models of the sites of interest. On these models we have subsequently computed the principal classical morphometric parameters along with their statistics (i.e. elevation, gradient, aspect, profile convexity, plan convexity etc.) and also the fractal ones, drawn by the variogram method, based on the analysis of the changes in elevation at different correlation lags.

In the next interpretation phase we first carried out the comparison between the two methodologies and then we tried to get at the general morphometric description of the examined areas based on the whole set of findings.

On the basis of our first results it seems possible to suppose, in the greater part of the cases taken into account, the existence of variation in the values of D, showing a multifractal behavior. The spatial limits (or cross-over scales) within which the values of D are valid can be considered as the scale boundaries where a specific geomorphological process dominates.

FILIPPO CATANI, RICCARDO FANTI & SANDRO MORETTI

Vulnerability and geomorphologic risk assessment for architectonic and archaeological heritage conservation

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The international activity dealing with the evaluation and conservation of the cultural heritage is commonly done by Unesco which is promoting several initiatives especially directed at specific monument or archaeological sites. These initiatives are often in the field of restoration or conservation works but rarely in prevention of damages. This is due mainly to the fact that there is a lacking in the connection between the knowledge of environmental condition and

the cultural heritage. In Italy the National Research Council developed a Task Research Project on Cultural Heritage with the intention to obtain a more comprehensive and interconnected frame among the several research fields working on this subject. This paper describes the research activity brought on in some sample areas in Italy (Central Italy and Sardinia) dealing with the evaluation of geomorphologic hazard and risk with regards to the landslide, flood and erosion processes for the historical sites.
The first part of the work describes the data base creation of the good and the analysis of the geomorphologic processes interacting on them. This activity employs the Arc/Info (© Esri Inc.) software in which the data base is included for organising and georeferring all the information obtained with the first survey analysis.
The second phase includes the risk evaluation in according to the Unesco procedure, in which Hazard is described as the probability to take place, for a defined period and area, of a potential destructive phenomenon; the Vulnerability results as the degree of loss for a defined element or group of elements resulting from taking place of a natural phenomenon of a certain intensity: it is scaled from 0 (no loss) to 1 (total loss); the definition of Risk is coming from the combination between the Hazard and Vulnerability as degree of the expected damage due to a natural phenomenon of a defined intensity.
On the base of these definitions all the geomorphologic processes influencing the good stability (both on slope and flood plain) were analysed to highlight the time and space hazard elements distribution that are threatening on regard to their safety. Hence for a correct cultural heritage conservation is of primary importance the good and site vulnerability characterisation, their classification, including in space, and the prevention of their degradation by means of specific and compatible intervention identification. The use of Geographic Information Systems results the most effective procedure for a global and integrated analysis on the site information and on the intrinsic and external condition of potential instability.

FILIPPO CATANI & SANDRO MORETTI

Fractal analysis of roughness profiles in agricultural lands

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The aim of the work summarized in this paper is trying to verify the actual existence of some kind of correlation between erodibility and geometrical fractal properties of roughness profiles in agricultural fields with different management conditions.
Terrain roughness profiles at scales varying from 10^{-1} to 10^{2} meters showed in many cases statistical self-affinity. This means that in the elevation versus distance pattern it is possible to find out a scale invariance. This property is typical of fractal objects in such a way: scaling of a factor r along the x axis and of a factor r^{-H} along the y one brings to the same probability distribution with respect to the original function:

$$x(t) \stackrel{d}{=} r^{-H}(rt)$$

One famous example of process with this type of probability distribution is the Fractal Brownian Motion, where the values of a realization in time are summarized in a simple power law in the form f^{-2} as function of frequency f. Such homogeneous spectra, and the space or time records from which they result, exhibit a scaling invariance: if such a process is compressed by a factor s, the corresponding Fourier spectrum is expanded by the reciprocal factor $1/s$.
The practical application of this concept not only allows us to conduct extrapolations of data at different scales but also leads to the definition of quantities, like for example the fractal dimension D, which hold all the concerns of a good morphometric parameter: conceptually descriptive, easily measurable and suitable at a variety of scales.
In the present paper we describe the research activity carried out in the framework of the X-Sar/Sir-C project, devoted to the characterization of the terrain physical properties (i.e. soil roughness, soil moisture, etc.) by means of microwave sensors and to their following utilization in the hydological and erosive modelling.
In this case our analysis took into account the roughness parameter which hardly conditions the dynamics of erosive process in cultivated lands. The experimentation consisted of two different phases, the first one devoted to the definition of erodibility (k) and roughness parameters by rainfall simulations and shape tracer measurements, the second one aimed to understand scale invariance properties by the application of fractal and signal processing based techniques to the roughness profiles.
In a following data interpretation phase, we then tried to make a correlation able to explain and describe the links existing between the erosive processes and the geometric nature of geomorphologic forms, at the scales of interest. This can be useful also in order to forecast the impacts of human activity on soil and landscape characteristics.

ALGIMANTAS ČESNULEVIČIUS

Postgenetic changes of glacial relief of Lithuania

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The large forms of Lithuanian relief developed during the Quarternary glaciations, namely: the last but one Saale and the last Vistula glaciations. In the post-glacial epoch the re-

lief formed by glaciers was transformed by numerous geomorphological processes: fluvioglacial, limnoglacial, solifluctional, erosion, eolian, thermokarst, littoral, limnic, fluvial, suffusion, karst, organogenic and anthropogenic. The action of these processes in different age formations of Lithuanian glacial relief varied. The duration and intensity of processes predetermined the degree of transformations. Most intensive postgenetic changes took place in the Lithuanian uplands. The largest area of postgenetic change is taken by erosion, thermokarst, organogenic, fluvioglacial and fluvial formations. The link was determined between the age of relief and postgenetic complexes and their intensity in the morainic massifs and moraine chains.

Postgenetic changes of glacial relief of Lithuania (area, %)

Age	Processes				
	fluvioglacial	fluvial	thermokarst	erosion	organogenic
			Morainic massifs		
Saale glacier	5,1	0,9	4,11	9,7	6,7
Vistula glacier					
Brandenburg stage	-	-	2,2	21,4	1,3
Frankfurt stage	1,9	1,2	10,4	11,0	9,8
Pomeranian stage					
East Lithuania phase	3,3	-	12,3	10,0	8,3
South Lithuania phase	-	0,3	12,6	11,5	6,8
Middle Lithuaniaphase	-	0,5	7,4	15,4	4,7
			Morainic chains		
Saale glacier	5,0	1,0	1,4	24,2	0,4
Vistula glacier					
Brandenburg stage	4,0	0,5	8,2	13,1	14,8
Frankfurt stage	-	1,5	12,7	12,4	12,5
Pomeranian stage					
East Lithuanian phase	1,1	3,9	11,3	10,4	11,3
South Lithuanian phase	-	-	14,6	9,8	10,3
Middle Lithuanian phase	-	2,2	19,6	9,8	11,0

D. CHANDRASEKHARAM & H.C. SHETH

Significance of flow stratigraphy in deciphering erosional history of flood basalt provinces

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In huge continental flood basalt provinces such as the Deccan, India, multiple eruptive vents are generally the rule, each having its own sphere of influence. Often it is difficult to estimate the rate and volume of erosion from topographic expression only. It must be decided before estimating erosion rates that the lavas did once extend over the presently observed valleys. For example the gap between areas A and B (fig. 1) could have been due to erosion, but it could as well have existed originally, with A and B being separate areas of eruption. Thus an independent check for original continuity becomes necessary. This can be achieved if flow stratigraphy is superimposed on the topography. Deccan flood basalts, due to their time of eruption (Cretaceous - Tertiary) have achieved international importance and several groups are currently establishing flow by flow stratigraphy of the Deccan volcanics.(e.g. Subbarao & Chandrasekharam, 1995). Flow stratigraphy can be established based on field relationships, petrography, geochemical and paleomagnetic signatures. One such flow stratigraphic sequence from the Deccan province (Devey & Lightfoot, 1986) extending over 300 km is shown in figure 1. Such a flow stratigraphic sequence enables us to decipher the thickness and attitude of the flows on regional scale. Thus, as shown in figure 1, if the flow stratigraphic sequences for areas A, B and C match,original continuity of the Formations 1 to 4 is confirmed and this can be of much help in estimating the volume of rock eroded in a unit area. Such a flow stratigraphy superimposed on topography would be a useful tool in assessing the erosion caused geomorphic evolution of flood basalt terrains. In certain cases, as seen in figure 1, flow stratigraphy would help in deciphering even the basement topography.

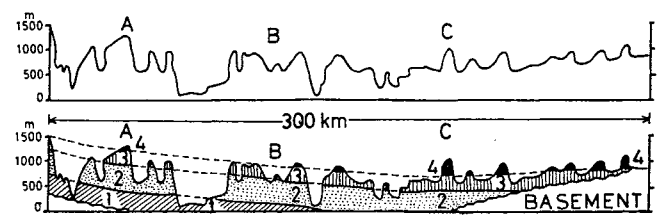

FIG. 1

JUI-CHIN CHANG

Geomorphological changes on the Tsengwen coastal plain in Southwestern Taiwan

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Tsengwen River, one of the main streams in southwestern Taiwan, is marked for its meandering channel and high sediment yield. The coast of this area is significant for the offshore bars and lagoons. According to the historical archives available in the last three hundred years and the comparision of detailed topographical maps in this century, the «paleo Taichiang Inland Sea», a lagoon with an area of 350 km^2, had been filled up and reclaimed as salt pans and fish ponds since 19th century. The coastline had migrated to the west about 5 km due to rapid sedimentation during 1904-1990. In addition, the Tsengwen River had four avulsion events in the typhoon seasons. The interval of river change was about 50 years in average without human interference since 19th century. On the other hand, the sand dune on the offshore bars with a height of 10 m, has decreased its magnitude due to the expansion of built

area. Overall, the geomorphological changes of Tsengwen coastal plain were caused by physical processes in long term but modified strongly by human agency in the recent time. The geomorphological changes have induced some impacts on the human beings including the decline of port, moving of village to prevent flooding , confusion of administrative boundary, etc.

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Arc tectonics in the northern margin of the Pamir-Tibet Plateau

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Arc tectonics is a key feature in intracontinental orogenic belts in west China. Several rows of high-rising arcuate mountain ranges, which caused by strongly lithospheric compressing and uplifting owing to collision of the Indian and Eurasian plates, mark the northern margin of the Pamir-Tibet plateau. Two major arcs can be identified as the Pamir-west Kunlun arc and the Altun-Qilianshan arc respectively from west to east.

Analysis and comparison of accumulated neotectonic deformation and of seismicity between these arcs has been carried out recently on the basis of data related to sediment strata deformation, geomorphic evolution, offset of drainages, paleoearthquake events, and so on. Some results have been gotten, even if they probably are unperfected.

1. These arcuate mountain ranges are alternated with intramountain basins or piggy-back basins in space. From the inner arcs to outer ones, their altitudes are getting lower, their curvatures bigger, and their ages younger.
2. Every arc tectonic is composed of a series of varying scales of sub-arc that is a separate fold-and-thrust sheet with independent characteristics of geometry, kinematics and mechanics and is a self-similar system as well.
3. The geometry and kinematics of arc tectonics changes from thrusting at the top of the arc (where thrusts are with gently dipping planes and has the largest slips) to oblique thrusting and wrenching at the limbs (steeper faults with sinistral wrenching at the left limb and dextral wrenching at the right limb), and finally thrusting to the end of the arc. For example, in the Pamir-west Kunlun arc which verges to the north, the kinematics of arc changes from the top (thrusting in the south of Kashigar) to the east limb (dextral wrenching in the south of Yingjisha-Zepu, where a large dextral pull-apart basin called the Tashikuergan basin was developed as the result), and finally to the end (thrusting in the south Yecheng).
4. These arc tectonics consist of frontal, lateral and oblique ramps in deep, which merged downward into a series of decollements in different depth.
5. Every earthquake deformation belt is probably related to the independent arc tectonics one by one. Strong earthquakes correspond to the large scale arcs, and middle to small earthquakes to smaller ones.

ZHIMING CHEN

Analysis on the plate geomorphic effects in West China

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The term «plate geomorphic effects» denotes that since the end of Mesozoic era, especially since the continental collision 40-45 MaBP under the drive of plate tectonics and its stress field, there emerges a regional effect of systematic geomorphic deformation or rejuvenation. Researches indicate that during the Meso-Cenozoic period, the Indian Plate made it a rule to subduct and collide against the Eurasian Plate generally in a NNE direction. Thus, those morphotectonics in west China and its adjacent areas have taken place systematic deformation as the following:

1. Pattern of mountain system as vertically against the main compressive axis: The trend of mountains and basins in West China was generally in a vertical arrangement with the principal compressive axis of the plate (NNE), whereas its specific distribution had something to do with the geometric forms of landmass boundaries. Moreover, in areas ranging from Mt. Himalayan extending N-ward to Mts. Kunlun-Altun-Qilian, Mts. South and North Tianshan, and Mt. Altay, both the heights of mountain ranges (in the average and in the highest) and the thicknesses of piedmont molasses are becoming gradually lessened from south to north:
2. Nappe-type mountains spreading extensively in the foreland zones: After having undergone compressive stress through longstanding stability, those marginal lithospherical substances of the orogenic belt were squeezed into and thrusted above the old landmass, while the foreland crust was underthrusted below the orogenic belt, as a result of which these nappe-type mountains at all of the plateau margin took shape. These nappe mountains, though varied in age, became active violently in the Quaternary period, as reflected conspicuously in relief. It is shown in the computer-aid mapping from the piedmont relief, for example, that there were inward plateau staircase planes contrary to the normally tilted outward ones to be frequently seen;
3. Occurrence of the latest folded in semi-cemented strata: in the region adjacent to the main compressive axis, due to the fracture of rigid basement and the shortening of earth's crust, the fluviolacustrine facies Tertiary and Quaternary systems in some compresso-depressed basins gave rise to a peculiar kind of the latest folded landform above their semicemented caprocks. as shown in the considerable amounts of massifs and hills in the satellite images from those basins of Qaidamu, Junggar and Talimu.

4. The forming of strain basins along the strike-slip belt: owing to the non-smoothness of certain boundaries of strike-slip fault zones, there occurred pull-apart basins at the time of fracturing and shearing, spreading usually in rows alternating with upheavals. Researches reveal that there are as many as one hundred of these basins in the Qinghai-Xizang Plateau. In the interior plateau, this kind of pull-apart basins is gengeally the origin of the Quaternary lakes;
5. Landmasses squeezing laterally out of the main compressive axis: If we should connect the two largest Indian and Siberian old landmasses into a line as a principal axis of stress, then the crustal blocks to the east of this axis would have all undergone the E-ward squeezing-out movement. For example, the N. Xizang Block turned NE-ward at a moving speed of 28 mm/y; the Xikang-Yunnan Block, SSE-ward (8 mm); the Yangtze Block, SE-ward (6 mm); the Qaidamu Block, SE-ward (6 mm), and the N. China block, NE-ward (4 mm). On the other hand, those blocks to the west of the axis were dispersed W-ward, as indicated by the following examples: the Afghanistan Block turned SW-ward; Mt. Pamirs and Mt. West Himalayan, NW-ward; the Tarim Block, NW-ward and the Junggar Block, NW-ward (3 mm) respectively.

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Yangtze Delta, China: changed topography and Neolithic migration, a response to the Holocene sea level rise

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The southern Yangtze delta plain, located along the east coast of China, is primarily characterized by a large-scale depression including the Taihu fresh-water lake in the center, and a series of chenier ridges to the east. This depression area, ~2 m above mean sea level (msl) is surrounded by hills to the west, chenier ridge system (4-5 m, above msl) to the east, and the deltaic-fluvial plain (3-5 m above msl) to the north and south. It is of special interest that numerous Neolithic settlements (>150) have been found in the depression.
Recently, an active sedimentological and archaeological combined investigation was conducted to have demonstrated that the origin of the Taihu lake and chenier ridges, and the migration of Neolithic settlements in the study area were closely associated with the Holocene sea level rise. Prior to ~10,000 a B.P., when sea level was >40 m below present, the Taihu region was subaerially exposed. There is no evidence of the early settlement found, obviously due to the lack of organic content in soil, which can not support ancestors to engage in agriculture. Sea level rose rapidly from 10,000-7000 a B.P. and became very close to present. This immediately lift up the ground water table of the study area. In addition, due to deceleration of sea level rise in ~7000 a B.P., sediment rich in organic matter brought down by the Yangtze river initiated to construct the fertile delta plain. These combined factors induced the evolution of settlements and cultivation, including rice in the former Taihu lake region. Continuing rise in sea level from 7000-5000 a B.P., in association with large amount of fluvial accumulation distributed around the Taihu region via runoff, tidal and littoral currents, as well as typhoon processes aggraded the periphery the delta plain, including the chenier ridges. This changed topography with time, in direct response to sea level rise, has gradually turned the former habitat area into a dish-like depressed basin. Marshland expansion in the depression had driven the settlements migrated eastward to the backside of the chenier ridge and on the ridges, which occurred as a coastal barrier to enable temporarily protecting the Neolithic occupations from sea invasion. Eventually, continuous expansion of the Taihu lake (once was 2-3 times larger than present) in ~4000 a B.P., aggravated the settlemental condition. The paleoculture was declined.

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Water shape factor in process of speleothem deposition

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Speleothem origin has been a study project for many scholars, especially on control factors of speleothem deposition. Many papers have mentioned this question, such as temperature factor, CO_2 pressure, and water factor, etc. According to interface factor and CO_2 escape mechanism, this paper presents a viewpoint of water shape factor and points out that under different water shapes the depositional velocity will be changing. The influence will reach a non-neglected degree. For same volume of water, because of their different shapes or their changes in shape, the velocity will be quite different among them.
In other words, a equillibrium-saturated water will deposit $CaCO_3$ from the change of water shape. As a result, we shouldn't neglect watershape condition in discussion of depositional velocity of $CaCO_3$. Based on contrast experiment research on different-shaoed water with same volume and experiment of changes from same volume water to different shapes, the paper presents that the change of water body is an important influence factor for depositional velocity of $CaCO_3$. When CO_2 goes out from water-air interface, it will go through a distance and water body change in shape will alter this distance. As a result, this will result a change of the depositional velocity. A change of water body into much sprays with many bubbles filled will greatly change the

depositional velocity of $CaCO_3$. Underground water in caves exist in a state of large volume but with a small water-air interface. When it flows to surface as discharge, the water shape will change into a state of large interface but with shallow depth, which result in tufa deposition. Much continental $CaCO_3$ deposition may be formed in this way.

SERGEY S. CHERKASHIN

On the Black Sea level changes along the shores of Odessa Bay during past century

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Odessa Bay is situated on the Northern coast of the Black Sea. The length of the Bay shoreline constitutes 14.5 km between capes Langeron and Nothern. The Southern part of the bay occupied by Odessa sea port along 5.7 km. The remaining 8.8 km - though natural, but greatly developed shores within urban boundaries of Odessa. 5.4 km of them represent doubled barrier Khadgibey and Kujalnik limans, the remaining 3.4 km are occupied by active abrasive-landsliding cliff. The given topic is of important practical significance, though Odessa Bay coast is on the territory of Odessa City as one of biggest cities in Ukraine, are intensively developed and densely built on.

The sea port is the greatest in Ukraine. It territory is situated along the part of the Khadgibey liman barrier, and at the foot of high stable shore slope (up to 45 m) on marks 2-5 m above the zero-water level. The active abrasive-landsliding cliff, about 50 m high, is located in the north-eastern part of the bay. It is subjected to the action of landslides and the rate of its foot retreat constitutes from 0.2 to 3.5 m/year during different years. The shorelines of liman barriers are low, their height equals 1-2 m above average the sea level; the level of limans is 2-4 m lower than the sea level. Along the bay shore drift flow ends, with the capasity 20,000-30,000 m^3/year. That is why the shoreline of barriers is stable in general. Clayey benches are located on the nearshore bottom in the north-eastern part of the bay opposite the active cliff (the average inclination 0.0013). The main part of the bay bottom is represented by underwater sandy part of the barriers, its inclinations are within 0.0035-0.0046. Such inclinations are favourable for coming of sandy drifts to the shore (beach) during storms, which is also favoured by dumping of alongshore drift flow in the bay. The characteristic of the hydrometeorological regime of the sea is done by the data of marine station «Odessa-Port», on which instrumental measurements have been carried out since 1870. The following changes are pointed out: *a)* short-term level changes, caused by hydrometeorological reasons (mainly by wind); *b)* long-term, caused by the influence of hydrocratic and geocratic reasons (mainly by changes of sea water balance and vertical movement of coastal blocks of the earth crust). Short-term level changes connected with wind set up and wind tide phenomena are conditions by the activity of strong winds, maximum amplitude reaches 2.26 m, absolute maximum of wind set up being 1.52 m, absolute maximum of the wind tide being –0.74 m. The average annual amplitude 50% providedness equals 0.52 m. Seiche fluctuations, the amplitude of which reaches 0.5 m, can be put on these values. Summary generalized rates of wind set up and wind tide rise and fall of the sea level usually are within 2-6 cm/hour (maximum 25.7 cm/hour). In such conditions the profile of the coastal zone changes very quickly, and it is obviously adapted to such intensive changes. But storm surges increase of the level sharply increases rates of cliff retreat and beach erosion, as during very short time enourmous amount of wave energy dissipates near the shore.

The increase of the general humidity of the Black Sea basin activized eustatic level rise to the average rate 2.67 mm/year. Relative vector rate equals 2.91 mm/year during 1926-1990. Against this background during 1921-1949 the rate of the rise turned out to be equal 0.9 mm/year, in 1950-1973 it was already 4.5 mm/year, and in 1974-1991 rate was 6.3 mm/year. No sure prognosis up to 2050 and the more so up to 2100 can be given, as the rhythms of level changes have not been studied yet. However three main scenarios of the level elevation values up to 2100 can be probable: low up to 0.5 m, middle up to 1 m and high up to 1.5 m.

If these scenarios become real and storm activity of the Black Sea increases, by the end of the next century there will appear the real threat to the Odessa Bay shores, accordingly to their structure and dynamics. Most probable the rate of abrasion of clayey landsliding cliff in the north-eastern part of the bay will grow, normal work of the Sea port can be disturbed. As alongshore drift flow is fed mainly by the sediments from abrasive destruction of cliffs and benches, more drifts will move to the Odessa Bay from Eastern coastal sector, the sandy bottom erosion opposite the barriers of Khadgibey and Kujalnik limans will bacome more intensive. In these conditions the adaption of accumulative forms to the level rise and increase of their dimensions are most probable. The rise of underground water level and lithodynamical influence on the port constructions will play certain role as well.

SORIN CHEVAL

Relations between the climate and the morphology of the south Dobroudja Plateau. Special view on the impact of the climatic hazards

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Besides other factors influencing the aspect of a regional relief, the climatic ones occupy a very important place.

With the South Dobroudja Plateau things stand exactly in the same way; the morphology of the region (placed in the South-Eastern of Romania) is particulary under the influence of the meteorological phenomena or, generally speaking, by the climate. The meteorological agents can act «freely» enough, having on their side a profitable geological support (the upper part of the South Dobroudja Plateau is built from limestone and loess).
In the space chosen for analyse can be found landforms resulted of slowly acting processes, as well as landforms resulted of rapidly acting processes. For the morphology of the region, both types of processes are very important, but latter are much more intersting from practical point of view; they could represent an obvious danger for the economic activities, as there at least 2 objectives which are of wider than Romania's borders important: the Nuclear Power Station at Cernavoda, and the Danube-Black Sea Canal.
The establishment of some quantitative relationships between climatic conditions, climatic hazards, morpholoy and geomorphological hazards in the area should represent the objective of the paper.

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Geomorphological survey of sheet 367 «Tagliacozzo» at a 1:50,000 scale (Central Apennines)

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Among the main institutional tasks of the Geological Survey of Italy is to realize geological and geothematic maps. In this frame, the rules to achieve the Geomorphological Map of Italy at the scale 1:50,000 had been established (Servizio Geologico Nazionale, 1994). To test the above mentioned rules in the field a survey on the area of the Sheet 367 Tagliacozzo had been carried out. The area was chosen both for the complexity and variety of its geomorphological processes as well as for the existence of an updated geological cartography. Studies conducted in this area have provided at the present a valuable information for the drafting of the rules, and will contribute to their improvement.
The area is located in the Central Apennines; it includes the Carseolani mountains, the Faito-Val di Varri mountain ridge, part of the Simbruini and Sabini chains, the Duchessa mountains and the plains of the Cavaliere, Corvaro and Imele river. Most of the area is included within two hydrographic basins: the Salto river on the east and the Turano river on the west. The territory is characterized by carbonatic ridges with northwest-southeast trend, belonging to meso-cenozoic successions. These are separated by terrigenous basins filled with tertiary flyschoid sediments and plio-quaternary continental deposits, mostly of fluvial and lacustrine genesis. The area has been affected by some tectonic compressive phases since the upper Miocene. These phases caused the overlapping of the carbonatic deposits over the terrigenous ones. Afterwards these successions had been affected by a tectonic extentional phase (Compagnoni & *alii*, 1990) that concerned the present morphological features, controlling the following modeling processes.
The two main morphogenetic processes in the area are of a fluvio-denudational and karstic nature, associated with those gravitational, volcanic, lacustrine and glacial. The anthropic activity in the plains and along the river beds should also be taken into account.
Carbonatic ridges are typical for their structural escarpments and well marked fault slopes, preserving large parts of structural surfaces too (i.e. on the Carseolani mountains). These ridges are mostly affected by karstic processes that show themselves as underground and superficial forms, mainly developing at the top of the reliefs. The fluvio-denudational and gravitational processes dominate the slopes as well. The former have caused linear cuts, and in some cases, profound gorges, controlled by the presence of fractures and faults, as well as sheet runoff in the non-forested zones. The gravitational processes have originate the talus heaps placed at the base of the reliefs, and the rockfalls and rockslides that have taken place in limited zones of the Sheet. Relict landforms are present on the top and on the sides of the reliefs, such as valleys and planation surfaces, linked to the landscapes of the past.
In the areas where flyschoid deposits outcrop prevails the fluvio-denudational process, showing itself with curved valleys and fast deepening river-beds, gullies and widespread sheet erosion phenomena. Emphasis should be given to the gravitational processes that originated localized landslides and diffused solifluction. Within the flysch the main endoreic basins of the area develop, ending in sinkholes located at the contact point with the carbonatic dorsals (Luppa, Ovito and Val di Varri basins). The Orbulina marls, outcropping occasionally within the Sheet, need a different interpretation. These marls, when covering limestone strata, with dip slope attitude, give place to translational slides in wide portions of the slope, often evolving into flows.
Most of the Plio-quaternary fluvial and lacustrine deposits are the product of dismantling of the meso-cenozoic reliefs. These deposits have gradually filled the large depressions created by extentional tectonic events. Among these are worth mentioning the clay-silty and sandy-silty sediments found in the Cavaliere and Imele river plains, as well as the conglomerates, sands and clays outcropping between Torano and Borgorose. The conglomerates of fluvioglacial origin laying in the Corvaro plain and in the Ruara valley, and the alluvial deposits in the Salto and Turano plains should be mentioned as well.

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Geographic Infomation Systems for morphometric characterization of drainage basins

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Quantitative definition and representation of natural phenomena and of their morphological effects is a growing need both in geomorphological researches and in the applications of geomorphogical knowledge to the problems of proper land management. This paper is framed into this context and its aim is to estabilish a methodology to analyze and classify the studied territory on morphometric basis.
It is well known that drainage basins are the basic geomorphic units and many studies from all over the world showed that most of their orographic and hydrographic characteristics can be expressed, synthetically and properly, throught appropriate geomorphic parametres; for this reason, the sample area of this study is a drainage basin. More precisely the drainage basin of Fiume Salto has been chosen; it is located in Central Italy and shows wide heterogeneity in the geological and morphological conditions within an area of suitable size.
The most significant geomorphic parametres have been calculated for the sample drainage basin; the interdependence among the chosen parametres and their spatial variability as function of lithological and tectonic conditions have then been investigated in order to produce cartographic synthetic representations.
The enquiry has been carried on applying computer assisted procedures according to Arc/Info system and new special programmes elaborated by the authors.
Orographic digital data by Igmi available at the scale 1:25,000, have been appropriately controlled and integrated by introducing new spot elevation. Hydrographic data have been drawn from Igmi topographic maps at the scale 1:25,000 and integrated through aero-photographic and field observations; successively they have been transferred on paper stand and acquired as numerical values by scanner. The digital hydrographic network has finally been verified by checking stream junctions.
Data processing procedures can be summarized into the following three groups:
– elaboration of a digital elevation model which considers divides, thalwegs and closed depressions; elaboration of slope and aspect maps, relief amplitude maps, shaded relief maps;
– automatic hierarchization of drainage networks, calculation of morphological parametres of single drainage basins by means of programmes assembled by the same authors; construction of maps of hierarchizated drainage networks and of drainage density;
– identification of stream preferential orientations through automatic analysis of stream rectilinear segment azimuthal distribution (this analysis, executed by cumulative length, has been applied to the whole drainage network and to the different stream order within each outcropping lithologies); identification of fault and slope preferential directions by means of programs suitably run by the authors.
The basic result obtained following the above methodology is the construction of a data base for the study area, which allows the surveyed data to be speedly elaborated, compared and mapped. Moreover the integrated analysis of the different information levels can led to the automatic production of diagrams and map. Some examples of both the possible representations have then been produced.
The first example is a set of graphic elaborations which show the prevailing orientations of slopes and the preferential orientations (domains) of stream directions, as a function of stream order and outcropping lithologies; the integrated analysis of the two kinds of graphs can allow the identification of stream orientations which, being not congruent with slopes, are likely to be structurally controlled.
The second example is one of the possible thematic map obtainable. The map chosen as sample shows the areal variations of denudation process entity evaluated as function of drainage density and slope, taking into account also the different outcropping lithologies.

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Dusty storms as a factor of modern relief-formation (by example of Belarus)

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The territory of the Republic of Belarus is in the humid zone. The moderate climate conditions cause a favourable geomorphological surrounding. Nevertheless the climate conditions in some years may change in rather considerable ranges. For all that the extreme climate parameters (strong winds, low air humidity, sharp daily temperature overfall, low amount of precipitations, genetic features of the earth surface (a wide spreading of the loess-like rocks) promote the creation of the favourable conditions for the manifestation of the catastrophic nature phenomenon-dusty storms. Dusty storms envelop considerable areas and draw into air stream a bulk of soil by moving it both on the surface and on the different height. They assumed the most destructive character on the territory of the Belarus Polesje (the south part of the Republic). By the data of Belgidromet, it is fixed more than 40 cases of dusty storms during the last 30 years in the region of Gomel (the maximum amount for Belarus), near Lelchitsy-about 40, near

Vasilevichy-more than 30. For all that the duration of the storms may vary from minutes till days (the most long dusty storm was observed in t. Vasilevichy in the April 1978-38 hours). The wide development of the drying melioration during the last 50 years promoted in the considerable degree the growth of this phenomenon. Here prevailed marsh-ridden mineral and peat and swampy soils before drying. They were greatly watered and covered by natural herbal vegetation and forests and that is why they were not exposed to the action of the wind. The deep changes of the water and airial, chemical, biological and other properties occur by the drainage. In the peat and swampy soils the destruction of the aggregates and the dispersion take place. The lowering of the level of the first waterbearing horizon, the decrease of the moisture capacity and the increase of the filtration factor give rise to the drying-up of the upper layers of soil, that cause their fast mineralization and destruction. Dusty storms further the removal and accumulation of the material and the creation of the eol-like forms of the relief; eolian hills, blowing hollows, deflation fields.

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Nivation forms and processes in higharctic Greenland

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In higharctic Greenland perennial and seasonal snowpatches dominate large parts of the periglacial landscape and control the distribution of the vegetation. Knowledge of the combination of geomorphological processes and forms that result from their existence therefore is important in order to use the resulting landforms and sediments as indicators of environmental change. The existence and distribution of the snowpatches are mainly controlled by the dominating winter wind direction and the amount of precipitation, primarily the amount of snow, whereas the aspect has less influence. This causes snowpatches to respond and adjust quickly to climatic changes and their associated landforms are correspondingly climatically sensitive.

Nivation forms and processes have been studied in a sedimentary landscape at Zackenberg, NE Greenland. A model containing the different processes transporting sediment to and from the snowpatches is presented, and the resulting landforms are shown. The dominating processes are backwall sliding, niveo-eolian resedimentation, supra- and ennival sediment flows, niveo-fluvial erosion, development of stone pavements and pronival solifluction. A morphological complex of nivation hollows, associated niveo-fluvially eroded channels and pronival alluvial cones or depositional basins is typical. In the dry higharctic landscape, with continuous permafrost, the snowpatches are controlling the vegetation in large parts of the terrain below the snowpatches, creating distinctive vegetation zones.

SHYH-JENG CHYI

The forming of main alluvial terraces in Taiwan, a continuously and quickly uplifting area

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Terraces of five drainage basins and their ^{14}C dates are analyzed in this study. Those drainage basins are Liwu River, Lanyang River, Hoping River, Mougar River, located in northeastern Taiwan, and Choco River, located in southwestern Taiwan. The analysis reveals a complex erosional history of these areas during Holocene. Almost all terraces of Liwu River, Lanyang River, Hoping River, Mougar River are alluvial terraces. It is very common that the terraces' sediments are thicker than and the relieves are higher than 50 meters or even 100 meters. The terraces with the highest relief (which is almost 400 meters) and the thickest sediments (which is near 200 meters) are located in Taosai River, a tributary of Liwu River. Nevertheless, each drainage basin has different number of terrace's flights. In Choco River, all terraces are rock terraces and meander scars, covered by thin sediments.

The continuing landmass uplifts with different rates and the climatic changes since the latest Pleistocene have induced rivers' downcutting. Downcutting produced many unstable slopes. It must be the precondition of whether a large quantity of sediments could be yielded from a drainage basin in a short time span. The concentrated sediment yield will cause river's aggradation. The highest average downcutting rate is about 5cm/yr, found in Taosai River. This may explain why the terraces of Taosai River have the highest relief, the thickest sediments, and the most number of terrace's flights.

Climatic fluctuation might have no significant effect on the forming of alluvial terraces during Holocene, unless there were enough unstable slopes in a drainage basin. Therefore, climatic fluctuation is not the indispensable factor for the forming of alluvial terraces. For instance, there is no alluvial terrace in Choco River. According to the ^{14}C dates and the sedimentologic and topographic properties of alluvial terraces, the number of times of rivers being aggradated in other four drainage basins is different. The time interval that separated the prior aggradational stage and subsequent stage in each drainage basin is clear. There were four aggradational stages in Taosai River. Those stages are about 6000 yr. BP, about 2500 yr. BP, about 1000 yr. BP, and about 400 yr. BP. In upstream of Lanyang River, the main terraces are alluvial fan terraces, located in the confluence of tributaries and principal stream. Only three main aggradational stages could be recognized. Those are about 2000-1500 yr. BP, about 1000 yr. BP, and about 400 yr. BP.

Finally, whether a river had been aggradated seems to be mainly controlled by the fluvial systems themselves, the operating mechanisms, and the interaction among subsy-

stems. For those drainage basins with higher average downcutting rate, with finer landscape texture, with rounder basin shape, with higher relief ratio, with weaker rock mass or regolith, and with a longitudinal principal valley, it seems to be more sensitive to climatic changes and easier to be aggradated. The aggradation of a river would affect other rivers through the uplift of confluent points, or the local base level. For example, when Taosai River was aggradated, Takkili River (the confluent river) was not aggradated significantly in the meantime. The uplift of confluent point would stabilize Takkili River's downstream river bed and accelerate lateral erosion. Rock terraces or other similar landscapes were formed when the river downcut again.

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Variations of the Emilia-Romagna litoral (Adriatic sea)

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Among the Mediterranean countries, Italy with a surface area of about 300,000 square kilometres and 7,500 kilometres of coastline (40 square kilometres per kilometre of coastline) and therefore a land management system with a profound influence on marine areas, is perhaps the country that has suffered most from a careless, insufficiently planned pattern of human settlement.
An idea of the importance that Italy attaches to its problems in coastline engineering comes from the northern Adriatic beaches, holiday destination of more than 90 million tourists from Italy and northern Europe.
The annual revenue from a typical square metre of beach from touris-related activities approaches US $ 3,200 which is roughly equivalent to the current market vaule of a square metre appartament!
The northern Adriatic coastline, characterised by alluvial deposits particularly exposed to coastal erosion, during this century and especially over the last forty years, has undergone a gradual deterioration and impoverishment of the beaches. Emphasis is laid on anthropic activities that have altered the delicate equilibrium between subsidence-eustatism and fluvial deposits which underlies the physiographic features and evolution of the coast.
The known effect are the flattening of the shape of river deltas and the sometimes conspicuous erosion of beaches, accompanied by an increase in the gradient in the adjacent sea bottom. The causes of such phenomena are numerous: the fall in the quantities of materials transported to the sea as a consequence of soil erosion control in mountain basins, the building of dams to create reservoirs of water, the digging of quarries in river beds for the extraction of inert materials; the construction of maritime infrastructures such as piers; the demolition of the litoral dune ridges related overall to urbanisation and tourist industry; the sharp increase of subsidence due to removal of water from the subsoil and the extraction of gas. Within the Emilia-Romagna region alone, the quantity of inert materials extracted from the beds of its main rivers during the period 1970-79 amounted to as much as 20,546,830 cubic meters per year.
The aim of the present work is to emphasize and discuss the shoreline variations along the Emilia-Romagna littoral during the period 1970-95 with reference to the most significant stretches.

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Geomorphological evolution and neotectonics of the Sulmona intramontane basin (Abruzzi Apennine, Central Italy)

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The Sulmona intramontane basin, elongated NW-SE according to the main tectonic structures of the area, is the easternmost of numerous tectonic depression which characterize the inner part of Central Apennines. Although its NW-SE trending, just a few kilometers to north and east the basin presents N-S and E-W tectonic structures. These depressions have been formed during Middle-Upper Pliocene, after the end of main tectogenetic phases of the Apennine chain.
In order to outline the geomorphological evolution of the area, detailed geological and geomorphological investigation have been carried out, basing on both air-photo interpretation and field survey. The resulting framework is the following:
a) formation of a half graben depression (Middle-Upper Pliocene);
b) sedimentation in a lacustrine-swampy environment (Lower Pleistocene - early Middle Pleistocene);
c) sedimentation of alluvial conglomerates and formation of a wide alluvial plane (Sulmona summit surface - Late-Middle Pleistocene);
d) cutting of the threshold by regressive erosion due to regional uplift and incision of the summit surfaces (Middle Pleistocene);
e) formation of alluvial fans and fluvial terraces (Late-Middle Pleistocene - Upper Pleistocene);

f) deposition of recent and present-day alluvial sediments (Holocene).
Tectonic activity, producing E-W and NW-SE trending faults, affected the area since half graben formation up to present times.
This sequence of events is also recorded in other depression of the area and may be considered representative of the Middle Pliocene-Quaternary evolution of Central Apennines.

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The Roccamonfina Volcano: relations between morphology and tectonics

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This work is part of a wider research concerning the Quaternary volcanism of Central Italy which aims at determining the relations among the structural arrangement, the volcanic history and the present landforms.
The Roccamonfina volcanic district is characterized by the existence of a central edifice; it belongs to the «Provincia Romana», a K-alkaline volcanic province that has been active since 630 ka and up 50 ka. The volcanic edifice is located where two evident, NW-SE and NE-SW trending fault systems intersect. The volcanism of the Roccamonfina district showed three main epochs. The first epoch (630-400 ka) was characterized by both effusive and explosive activity which gave rise to a strato-volcano and ended when the volcano summit collapsed and a wide depression originated. The second epoch activity (385-250 ka) concentrated on the volcano eastern slope, along NE-SW trending lineaments. The last epoch activity (250-50 ka) produced intracalderic lava domes and volcanic centres aligned along N-S trending lineaments.
Geomorphological analysis has been carried out by using complementary methods; the aim was to evidence all the possible controls exerted by tectonic phenomena – and by the recent ones in particular – on the morphological evolution of the study area. A precise aero-photo interpretation has been executed , followed by systematic controls on field and a geomorphological map of the study area has been produced. Successively, among the morphological features surveyed, those identifyable as indicators of tectonics have been evidenced and all their significant alignments have been interpreted as faults, probable faults and fractures; in this way the map of morphological evidence for tectonics has been drawn.
This analysis was supported by morphometric studies concerning both the hydrographic network and the relief trend of the investigated area. In particular the areal variations of the parametres amplitude of relief (*Ar*) and drainage density (*D*) have been examined, since they proved to be good indicators of lowered or uplifted areas. Of remarkable interest has resulted the analysis of the stream channel azimuthal distributions, subdivided into rectilinear segments by a semiautomatic digitizing process. The results have been evidenced by means of rose-diagrams, the main peaks of which show the preferential orientations , or «domains» of drainage networks. This analysis has been performed for each of the chosen zones, considering the whole networks and the channel of each stream order, since it is likely that streams of different order are controlled by tectonics in different ways and times.
The analysis of morphological evidences showed the existence of a rather marked tectonics which controlled the morphological evolution of the studied area. Four main tectonic alignments have been evidenced through this kind of analysis, their directions being respectively NW-SE, NE-SW, N-S and ENE-WSW. In particular, the first tectonic alignment is of regional importance and is clearly observable also outside the studied area; here it borders the volcanic complex on the eastern side. Of great importance is also the N-S trending tectonic direction; since it intersects the main volcanic depression, its activity is likely to have controlled the morphological evolution of the area in very recent times.
The analysis of amplitude of relief (*Ar*) and drainage density (*D*), both of them calculated for unit of area, afforded useful information about the role of tectonics on the present morphological arrangement of the studied area. The areal variation of these parametres allowed the identification of different zones which can be considered downthrown as respect to the adjacent ones.
The statistical analysis of the preferential orientations of stream channels confirmed the above expressed considerations. Although the existence of the volcanic relief favours the development of a centrifugal drainage pattern, many anomalies exist within it, which suggests the existence of a marked structural control. In conclusion, geomorphological analysis carried out evidenced that the volcanic activity and the morphological evolution of the studied area were strongly controlled by tectonic activity also in very recent times. More in details it has been evidenced that the tectonic directions NW-SE, NE-SW and ENE-WSW were responsible for the general arrangement of the area which can be subdivided in different sectors differentially uplifted and downthrown starting from Upper Pliocene. Moreover the surface effects of the N-S trending tectonic direction are discernable; this direction crosses the volcanic products and conditioned the emplacement of lower order stream channels, thus testifying the important role it had not only in the recent volcanological history but also in the very recent geomorphological evolution of the Roccamonfina area.

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Geomorphological features of Monte Vulture Pleistocene volcano (Basilicata, Southern Italy)

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The Monte Vulture volcano is located on the eastern border of Southern Apennines at the inner margin of the Bradanic foredeep. It belongs to the Roman Comagmatic Province though it is atypical because of its particular position (it is the only volcano of this Province not aligned along the Tyrrhenian Sea margin on the western side of Apennines) and some differences in the chemical composition of its products. Monte Vulture is formed by a central cone of altitude 1327 m and secondary eruptive centres mostly placed in the peripheric areas. The volcanic products are spread over an area 184 km^2 wide and represent the result of explosive and effusive activity occurring from the Middle Pleistocene (about 730 ky B.P.) until the Upper Pleistocene (about 132 ky B.P.).
A multi-disciplinary method taking into account geological, petrographic, volcanological and morphological aspects was used to reconstruct the geomorphological evolution of Monte Vulture.
The geomorphological analysis was performed using different complementary methods. The morphographic study was carried out by means of aerial photo interpretation and detailed field survey which supplied the basis for a detailed geomorphological map. It displays not only the volcanic landforms occurring in the area and their chronological sequence, but also the tectonic control on the geomorphological evolution of the volcano.
The morphometric study concerned both the hydrographic network and the relief physiography of the area. As regards the drainage net, the geometry, the degree of organization and the preferential orientation of streams were examined according to a well-known method, widely described in literature. The morphometric study of the relief was carried out by means of spectral analysis of the physiographic features of the area. This method allowed landforms of different magnitude to be separated, starting from a numerical representation of surface in the form of a regular grid of altitude values. The land surface analysis was realized by means of the Fourier transform which reduced the surface analysed to a number of sinusoidal wavy surfaces with different possible wave lengths. A synthetic view of all the elementary surfaces forming a landscape was supplied by a bidimensional amplitude spectrum, generally characterized by the presence of relative maxima. The position and the values of these relative maxima allowed both preferential patterns in the development of landforms and the length and the orientation of the main sinusoidal surfaces to be recognized.
Together, the data collected have allowed the volcanological and geomorphological evolution of Monte Vulture to be reconstructed. In particular, the study points out that this evolution was strongly influenced by recent tectonic activity linked to four main tectonic directions NW-SE, NE-SW, E-W, N-S oriented. On the other hand, the analysis suggests that the main landforms of the area cannot be related to flank instability of the volcanic cone.
The volcanic activity began in a depressed area bordered by NW-SE and NE-SW scarps which could represent a graben-type structure. Tectonic alignments with the same orientation led the geomorphological and volcanological evolution and have been active until very recent times as they have influenced the present drainage network evolution In more recent times the N-S and E-W tectonic alignments also seem to have played an extremely important role in the landscape evolution. In particular, the former borders the volcanic area along its eastern side and characterizes the area between Atella and Rionero which is probably a graben-type structure filled up with pyroclastic and lahars deposits. The latter alignment induced the lowering of the southern sector of the main volcanic cone in correspondence with the Valle dei Grigi-Fosso Corbo alignment. This lowering occurred about 480 ky B.P. and strongly influenced both the volcanic evolution and the general morphology of the central cone. The E-W tectonic direction has strongly influenced also the drainage network development up to the present as the numerous anomalies characterizing the drainage pattern testifies.

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The Pliocene-Pleistocene coastal terraces of Luanda Region (Angola)

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A long portion of Angola's Atlantic coast is characterized by a widely-extended surface of very low relief that spans between 50 and 170 m of altitude. This surface is particularly wide in the surrounding of Luanda where it extends up to 50 km inland, mantaining a mean slope towards the ocean of about 0.2 %. The tentative reconstructions reported in the existing literature about the origin and age of this surface appear unsatisfactory both for the lack of objective constraints and for the abuse of correlations traced between non-equivalent sectors of that composite surface.
As a matter of fact, the coastal strip comprised between 50 and 170 meters a.s.l. discloses morphological features that allow to interprete it as a polycyclic landscape resulted from different phases of planation and downcutting. Such landscape unconformably cuts across a faulted and warped

marine succession ranging in age between Lower Cretaceous and Neogene (Kwanza Basin succession). Still uncertain is the exact age of the youngest, regressive terms of this succession in the onshore portion of Kwanza Basin (Luanda formation), which have been dated by different authors between Lower Miocene and Pliocene.
The higher portion of the 50-170 strip (above 90-100 m a.s.l.) is a planation surface to be interpreted as the result of pedimentation processes. Due to differences in the bedrock resistence, dip of strata and the presence of ancient faults, this planation surface (hereinafter named Terrace I) includes gentle cuesta-like reliefs and fault-line scarps. The associate deposits are represented by a discontinuous blanket of alluvium (siliceous sands and conglomerates up to a dozen meters thick) which was fed by streams eroding the main escarpment of the Angolan margin. On top of these alluvial deposits is sometimes preserved a truncated laterite profile. A younger and more extensive cover is represented by few meters of finely laminated red sands which can be ascribed to later phases of reworking and weathering of the materials exposed on the planation surface (former alluvial cover and/or siliciclastic formations of the Neogene substratum). Where the above mentioned covers lies on calcareous terms of the Cretaceous-Neogene succession, the planation surface appears punctuated by very large closed depressions (up to 3 km across and 20 m deep) due to localized chemical downwearing (dambos).
A first phase of dissection of Terrace I is witnessed by a series of hanging rivery valleys that are few tens of meters deep, have gentle flanks and very low longitudinal gradients. Some of these incisions appear markedly oversized with respect to their present discharge because most of their catchment area was pirated by other rivers (Kwanza and Bengo) during the final, deep dissection of the surface. The base level that controlled the first phase of Terrace I dissection is represented by remnants of an ancient marine abrasion platform (Terrace II) that occurs between 50 and 60 m a.s.l..and carries a thin, discontinous cover of fossiliferous litoral sands followed by fluvial deposits. The coastal cliff that bounds the Terrace II are locally cut by a younger order of marine terraces between 15 and 20 m a.s.l. (Terrace III). Along rocky promontories, it consists of narrow and discontinuous remnants of a wave-cut platform with associated fossilieferous beach deposits, whilst it is represented by progradational fluvio-marine bodies in front of some river mouths.
As the fossils we collected on the Terraces II and III have little chronological value and, moreover, no numerical dating is at the moment available, it is not possible to precisely constraint the ages of the various orders of terraces we have described above. Neverthless, the results of our investigation coupled with a carefull reinterpretation of the pre-existing data permit at least to refine the relative chronology of the events and the tectonic significance of the steeped profile of this tract of the Angolan coastal margin. The Terrace I appears to be a polycyclic surface whose erosional modelling extended from the NE to the SW following the gradual emersion of the Kwanza basin. As the stratigraphy of offshore wells demonstrates, during the Pliocene (and Early Pleistocene?) this continental surface extended towards SW far beyond the modern coastline. Subsequently, a phase of downfaulting caused a large, outer portion of the Surface to collapse under the ocean and a first, moderate wave of fluvial dissection to invade the emerged sector. After the genesis of the Terrace II along the newly defined coastline, an uplift of few tens of meters occurred which promoted a second, stronger phase of rivers entrenchment and drainage re-arrangement. By taking into account both the degree of preservation and the substantially uniform elevation of the 15-20 meters sea-level marks (Terrace III) along the whole Angolan coast, we are inclined to assign it to a late Quaternary high-stand, possibly to one or more peaks of the Oxygen Isotope Stage 5.

ADRIAN CIOACA

Geomorphological contributions to a natural reservation conservation programme

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According to local and country administration reports, there are nearly one thousand reservations in Romania. No state-of- equilibrium studies were previously made. Today, they appear to be in part degraded, hence the need for a complex geomorphological study of natural rehabilitation opportunities.
The relief, a major element in the perception of the landscape, undergoes quantity and quality alterations with consequences on all the components of the landscape. If the agregate of landforms affected by these alterations is rapidly changing in aspect, this fact is primarely the work of catastrophic geomorphological processes.
An inventory of the landforms in which nature reserves have been grouped by geo-type criteria (according to one or several dominant geomorphological processes) enable their classification in terms of the geomorphological hazard they are prone to. This also allows for conservation proposals to be put forward.

DARIUSZ CISZEWSKI

Influence of geomorphological factors on accumulation of heavy metals in polluted river channels

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The content of heavy metals in river bottom sediments was investigated in longitudinal and cross profiles of rivers

draining south-east part of the most industrialised area in Poland - Silesian Upland. The surveyed rivers: Biała Przemsza, Sztoła and Chechło, receive mine waters from the greatest lead and zinc mines in Poland, at Bukowno and Trzebinia. 2 m^3/s, 1.3 m^3/s and 0.5 m^3/s of mine waters, respectively, is dumped into these rivers, the amounts accounting for 50%, 99% and 60 % of their mean annual discharge.
Samples of the bottom sediments were taken at 11-18 sites along investigated river courses, at each site in three cross-sections situated in meander loops, pools and riffles (Chechło River) or in braided reaches (Sztoła River). Six grab samples were taken in characteristic points of cross-sections in the deepest points, channel bars, at the banks (below and above the water table) and on floodplain. Grain size distribution of the sediments was determined and the Zn, Cd, Pb, Ni, Cu, Mn, Fe and Ag concentrations in fractions < 1 mm and < 0.063 mm were analysed using flame AA spectroscopy. Additionally, the X-ray analysis of selected samples was performed.
The heavy metals present in a solid phase are basically associated with fine particles (especially < 0.063 mm) transported from mines. Accumulation of the material coming from mines changes both the concentration of heavy metals and the content of silt and clay fractions in bed sediments, so it is easy for identification in sand-bed channels.
Among factors controlling accumulation of heavy metals in the investigated channels the four are well seen; i.e. the density and size of transported particles, channel morphology, river flow amplitude and water stage.
On relatively short reaches immediately below outlet of mine waters, the highest concentrations of Zn, Cd, Pb and Ag in cross profiles occur in the deepest points of cross-sections and on channel bars, whereas the lowest ones at the banks. Observed regularity can be explained by the effect of mechanical sorting; light particles of dolomite being washed away by a strong current and dense particles of sphalerite and galena, leaving behind. These particles of heavy minerals are transported as a bed load. The reversed distribution occurs along reaches where heavy metals present in a solid phase are transported in suspension. There, the highest concentrations of heavy metals in fraction <1 mm occur at the banks below water table, in the frequently inundated parts of the floodplain and on the channel bars of the braided river reaches with low channel gradient. The accumulation of the fine particles, rich in pollutants, is facilitated by water plants (grass, moses) as in the overgrown sections resistance to flow increases and velocity decreases. The lowest concentrations in such reaches were found on channel bars, especially point bars. This is caused by the most intensive reworking and mixing of the polluted sediments with uncontaminated alluvia eroded from river bed and banks. Low concentrations in the deepest points of the channel are caused by strong currents washing fine, polluted particles out of the thalweg. Average concentrations of heavy metals in the sampled sediments were compared with the content of silt and clay fractions. The applied multidimensional scaling procedure allowed to estimate that nearly 2/3 of heavy metals are trapped in relatively narrow near-bank zone whereas only 1/3 in broad, active channel zone.
In the river with artificially lowered flow amplitude (as a Sztoła River having almost constant discharge) the amount of the strongly polluted suspended matter which accumulates in the channel, is much higher than in rivers with more natural regime, where fine sediments are flushed out downstream or become accumulated on the floodplain during high water stages. Moreover, during low water stages there is an evidence of highest concentrations of heavy metals in the deepest points of the channel, especially in pools, where the most polluted, fine material accumulates as a result of the slowing down of the current.

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Dunes and lakes at the Ceara State, north-east coast of Brazil: problems of recent dynamic

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The coastal zone of Ceara state, north-east of Brazil, extends on 577 km and long 3km along SE-NW to EW trends. It presents sub-humid climatic conditions with torrential rain system, but is very influenced by the semi-aridity of the continent, mainly in terms of fluvial drainage and sedimentological influx. The region is characterized by extensive sand beaches and by cliffs mainly eroded in the continental sediments of the Barreiras Formation. Large dunes field are developed along most parts of the coast. The south-east trade winds play an essential role in the present and recent coastal dynamic of the area, wich is complex in relationship with variations in the trends, the morphology of the coastline and the changes of morphogenetic systems in recent times.
In this coast, the typical foredunes are rare. The dunes are often well developped, being as high as 50-60 m. They are not only present along the coastline, but may also develop into the continent on 10 km or more. They are mainly mobile, the features of barkhanes or barkhanoides and derivate being the most frequent. Sometimes the barkhane fields interchange with parabolic dunes, wich indicates a situation of sand remobilisation during past and recent times.
Two phenomena are remarkable : (1) the presence of many types of small lakes or ponds in the middle of the dune fields or behind and (2) the marks of the sand migration printed in the ground, specially through capes or points where fields of barkhanes migrate from one side to the other.

In the first case, it is clear that the lakes are strongly associated with the dunes. Some of them are temporary and result of the seasonal oscillations of the water table, the depression being covered by the sands during the drougth periods. However other lakes are perennial, in response to particular geomorphological conditions (accentuated deflation action above the water table, natural damming of fluvial drainage), wich gives an important consequence: very often, the dunes stop their migration when in contact with the lakes and become fixed. This process occurs without the action of any others, such as climatic changes, sea level variations, etc.
The second case, related to the marks of the dune migration on the ground, is also associated with temporary lakes: along the way of the sand movement, successions of dunes, longitudinal streaks and humid depressions can be seen that materialize their migration. In some places, only the humid depressions are present, whereas the barkhane fields are found kilometers inland or have been swept away by wave action on the lee sides of the capes. It suggests that these dune systems were disconnected from the sediment source at some periods of the recent coastal evolution. The reasons for this possible interruption may be multiple:
– climatic changes in the coastal area, specially short-term variations from sub-humid to more arid conditions, related to recurrent periods of drought
– variations in the regime of trade wind and shore drift
– fluvial drainage variations in the continent and related variations in the sedimentary budget along the coast
– other alterations of the coastal dynamic system related to human activity.

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Cosmogenic Be-10 and Al-26 exposure ages and denudation rate estimates from Central Namibia: implications for landscape evolution in a passive margin setting

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The development of cosmogenic isotope analysis has provided a powerful, new technique for the estimation of exposure ages and denudation rates over time scales of up to several million years. The measurement of cosmogenic nuclide concentrations in surface rock samples can place quantitative constraints on rates of landscape change across a range of environments and over time scales intermediate between the short-term measurements obtained from modern surface process studies and the very long-term estimates based on techniques such as fission-track thermochronology.
The concentration of cosmogenic isotopes found in sufaces is dependent on a number of factors including isotope production rate, exposure geometry of the site to cosmic rays and the exposure history of the site. Exposure ages and erosion rates can be calculated using simple models of isotope accumulation and removal when these other factors are known or can be reasonable estimated. Since the information derived from in-situ bedrock samples is highly site specific, the technique is best applied in well constrained geomorphic settings.
Since continental rifting was initiated around 120 Ma B.P., the landscape of southwestern Africa has been subject to significant denudation. Estimates of depths of crustal section removed based on apatite fission-track thermochronology indicate that up to 4-5 km of post-rifting denudation has occurred along the coastal fringe, with lower depths of denudation further inland of around 2 km. The present day large-scale morphology of the area comprises an erosional escarpment separating a high interior plateau from a variably dissected coastal lowland. Drainage consists of relatively small coastal orientated systems oceanward of the escarpment, with larger, interior catchments draining to the Atlantic coast via the Orange river. Fission track data suggest some differential denudation across the escarpment and are broadly compatible with a model of landscape evolution involving a flexural isostatic response of the lithosphere to higher mean rates of post-rift denudation oceanward of the present escarpment compared to the interior.
Cosmogenic ^{10}Be and ^{26}Al analysis has been used to estimate rates of denudation at a range of selected sites in the escarpment zone and across the coastal lowlands in order to assess rates of landscape change under the hyper-arid to semi-arid climatic conditions of the past few million years. These rates are compared with the long-term estimates of denudation derived from fission track thermochronology in order to elucidate changes in the rate of landscape change since rifting and specifically the rate of escarpment retreat over the past 10^5-10^6 years.

ANA LUIZA COELHO NETTO

Catastrophic landscape evolution in humid environments: inheritances from tectonic, climatic and human induced changes in SE Brazil

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Humid environments comprise landscapes under permanent riverflow regimes, including areas with distinct geo-

biophysical and sociocultural conditions as a product of theil respective geological, climatic and human histories. Over time, enviromnental changes of a certain order of magnitude may shift the direction of landscape evolution leaving bellind degradation/aggradation cycles, sometimes at very intense rates or catastrophically. Therefore humid landscapes are expected to preserve at least some relict features from these cycles, specially on the hillslope morphology and stratigraphical records providing partial arguments for the reconstruction of landscape evolution over space and time. In this lecture I will address questions about the role played by such inherited geological-geomorphological features in controlling present-day processes that govem landscape evolution. Special attention will be driven toward the geomorphic responses to antropogenic enviromnental changes within an ecosytemic approach. Field arguments derive fiom researches conducted in SE Brazil, specially in the Paraiba do Sul rivel valley. Following the pleistocene savanna-like environment, this region was dominated by the tropical rainforest (called Mata Atlantica) throughout the Holocene despite minor climatic fluctuations toward to relative drier climatic conditions. Deforestation started in the mid-XVIIl century when coffee plantatiolls spread all over the region and remained until the end of the XIX century; then the region was domillated by cattle grazing. As pointed out in the previous work conducted by Meis and hel collaborators, based on detailed morpho-stratigraphic records, hillslope evolution followed a highly discontinuous evolutionary pattern: denudation was concentrated within the so-called rampa complexes (topographic hollows) being submitted to sucessive episodes of higll erosion-depositional rates in response to paleo-hydrological changes (Meis & Monteiro, 1979; Meis & Moura. 1984; etc.). In the last 20 years we have integrated morphological, stratigraphic and process studies arguments to support Meis's theoly and bring into view a mecanicist explanation of landscape evolution withill an ecossystemic approach. Emphasis has been given to a better understanding on erosion mechanisms and variablecontrols, focusing the geomorphic responses to recent environmental changes. Despite a complex geomorphic history of such Dunnean-Hortonian landscape, present-day processes reproduce the same mechanisms and routes from recent geological times (Late Quatemary at least); the evolutionary pattern have coupled episodicity and synchronization at both hillslope and fluvial degradation-aggradation cycles under high rates; the spatially nonuniforrn hillslope evolution is strongly controled by the underlying litho-structures (fractured, well-banded gneisses & granitoid rocks) derived from ancient times; the regional denudation is therefore governed by local slope retreat and relief inversions due to the destruction of watershed divides; therefore the remnants of older erosion surfaces are gentle inclined as the density of local process dynamic increases from the mountain compartment toward to the hilly lowlands and to the main regional collector, the Paraiba do Sul river.

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Geo-hydroecological responses to human induced changes in the mountainous atlantic rain forest of Rio de Janeiro: basis for land recuperation and erosion mitigation

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Nowadays, the Tropical Atlantic Rain Forest remnants is only 8% of what has been its former extension along the brazilian coast; in the city of Rio (23°S), despite the strong human interference since the european colonization times (mid-eighteen century), the forest cover still prevails mainly in the upper portion of the coastal mountain ranges; since 1992 it has been declared a Biosphere Reserve by Unesco. This forest ecossystem needs to be urgently recovered not only for its self-sustainment and biodiversity preservation but also to recover its hydrological and mechanical functions, specially to promote landslides mitigation on steep slopes. Given the importance of such ecossystem, in the last 20 years the Geoheco Research Program has been conducted field investigations in order to provide for a better understanding on the interactions among vegetation-fauna-soil-water under distinct hillslope morphology and geologic background, as a basis to explain erosion mechanisms and variable controls within a small drainage basin (3.5 km^2) under well preserved forest ecossystem (Experimental Station of Alto Rio Cachoeira, National Tijuca Park). More recently new questions were addressed to investigate both hydrological and erosive responses to man induced changes of such forest ecossystem, particularly due to a strong urban-industrial pressure from the surrounding lands. Both atmospheric (air pollution, fire-balloons, acid rain etc.) and terrestrian (roads, buildings, etc.) vectors are responsible for vegetation changes or removal in other portions of the mountain range. The heterogeneous, well-stratified native forest vegetation is now being substituted by a non-stratified shrub-like vegetation as the higher trees are disappearing, or changing to grasslands, specially in the northern hillslopes, which is submitted to higher insolation, lower environmental umidity, higher pollution and frequent fire. Infiltration capacity remains very high under such degraded forest, as much as under the dense grass cover; however, major changes occur within the soil profile: at one hand, the death of root systems (related to higher trees) tend to reduce water percolation deep into the soil, on the other hand, a dense root system near the surface provide saturated conditions, spe-

cially during intense rainfall periods, increasing the probability of triggering shallow landslides. In fact, during the extreme rains (400 mm/24 hours) of last summer (February/96), when landslides (rock debris avalanche type) have spread onto these steep slopes, 42.3% occurred under the degraded forest cover and 43.2% in grasslands. An extensive field survey around the 1996-landslides generation have shown that root systems have ambivalent hydrological and erosive functions: when alive, it favours infiltration and soil formation into the bedrock joint-network and hold the residual blocks, specially in homogeneous rock-lithology; when dead, it favours turbulent pipe flow generation and ceases its holding function, leaving unstable the residual blocks. It seems probable that block detachment was at least partially responsible for the initiation and propagation of the extensive rock debris avalanches, which were triggered in the very uppermost portion of the mountain, where a highly jointed granitic bedrock dominates. One cannot say that a well preserved forest cover would impede such catatrophic events, but certainly the prevailing degraded forest vegetation have increased the propagation effects, as indicated by some field evidences. Some of the 96-landslide events were recurrent from older landslide-scars, particularly from February 1988. The short time interval for such recurrence was mainly associated to forest degradation due to border effects around the previous scar. Therefore, we have started another investigation line searching for a methodology to recover the vegetation within landslide scars of different sizes and soil conditions: the main goal is to improve the vegetation growth and quality within the scar and its surrounds in order to get back (and faster) those elements which are relevant in controling hillslope hydrology as we found in the local, well-preserved forest ecossystem (litter cover, fauna activity, macropores in the A-Horizon and deep root systems) and, consequently, to promote the mitigation of hillslope erosion (with deep root systems anchored within cohesive materials) on steep slopes. In the last two years we started to monitore the vegetation succession by spontaneous and induced processes, within a few landslide scars together with measurements of both hydrological and erosive responses to rainfall inputs. Field data will be presented and discussed during the meeting.

ANTONIO C. COLANGELO & OLGA CRUZ

Spatial magnitude-frequency index of mass movement event deposits in an humid tropical precambrian plateau, and its connection with MFI of daily rainfall: according to Ahnert's approach

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Rapid mass movement processes are discontinuous events, of varying spacial magnitude and frequency, which deposits may be mapped. In this way it's possible to apply the Ahnert's (1987) approach wich respect to this kind of events, slump in particular. In humid tropical relief sistems, mass movements is not only the result of breakdown in strength parameters, its play too an important geoecologic role: scars offers an opening to the sun light, scarce under the forest canopy and is a renewer factor to the soil minerals; «colluvium» deposits constitute a special ambient with thick soils rich in organic mather and water. Cruz (1974), De'Ploey & *alii*, (1978) and De'Ploey & Cruz (1979) already presented mass movement as integrated part of dinamics of slope evolution: thick weather materials, high temperatures and rainfall. It explains the mapping of 750 slump deposits (Holocene) in 150 km^2 area ($5/km^2$), at São Luis do Paraitinga, in the «Planalto Atlantico», São Paulo State. Nine kinds of other deposits are identified and mapped (total 1900 unities). This paper focuses slump unities deposits because it's the more representative process and for the ease identification and delimitation in airphotos Colangelo (1995).

The Ahnert's (1987)semilogarithmic approach was applied directly in the slump unities deposits mapped in the airphotos and transfered to the topografic maps (1:10.000 scale). In this way, the magnitude-frequency index refers to the spacial recurrence interval or frequency (deposits unities/km^2) for deposits of varying magnitudes. The results are: $A\ (m^2) = 1.667 + 1.667.\ \log RI$, for migmatites with very steep slopes, and $A(m^2) = 3.000 + 5125.\ \log RI$, for basement with terciary sediments, with more smooth relief (moderate gradients): A is the deposit area magnitude (in square meters) and RI is the spacial recurrence interval of the unity deposit of determined magnitude. The daily rainfall analisis of two years data, at Paraibuna station (source of data: Cesp), in the proximity of the study area (10 km), present the regression equation: P_{24} (mm) = 62 + 36,3.logRIy, Mfi (62.0; 36.3), $P_{24} > 15$ mm. These results suggest, apart from the constraint strutural lito-tectonic factors, that there is a relationship between magnitude-frequency index of rainfall and spacial magnitude-frequency index of specific process deposit unities: slumps, for exemple. The map exibits the spatial arrangement for this kind of process, and it's possible to evaluate the total surface represented, unity for unity in the space, which may be combined with magnitude-frequency index of rainfall and hidraulic conductivity (K) for establising the relationship above in terms of thresholds of magnitude-frequency, and quantify the prodution of mobilized material.

In these terms it is possible discuss some results with respect to evaluation and mapping the hazard areas. Both laboratorial and field tests are very important in this approach. In the field, apparent cohesion and apparent angle of internal friction are recorded by means of the soil shear-graph apparatus. Combining this results with analysis of magnitude and frequency, it is possible to evaluate the production of surface of rupture, and correlated deposits, in the space and time, in a determined range of scales.

ANDREW J.C. COLLISON

Simulating the development of preferential flow paths and gully head collapse using plastic deformation-hydrology-stability modelling

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Much research has highlighted the importance of preferential flow processes in the development of gullies by head-collapses. In addition to piping, recent studies have shown how preferential flow can be caused by water accumulation in tension cracks. This paper investigates marl gullies in South East Spain using a combined hydrology-slope stability model to demonstrate how water flow in tension cracks can trigger head-collapse, and a finite element deformation model to show how such cracks can develop in new gully heads by the processes of plastic deformation. The results suggest that slope undercutting leads the marl to deform plastically, introducing tension cracks. These are then exploited as preferential flow paths by overland flow and throughflow, resulting in the development of positive pressures at the gully head. These reduce gully head stability by two processes. Firstly, loss off suction at the gully head can initiate failure by slumping or toppling. Secondly, throughflow velocities are raised by an order of magnitude, favouring the development of suffosion and piping. This composite model pulls together many hitherto neglected processes in gully head development and provides an alternative mechanism to the conventional view of head retreat by runoff and erosion.

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Managing climate change impacts on landsliding - using a combined hydrology-stability model to assess the relative sensitivity of a landslide to climatic versus landuse change in South East England

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Much recent research has focused on the sensitivity of landslides to changes in climate associated with global warming. Climate change predictions for the SE of England suggest that whilst mean rainfall will persist at current levels, the distribution will be more uneven than at present, resulting in more landslide activity. However, these climatic changes have to be considered in the context of widespread changes in European landuse associated with set-aside and re-afforestation. This paper uses a combined hydrology and stability model to evaluate the relative significance of climate change predicted from downscaled Gcm outputs, compared with changes in hydrological regime associated with landuse shifts for a landslide complex in SE England. The results suggest that whilst climate change has the potential to increase landslide activity, this trend is relatively insignificant when compared with changes in available moisture due to vegetation cover conversion and agricultural drainage. The results highlight the scope for managing landslides by changing landuse, and offer a potential methodology for assessing alternative landslide management strategies.

MAURO COLTORTI

Superimposition, river captures and the Plio-Pleistocene evolution of the Umbria-Marche area (Central Italy)

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A «planation surface» preserved on the Apennine ridge constitutes the starting point for the evolution of the drainage network in Central Italy. Its modelling has been associated to the subaereal erosion which occurred after the Messinian and possibly until the Lower Pliocene transgression. In the Middle Pliocene, and possibly until Upper Pliocene-Lower Pleistocene, a downwarping movement affected the Tiber as well as the Periadriatic areas which became basins while upwarping affected the Umbria-Marche and the Amelia Ridges. The Umbria-Marche Ridge was delimitated, to the east, by the Sibillini-Urbino thrust front and, to the west, by a flexure located in correspondence to the actual graben of the East Tiber valley. Many wide valleys were formed after the emersion and followed E-W Jurassic fractures which were locally reactivated during the thrusting. There were also Apennine valleys originated from the selective erosion of the softer Oligo-Miocene terrains which separate a thrust sheet from another. Until the Lower Pleistocene, a low energy landscape evolved with large valleys which were separated by hills with many planated remnants still preserved on their top and a not very well recognizeable watershed. The eastern side of the depressions were fed by alluvial fan and fan deltas. In fact, geomorphic evidence testifies that the main thrust front (i.e. Sibillini, Martani, etc) were locally reactivated by reverse faults. Both basins sunk well below sea level. The Peri-Adriatic basin was filled with marine deposits, while the Tiber Basin, separated from the sea by the Amelia Mountains, underwent fluvial, fluvio-lacustrine and alluvial fan sedimentation.

At the end of the Lower Pleistocene the uplifting became more generalized and affected the whole of Central Italy, although higher values were concentrated along the chain axe. The downcutting rates increased and were locally

higher along the softer terrains, oriented NNW-SSE and N-S, leading to the activation of many river captures. Almost at the same time, together with increased uplift, extensional tectonics reached the western side of the chain as well as the East Tiber valley creating huge grabens of which Gubbio, Gualdotadino, Spoleto-Foligno, Colfiorito, Castelluccio di Norcia, Norcia, Cascia etc. constitute some of the best examples. The activation of NE-SW faults can also be associated to this phase.
The activation of the tectonic depressions, frequently bounded by NNW-SSE and NE-SW faults, locally reoriented the previous drainage systems. In the Norcia basin, a NE-SW fault diverted N-S rivers to the west. The Paglia, which previously crossed the Martani Mts, was captured by the Teverone. The upper Gubbio basin, also oriented NS, was captured to the west by the Saonda. In the Colfiorito area, many eastward rivers were blocked by extentional faults and lacustrine deposition was established at 1,1 my. In this area the Chienti River continued to drain to the east but many parts of the basin were captured to the west. In the Periadriatic basin, only a few superimposed rivers continued to cross the limestone ridges, such as the Cesano (crossing the Monti delle Cesana), the Musone (crossing the Cingoli Ridge) and the Salinello (crossing the Montagna dei Fiori). Many other captures are documented and represent, to the east as well as to the west of the chain, one of the most important mechanism in the evolution of the drainage network in the area.

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Geomorphic and neotectonic evolution of the Ecuadorian Andes

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All writers on the Ecuadorian Andes recognize an East Cordillera, a West Cordillera and an Interandean Depression. They usually fail to write that the East and West Cordilleras are plateau, i.e. planation surfaces, and that there is an accumulation plateau in the Interandean Depression.
We recognize a planation surface all along the Andean Cordillera. There was originally a single surface, and it was planated to base level, the Pacific sea level. It cuts folded and faulted rocks from Precambrian to Late Miocene-Early Pliocene age. In places it is covered by Early Pliocene volcanic flows, ignimbrites and pyroclastites that form a volcanic plateau. The volcanics possibly represent the first extension associated with the beginning of uplift. The planation surface was modelled during the Early Pliocene age followed immediately by uplifting.
The tectonic depression that today separate the E from the W Cordillera did not exist at that time or it would have been filled with volcanic products. Uplift of many hundreds meters followed. Strato volcanoes began to erupt about 1,8-1,5 my ago and many are still active today. The accumulation plateau consists of conglomerates, sands, agglomerates, lava-flows and lahar deposits. In places it is deeply weathered by tropical soils and it is usually dissected by river erosion up to 800 m, in others it is buried under younger alluvial and volcanic deposits.
Folds and faults in the accumulation plateau result from gravity tectonics. The sediments affected by huge landslides up to 700 m thick.
The planation surface, preserved in the Cordillera at elevation of 3,000-4,000 m, indicates an uplifting rate of about 1000 B (metres/million years). Thrust faults toward the Costa in the West and toward the Amazonia in the east suggest spreading of the uplifted Andean Plateau and spreading may have created the extensional Inter-Andean depression.
The model of vertical uplifting of a planation surface, proposed here for the Ecuadorian Andes, may be extended to the rest of the Andean Chain.

LYLIAN COLTRINARI

Karstic-type forms and landscape evolution in Taubaté Basin (São Paulo, Brazil)

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Morphological mapping of São José dos Campos plateau includes in its SW extremity land forms with wide level interfluves (700-750 m) that become lower and more dissected (600-650 m) towards Caçapava at the NE end. Depressions and amphitheatre-like valley-heads on hilltops and interfluves, and flat valley bottoms with or without underfit streams are characteristic features in this section of Taubaté basin. Gradient is low (0 - 3°) and deep oxisols cover the area.
Interpretation of aerial photographs surveyed probably at the beginning of the '40 before the new Rio de Janeiro - São Paulo Highway opening allowed the detection of the quasi-original surface features in the area and comparison with present-day forms. The choice of a morphological legend was deliberate to avoid or at least to diminish the genetic bias in current geomorphological maps.
Differences in shape, size and distribution of depressions appear between the higher and the lower sectors under research. Between Jacarei and the Porangaba river depressions appear isolated or at the valley heads and drainage density is low. In the NE section sluggish streams move through extensive swampy areas, depressions are bigger and more numerous and may be isolated or arranged in different patterns. They may be flooded or present swampy bottoms permanently or seasonally.

Depressions and similar features in the sample area were described previously as forms of geochemical origin but only recently they have been studied in detail. As in other humid tropical areas these karstic-like forms evolve by vertical exportation of soluble material from the base favoured by lithological or tectonic discontinuities. More detailed research is needed yet dominance of geochemical evolution of landforms in southeastern Brazil must be accepted and a landscape evolution model homologous to etchplains evolution should be adopted.

ARTHUR J. CONACHER

Geomorphology and EIA in relation to agriculture

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Dryland agricultural practices set in train a very complex array of direct and indirect effects on the environment. Many of these effects take place in the soil or affect the soil, with the driving processes being pedological, hydrological and geomorphic in nature.

Clearing of pre-existing vegetation in order to plant crops or pasture affects the way in which rainfall reaches the soil surface, by modifying interception, canopy drip (throughfall), stemflow, storage in the biomass, drop impact, and evapotranspiration. Pedo-geomorphic processes of rainwash (rainsplash plus overland flow), infiltration and throughflow, and the translocation of soil materials by those processes and mass movements, are also influenced by vegetative changes as well as by the range of Dryland agricultural practices: including ploughing and seedbed preparation, weeding, seeding, fertilising, spraying and harvesting; and soil disturbances caused by the movements and grazing activities of stock.

Secondary salinisation of soils and water in Australia is one of the environmental consequences of dryland agricultural practices, and the mechanisms which are responsible for the problem show the need for an appreciation of both geomorphology and hydrology. Intensely and deeply weathered soils, deep and shallow aquifers, overland flow and streamflow are crucial, and are illustrated by data from the Western Australian wheatbelt. Geomorphology is relevant both for understanding the processes and for correctly 'reading' landscapes in order to predict the future occurrence of secondary salinity. In this latter context, landscape interpretation is being assisted by remote sensing, both in the traditional imaging sense and by the use of airborne sensors to measure electrical conductivity and magnetic anomalies, often in association with Gis.

There are several implications of this work in relation to environmental impact assessment. The implications include the inadequacy of most current Eia methodologies in the agricultural context for accurately identifying and understanding processes. The environmental impact matrix and its numerous derivatives, for example, are particularly inappropriate. Secondary salinisation in dryland agricultural areas, as is undoubtedly true for most environmental impacts of agricultural practices, is not a simple cause-effect situation.

A further implication concerns management. Accurate identification and quantification of processes is essential if effective remedial works are to be developed. Again with reference to the secondary salinity problem, for many years the standard remedial measure recommended to farmers was to fence off the affected area (in order to control grazing by stock) and to establish salt-tolerant vegetation. Whilst this approach may improve the aesthetics of the site, reduce erosion by water and wind, and provide at best some fodder for carefully controlled light grazing, it does not and cannot deal with the causes of the problem. These occur in the catchments of the salt-affected areas, connected to the latter by hydro-geomorphic processes, and influenced by land-use practices. Thus it is in the catchments that the processes must be manipulated by modifying land-use practices in order to rehabilitate the salt-affected areas. Manipulation takes place by essentially engineering-type approaches as well as by agronomic measures, both designed to control water movements on the slopes. Transpiration, deep infiltration, throughflow and overland flow are the main water movements targeted. In turn, if manipulation is successful, the depth of groundwater tables from the soil surface in salt-affected areas is increased, the translocation of saline water to the surface by capillarity and suction reduced, the accumulation of soluble salts in the root zone prevented, and leaching of the soil by fresh rainwater in the same zone enhanced, resulting in complete rehabilitation.

CARMELO CONESA-GARCÍA, FRANCISCO LÓPEZ-BERMÚDEZ, FRANCISCO ALONSO-SARRÍA & YOLANDA ALVAREZ-ROGEL

Hydraulic and morphological effects of the derivation Tagus-Segura Works on the ephemeral channels in the Rambla Salada Basin (South-East Spain)

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The Rambla Salada basin (131,6 kms^2), situated in the semi-arid zone of South-East Spain, is drained by a system of ephemeral channels with a torrential regime, part of which have already suffered the initial effects of the engineering works being carried out in connection with the 'Right Canal of the Tagus-Segura Aqueduct'. The building of the infrastructure was started as recently as 1979, and it is of great socio-economical importance for the agricultural areas of the South-East of Spain. In this work the changes brought about by the related structures (bridges, pipe-lines

and dams) are analysed in relation to the hydrodinamic characteristics of the flow, the hydraulic geometry of the channel and its bed-forms. Special attention is given to the calculation of local erosion of the bed by turbulence around the bridge piers and downstream from the dikes or dams, along with the evaluation of the sediment retention rates of the latter and their rapid loss of efficiency.
Scour at bridges is studied taking into account the approach stream velocity and depth, the pier size, shape and orientation relative to the flow, natural variation of bed elevation as sand dunes pass and the local adjustments of bedforms upstream and downstream from the piers. Downstream from the dams different morphological changes are analysed: a reduction of channel capacity, depositional berms within the old cross-sections and a local scour advance.

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Geomorphology of the NE slope of Mt. Etna (Sicily, Italy): evidence of Late Pleistocene glaciers

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The evolution of Mount Etna over the last 15.000 years and particularly the formation of the deep and extensive erosion depression of Valle del Bove (valley), has left several parts of the volcano isolated and no longer covered by the lava from the summit craters. Therefore, in these areas, it is possible to find early volcanic products, belonging to eruption centers preceding the Recent Etna* (15 Ka - Present-day), and which have been eroded and altered to varying degrees by morphogenetic agents.
A large sector with these exposure characteristics is found on the high northeast flank of Mt. Etna, in the area between Piano delle Concazze and Serracozzo. The present topographic surface in that area, has essentially preserved relict landforms of ages of over 15.000 years and which developed on volcanic products belonging to the eruption center of the Ellittico (34 Ka-15 Ka).
The geomorphological survey conducted in this sector of the volcano made it possible to gather detailed information on both landforms associated with effusive magmatic processes and other landforms more typically associated with exogenous morphogenetic processes. The data thus collected are useful for a reconstruction of the history of the evolution of Mt. Etna starting from the Pleistocene and serve also as a starting-point for an understanding of the evolution of the climate in the Mediterranean during the Quaternary.
Among the landforms that are most characteristic of this old flank of the Ellittico, the rounded edges of the caldera, lava flows that are frequently stripped of the scoriaceous portion and a relict drainage network composed of deep barrancos and rock beds with erosion potholes and smoothing. These landforms unmistakably suggest that the morphological and climatic conditions of the past differed significantly from present-day conditions and were probably characterized by heavier precipitation, including snow.
To account for the presence of these landforms, the authors also took the following hypothesis into consideration. During the last glacial maximum (25 Ka - 15 Ka), there may have been extensive glacierets or actual glaciers in the higher sectors of Mt. Etna, which reached altitudes of 3600-3700 a s.l. with the Ellittico.
This continues to be one of the most probable hypotheses, although no evidence was found that could considered as being of unquestionable glacial origin such as end moraines, roches moutonnées or striated pavements.

MIHAELA CONSTANTIN

Some considerations concerning to geomorphological hazards in Panatau Region (Buzau Subcarpathians)

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The Romanian Subcarpathians are recognized as being one of the regions in Europe most affected by intense geomorphological hazards. It is the youngest orogenic unit in Romania (built of folded and faulted Neogene molasse deposits) associated with Mio-Pliocene tectonic activity which continued into Quaternary. The seismicity of the region coincides with a continental climate that gives torrential precipitation and a land use which has large produced much recent deforestation areas. The results is large areas affected by intense erosion processes and landslides.
The Panatau region is situated in the southern part of Blidisel hill (Buzau Subcarpathians) and is developed on molasse deposits (sandstone, sands, marls and clays), who belongs to Calvini-Soimari syncline. The studied region is affected by intense mass movement and gully erosion.
Correlating the geomorphological map with the main hazards triggering factors (i.e. geological factor, heavy rainfalls and social-economical factors), the geomorphological risk map could be worked out.

ANDREA CORONATO

Late-Pleistocene alpine-type glacierization in the Fuegian Andes, Argentina (lat 54°)

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The Fuegian Andes range extend a in W-E direction, as a consequence of the subduction of the Pacific Plate underneath the South American Plate. The maximum altitudes vary from the 2500 m a.s.l. in the Cordillera Darwin (Chile, long. 70° O) to 700 m a.s.l. in Staten Island (Argentina, long. 64°). In the studied valleys, the summits do not surpass the 1200 m a.s.l. elevation.
Bedrock lithology corresponds, from west to east, to a granitic nucleus, Jurassic acid volcanic rocks and Paleozoic and Cretaceous methamorphic rocks. The present landscape shows a glacial modelling which took place during the Last Glacial Maximum (18-20 ka B.P., Late Pleistocene), when a mountain glacierization covered the pre-existing relief.
A net of outlet glaciers coming from an ice-mountain cap filled the entire valley systems, with an equilibrium line altitude of ca. 300 m a.s.l. The glacier network was also formed by smaller, high-altitude valley glaciers coming from lateral cirques which joined the local valley-glacier collector. This glacier joined then the regional glacier collector, the Beagle Glacier (200 km long, 10 km wide, 2 km thick). Erosional glacial features are dominant such as aretes, horns, cols, truncated spurs, cirques, hanging-valleys, troughs and rock-basins. The glacial depositional system is composed of marginal and frontal moraines developed between 300-150 m a.s.l. and glaciolacustrine plains, many of them occupied by peat-bogs.
The confluence areas between the minor high valley glaciers and the valley-glacier collector show erosive features as hanging valleys and truncated rocky-walls; on the other hand, between the valley glacier collector and the regional one, glaciolacustrine terraces, ground moraines, frontal moraines and kame-terraces are developed.
The stratigraphic correlation of the higher valleys drift-units with those defined for the regional glacier collector indicates that the ice-recession would have started during the beginnings of the Late Glacial (16-14 ka B.P.). Between 12-10 ka B.P., the equilibrium line altitude would have ascended to 600 m a.s.l. allowing the depositation of the morainic systems. The general ice retreat of these valley glaciers would have taken place between 10-9 ka B.P, giving rise to glaciolacustrine environments. Presently, the ice presence is restricted to small cirque glaciers and snow patches in the cirques (750-1350 m a.s.l.) with an equilibrium line altitude of ca. 1000 m a.s.l.

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Geomorphological investigations and management of the Corvara landslide (Dolomites, Italy)

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Geomorphological investigations aiming at the recognition, characterisation and management of mass movements have been recently carried out in the area of Corvara in Badia (Dolomites) within the framework of the Newtech Project, funded by the Environment & Climate Programme of the European Union.
The area studied, where tourism activities and infrastructures are highly developed, has been affected by several landslides since the retreat of the glaciers of the last glacial maximum and is at present still endangered by active movements which affect roads, houses and ski pistes.
In particular, the investigations have been focused on the Corvara landslide, the largest (3 km^2) and most hazardous mass movement in the area considered. It is a deep-seated complex landslide (slump-earth flow) located south-east of the Corvara village which involves the Pralongià relief (2088 m a.s.l.); the movement affects the pelitic rocks of the S. Cassiano Formation (Lower Carnian) and La Valle Formation (Upper Ladinic) which are particularly prone to landsliding owing to their ductile behaviour.
Detailed geomorphological survey and analyses of aerial photographs of different periods enabled the distinction of several units within the landslide body, this was mainly carried out on the basis of the degree of activity and frequency. The most active sector of the landslide is the source area where retrogressive slides and flows show either continuous or seasonal mobilisation. On the contrary, the accumulation area, which stretches as far as the southern edge of the Corvara village, shows minor longitudinal displacements but considerable lateral reactivations due to the erosion caused by two streams which flank the landslide on each side. The latter are responsible for heavy and repeated damage to the national road n. 244. It is likely that this lateral erosion prevents more intense longitudinal displacements since a condition of equilibrium is determined between the material deriving from the source area and that carried away by the water courses.
The drillings carried out up to now have reached the depth of 40 m without finding any continuous shear surface in the accumulation area. Therefore, on the basis of the data so far gathered and in order to detect the main failure surface, new drillings have been planned together with the installation of a monitoring system. This will enable a better understanding of the geometry and kinematics of the landslide and will lead to a correct assessment and management of the landslide-induced risk suffered by the village of Corvara in Badia.

GIAN CAMILLO CORTEMIGLIA

Méthodologie pour une évaluation expéditive des caractères morphodynamiques des plages italiennes

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La détermination de l'état morphodynamique d'une plage requérit la connaissance non seulement des caractères morphologiques et texturales, mais surtout des caractéristiques ondamètriques au brisant. La réalisation et l'établisse-

ment gestionnaire des indispensables outillages d'enregistrement et de rassemblement des données ondamètriques entraînement non seulement des engagements de personnel et économiques de plus en plus onéreux, mais surtout demandent d'engager un convenable intervalle temporel pour acquérir les données.
Afin donc de gagner du temps on a prévoit une méthode rapide de calcul pour n'importe quelle plage italienne des valeurs ondamètriques au brisant en utilisant les cartes isobares bijournalieres (12 Utc e Oo Utc) du Deutscher Wetterdienst relatives au Méditerranée. On a fait la digitalisation des ces cartes pour la periode 1984-1995 rapportant les isobares à un réseau avec des mailles de 120 km de côté, dont les sommets présentent coordonnées géographiques connues. Dans ces sommets on a déterminé pour chaque carte le gradient de pression et le vent géostrophique dont on a obtenu le vent (direction, vitesse, durée) à la surface de la mer.
Avec un procédé mathématique de B-Spline methods en appliquant les curves et surfaces de Bézier on a pu, pour chaque carte, déterminer les relatives spline functions. C'est aussi qu'on peut alors déterminer, pour n'importe quel point de la surface marine, les précités paramètres du vent.
Pour une plage choisi on peut aussi calculer, dans un point prédestiné en haute mer, les caractéristiques du vent à la surface (direction, vitesse, durée) et donc, avec les coordonnées azimutales des différents secteurs et la longueur des fetches, le relatif climat houleux. Avec la connaissance de ces caractères ondamètriques en haute mer de la plage, on a réalisé un programme pour déterminer, dans la zone de brisant de la même plage, l'hauteur et la periode de la houle d'ou en conséquence la détermination des paramètres morphodynamiques surf scaling de Guza & Inman (1975) et environment parameter de Dalrymple & Thompson (1977).
L'application de cette méthode à quelque exemple des plages italiennes fournit des bons résultats sur leur état morphodynamique.

MICHAEL CROZIER & THOMAS GLADE

Magnitude and frequency of landslide events in New Zealand

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Landslide activity in New Zealand constitutes a significant natural hazard and an important geomorphological process. Questions of frequency and magnitude of events are therefore fundamental for social and economic planning as well as understanding landforming processes.
Magnitude of landslide events can be represented by measures of mass, volume (eg; total volume displaced per event), or measures of degree-of-presence (eg: number of landslides per unit area, or area affected). Frequency can be represented temporally by mean return periods for events and spatially by density (number of landslides per unit area). Temporal frequency can be determined either form the actual landslide record or by establishing the landsliding threshold of the triggering agent and determining the probability of occurrence of the threshold value. Thresholds are most usefully defined in terms of a given magnitude of sliding but in most cases there is insufficient information available to represent magnitude. Thus, reported thresholds and frequency may refer simply to event occurrence (without any reference to their magnitude), or to specific magnitudes of landsliding.
Because of the variability of inherent and triggering stability conditions, thresholds established from the triggering agent tend to be represented by a band of probable triggering values, rather than a definitive envelope. In this case, it has become practice to recognise a minimum triggering threshold below which no landsliding occurs and a maximum threshold above which all triggering values produce landslides, separated by a band of increasing probability of occurrence towards the maximum threshold.
Observations indicate that, even over the period of a few years, threshold values may shift in value, particularly in areas subject to recurring landslide events.
Magnitude/frequency analysis may also be applied spatially to the population of landslides occurring in one event. Concepts of geomorphic work and geomorphic effectiveness of landsliding events may also be approached through magnitude/frequency analysis. Calculation of the transient form ratio (recurrence interval/relaxation time) enables an assessment of the persistence of landslide impact and the identification of landsliding as a major terrain forming process in parts of New Zealand.

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Holocene evolution of a fluvial valley in the crystalline mountain: the Dore valley in the French Massif Central. First results

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The purpose of our research is to describe and explain the holocene evolution of the Dore valley. We have begun to reconstruct 8000 years of interaction beetween people and nature as part of paleo-environemental approach which appeal to geomorphological, archaeological, historical and palynological data. This paper summarises the first results of our investigations.
The Dore is a meandering river of the French Massif Central. The catchment (1716 km^2) is 80% in granites and metamorphic rocks and only 20% in Cainozoic sedimentary rocks (argillaceous and sandy rocks). These are the lowlands (<600m) of the Arlanc and Limagne plains where the studied valley sections are located.

The Arlanc plain area of 100 km^2 is in the upper catchment. Research has shown the diversity of the geomorphological evolution in the floodplain for 2000 years:
– stability of channel and floodplain in the downstream part of the valley;
– important instability in the upstream section.
Moreover, by means of deep soundings in the stream deposits along the river, it was possible to obtain ^{14}C datings which put forward geomorphological changes during the first part of Holocene period.
In Limagne the Dore flows away the north. We were specially interested in the right bank. The left bank topography had been recently modified by man.
In the right bank the alluvial plain is narrow (from 250 to 500 m). Farther to the east lies quaternary alluvial terraces and sedimentary piedmont at the foot of crystalline mountain. This part of valley is characterized by a lot of colluvial fans located at the boundary between alluvial terraces and the actual floodplain.
Indeed, the drainage network had largely dissected terraces and sedimentary piedmont, creating steep slopes. Many of these slopes had been deeply incised with valley-bottom gullies. Downstream of gullies colluvial fans spread on the alluvial plains of the Dore and its tributaries. Moreover some fans had been gullied. Therefore we have identified two generations of colluvial deposits.
The combination of geomorphological analysis, historical research and ^{14}C datings gave some precisions about the setting of these landforms. On the one hand, superior fans were created from at least 8000 ^{14}C years BP. Usually, deposits show fine-grained and silt load which indicates a relationship between these accumulations and land use changes.
On the other hand, inferior fans recover the old channel of the Dore which is drawn on the historical plans and cadastre. Fans were probably constructed during the 17th and 18th c., a period of intensive farming activities.

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Gypsum degradation in the Mediterranean area with respect to climatic, textural and erosional conditions

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Many are the experimental studies performed on the meteoric degradation of carbonate outcrops (Cucchi & *alii,* 1996; Trudgill 1977), but until now no one on the same phenomenon on gypsum.
The lowering of the gypsum surfaces was measured using the micro-erosion-meter (Trudgyll 1977): this method was proved to be far more suitable than the tablets one (Calaforra & *alii,* 1993), the systematic errors being limited to less than 0.05 mm.
In the last 8 years over 4000 data have been collected in 35 sites of Italy and Spain, selected for their different climatic and morphologic conditions in the range between the 47 and the 36 parallel. The study was related to over 20 gypsum lithotypes different in petrography, texture and cronostratigraphy.
Rainfalls ranged from 1500 to less than 150 mm/yr. and the observed lowering from 3 to 0.05 mm/yr. The wide degradation range reflects the dramatically different environmental conditions in each of the experimental spot. Anyway it was possible to detect the fundamental role of the water flow regimen in gypsum degradation, which is significant only with turbulent flow.
The mean degradation value for the whole area resulted of 0.78 mm/1000 mm of rain, which means an average 0.65-0.70 mm/yr. in the Mediterranean region. This relatively high value is the first experimental proof that the karst cycle in gypsum is always extremely young, no outcrop of this rock surviving more than a few hundred thousands years.

ELZBIETA CZYZOWSKA

Flood events recorded in the alluvial fan sequences

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The detailed reconstruction of transportation and deposition in the very unstable environment of the alluvial fan is very difficult.
On the base of the detailed sedimentological analyses of the present and fossil fan sediments, we can separate several sequences of layers recording the single flood events.
The sequences built from several layers (from three to five, six) showing pensimetric grain size is rarest. The middle, coarsest layer is record of the highest discharge. Underlying layers record the rising water level (coarsening of sediment). Overlaying layers showing finer sediments towards the top are the record of the falling water level.
The sequences built from two or three (sometimes - four) layers showing finer sediment towards the top are more frequent. These layers reflect only late phase of the flood event. The sediment sequences of the rising water lever phase is missing, these is the erosion phase.
Third and most frequent sequences formed during single flood events is built from one or two layers which does not show grading changes. This record represents only end of falling water lever or highest discharge. Discontinuity of the record of the falling water level may be due to increase of erosion or shift of the water course.
The flood deposition in the alluvial fan surface takes a space variability course which is conditioned by varying fan alluvial relief and alternate occurrence of the erosion and deposition phases during the same flood event. The course of the flood wave should be also taken into consideration.

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Recent evolution of the beaches of Calabria (Italy)

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Calabria is one of the Italian regions with the longest coasts. The region extends between the Tyrrhenian Sea (West) and the Ionian Sea (East) and its coastline has a length of about 700 km. Long term studies on this region gave a complete and unitary picture of the recent variations which have occurred in its shoreline in the past century and, above all, in the past 40 years.
This study, which was expected to define both natural and anthropic causes of these variations, relied on analysis of historical records, as well as on geomorphological, pluviometric and anemological enquiries. Geomorphological surveys were carried out on the coastline and on its tributary catchment basins, to identify active morphogenetic processes and namely those which influence the entity of solid supply to sea. In the lack of field measurements, information on solid load supplied to the beach by streams were obtained indirectly by processing precipitation data collected all over the region. Failing adequate data on wave-climate, resort was made to anemological studies to determine sea-climate conditions of the shore.
Shoreline variations were investigated on the basis of available maps and aerial photographs, which made it possible to reconstruct its history starting from 1850. This study showed that, over time, Tyrrhenian beaches have been the first to undergo a strong erosional crisis, with the loss of about 3,300,000 m^2 from the mid-1950s to the end of the 1970s. In the past decade, this coastline has reached relative stability: some of its sites have experienced minor replenishment processes, but its deltaic cusps have continued to be subject to severe erosion. Ionian beaches have been stable from 1954 to 1978, except for some deltaic cusps where marked erosion processes have been recorded; however, in the past decade a widespread and significant erosion process has taken place, which has decreased the surface area of these beaches by about 4,000,000 m^2.
The different evolution of Tyrrhenian and Ionian beaches may be ascribed to their different configuration. Tyrrhenian beaches are thin strips extending at the foot of steep slopes, whose watershed is shifted towards the Tyrrhenian Sea, involving considerable dissimmetry between the Tyrrhenian side and the Ionian one. Consequently, Tyrrhenian streams are short and their catchment basins are small. Conversely, wider beaches are found at the foot of the Ionian side, with gentler and longer slopes, especially in its northern portion. These beaches are supplied by streams with large catchment basins, featured by frequent outcrops of highly erodable lithologies. Furthermore, the two coastal areas also have differently shaped seabeds: along the Tyrrhenian Sea, the bottom is steeper and the abrasion platform is narrower than along the Ionian Sea. These differences infer that Tyrrhenian coasts are more vulnerable and thus were the first to undergo erosion.
The erosional crisis may have been triggered, at least in part, by climate. Anemological studies have indicated a sharp increase in wind speed and frequency and the radical drop in calms from 1954 to 1978. However, the sensitive equilibrium of beaches may have been disrupted also by human activities, i.e. flood-control measures in drainage basins, quarrying from the fluvial beds and directly from the beaches. After the 1950s, fast and sizeable urban development works have markedly destroyed the natural configuration of the beaches and of their backshore.
In the past decade, Tyrrhenian beaches have apparently reached some equilibrium, without recovering the width that they had prior to the 1950s. Unquestionably, this precarious equilibrium is due in part to the protective structures (started in the 1970s) and in part to suspension or reduction in mining from beaches and fluvial beds. Ionian beaches underwent erosion more than 20 years after Tyrrhenian ones. Their short period of stability may be justified by the supply of solid load from very large catchment basins and by limited urban development of coastline. Nevertheless, the erosion process which had previously involved Tyrrhenian coasts has also appeared on Ionian ones in the past decade. This process has occurred concurrently with a decrease of precipitations, which may have played a significant role in the evolution of the beaches of Calabria.

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Hypsometric analysis in the study of Italian drainage basin morphoevolution

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The plano-altimetric configuration of drainage basins is expressible, as it is known, through the hypsometric curves; many recent studie have shown that the interpretation of such curves can differs deeply as a consequence of the structural setting in which the drainege basins are located. In details, if in the study area the tectonics has been inactive since a long time, the hypsometric curves can express the stage of the «geomorphic cycle» of the basin itself, in accordance with the classic interpretation by Strahler. On the contrary, when the drainege basins ar located in areas where tectonics is recent or still active, this interpretation is not completely fulfilled. Previous studies demonstrated that in the case of Italy the plano-altimetric configuration of drainage basins can be more easily expressed in terms of typology and spreading of denudational processes, although, in some cases, the classic interpretation can be considered still valid.
This study is framed into this research sector and its aim is to improve the significance of the cause/effect relations between morphogenetic processes and plano-altimetric

configuration through the analysis of many drainage basins of Italy, located in areas having different tectonic histoires and various and complex geomorphological characteristics. The result of extensive inquiries have shown that the relations under study can be quantitatively expressed by regression equations connecting the hypsometric integral values (J_v), which synthetically express the present plano-altimetric configuration of drainage basins, to the values of some geomorphic parametres which describe the morphogenetic process spreading and effectiveness. In particular, the chosen parametres express - in connection with the drainage basin area (*A*) - the total lenghts of deepening streaan channels (*Le/A*), the area affected by sheet, rill and gully erosion (*Ad/A*), the area affected by mass moyement (*Am/A*), the amplitude of relief (*H/A*) and the extention of alluvial deposits (*Al/A*).
This kind of analysis has been applied to a statistically significant set of drainage basins of Central Italy; they have been chosen taking into account their different geological and morphological conditions as well as their geographical location on the Adriatic or Tyrrhenian side. The statistical analysis of the relations between the hypsometric integrals and the geomorphic parametres confirmed the close interdependence between the dependent and independent variables. Moreover the results obtained have shown that some interesting differences exist between the behaviour of the drainage basins of the two different sides of the Italian peninsula. More in details, the drainage basins of Central Italy which join the Adriatic Sea show plano-altimetric configurations characterized by integral low values; denudational processes, and slope processes in particular, are usually widespread and effective. The drainage basins of the Tyrrhenian side of Central Italy show a quite different situation; they are generally affected by denudation processes which are less spread and intense, although their hysometric curves have often integral low values. However, if partial basins affected by local structural conditions are considered the relations between integral low values and the type and intensity of denudational process is still verified.
Actually, it seems likely that the general plano-altimetric configurations of the drainage basins of Central Italy can be explained in different ways: the interpretation of hypsometric curves as function of the complexity of denudational processes and of the rate of geomorphological changes is surely more suitable in the case of the basins of the Adriatic side, while the Strahler's classic interpretation, in terms of stage of the geomorphic cycle, is generally more suitable for the basins of the Tyrrhenian side. This different behaviour can be framed into the recent tectonic of the central part of the Italian peninsula. Starting from Upper Pliocene, the Adriatic side was mainly affected by uplifting which resulted in an enhanced effectiveness of morphogenetic processes. On the Tyrrhenian side, instead, more ancient Horst and Graben tectonics prevailed which was more favourable to the ahievement of a more advanced stage in the geomorphic cycle.
Finally, the hypsometric analysis showed to be useful also to single out within the same basin the presence of areas which have undergone tectonic events of different kind and intensity.

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Stability analises and stabilization works of the Montepiano travertineous cliff (Central Italy)

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The paper relates results of the research carried out on the instability phenomena of a travertine plate resting on overconsolidated plio-pleistocenic clayey silts and silty clays through some thin beds of sands and conglomerates.
The travertine plate sets up a vertical face about 30 m high, marked by a sequence of arch-shaped features which result from the geomorphological evolution occurred mainly by means of rotational sliding and lateral spreadings. The edge of the travertine plate is strongly fissured: the main fractures set is parallel to the travertine face and concerns the whole thickness of the plate. As a matter of facts, the travertine behaves as a rigid plate resting on the underlying plastic silty clays; tension cracks develop at the boundary of the plate itself and cause the separation of large blocks of travertine. The lowering and/or the rotation of these blocks cause instability mechanisms of different type: the geomorphological evolution of the cliff has occurred, in fact, mainly by means of landslides phenomena classificable as lateral spreadings and rotational sliding.
The comparison of the geomorphological features at the present time existing and historically delineated before the last catastrophic event testify for the present activity of the same fractures sets and for the critical state of the cliff. The geotechnical and geomechanical characteristics of the outcropping material have been then characterized by means of field surveys, site investigations and laboratory tests with the aim to design the suitable consolidation works due to the high risk connected to a landslide phenomenon. A detailed geological and geomorphological mapping has been realized before the subsurface exploration programme was carried out by means of geophysical surveys and mechanical boreholes.
The stability analyses have been carried out using a finite differences code that shows the present state of stresses and strains in the whole slope. This technique is more complex than the conventional limit equilibrium methods, but it nevertheless can provide a detailed insight into the way that a slope will deform and fail and therefore provide a valuable addition to methods of analysing slope behaviour. The effectiveness of the proposed consolidation works has been tested afterwords using the same computer program with the new morphological and hydrogeological conditions. The control of subsurface water and the alteration of the slope geometry result to be, in fact, the only suitable methods of stabilization of the slope.

GIACOMO D'AMATO AVANZI

Landslides triggered by the intense rainstorm of 1996 June 19 in southern Apuan Alps (Tuscany, Italy)

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The Apuan Alps are a mountain range in Northern Tuscany; they are mainly formed by metamorphic rocks and attain the height of ca. 2,000 m above sea level. The chain imposingly rises on the coastal plain of Versilia, along the Ligurian-Tirrenian Sea; it is characterized by very steep slopes and deeply cut valleys. This particular geographic location very close to the sea, together with the altitude of the chain, produces the forced lifting of humid air masses of Atlantic or Mediterranean origin, so favouring their rapid cooling. Consequently, in the Apuan Alps high levels of rainfall are recorded, exceeding in some zones 4,000 mm per year; intense rainstorms are frequent, particularly in spring and summer and cause many landslides.
On 1996 June 19 a very heavy rainfall occurred in southern Apuan Alps, in the territory that is astride the watershed between Serchio River and Versilia River catchment basins; in a recording gauge in this area, a rainfall of 158 mm in 1 hr was measured during the rainstorm; the recorded total rainfall was 478 mm in 13 hr. The area involved in this rainfall was rather small: the 400 mm cumulative rainfall isohyet was 30 km^2 wide, the 150 mm isohyet was less then 300 km^2 wide.
The heavy rainfall triggered hundreds and hundreds landslides; in the mountains, in the maximum rainfall area, ancient villages, such as Cardoso and Fornovolasco, had many houses levelled, partly buried or heavily damaged by debris flows, hyper-concentrated flow and flood. The high runoff caused severe damages in the mountain areas along the streams; in the Versilia plain, the collapse of a river embankment produced the flooding of ca. 8 km^2. Owing to the catastrophic events there were 14 fatalities.
As to landslides, frequently they were rather shallow, with a prevailing thickness of some metres (1.5-2 m, with a maximum of 5-6 m); the involved material was mostly colluvium, talus and sometimes weathered portions of densely fractured rock masses (shales and slates). The rapid infiltration of rainfall, causing soil saturation and a rise in pore-water pressure is probably the mechanism by which most shallow landslides were generated. Translational slide was the most frequent type of movement; the failure surface usually developed at the contact between the regolith cover and the bedrock. Sometimes, the failure surface developed inside the cover or in a dormant landslide, often with a rotational mode of sliding.
Taking the Cardoso area (one of the more stretched) as an example, landslides mostly involved talus and colluvium slopes, accumulated on steep slopes and 1.5-2.5 m thick. Many typical failure sites were first-order basins and hollows filled by colluvium, often close to watershed heads; this geometry favoured the accumulation of colluvium and the convergence of groundwater flow. In many landslide sites, the bedrock showed a significant discontinuity (bedding, schistosity) dipping downslope, so forming a regular or a stepped 30°-40° inclined plane. Therefore, morphological parameters were very important in landslide development, often regardless to bedrock type; the involved areas were mostly covered by woods of big chestnut-trees.
Because of the slope steepness, many debris slides attained high velocities (at least some m/sec) and then turned into debris flows or debris avalanches; the movements were often canalized and characterized by low depth to length ratios and high length to breadth ratios. Many debris flows produced ground erosion, while others moved without causing erosion; likely debris flow waves were produced by breaching of temporary dam or obstruction in channels.
In addition, a lot of prevailing small landslides involved roads; they were often caused by high runoff erosion and led to many road interruptions; thus, several villages had been isolated. But probably debris-flows, and landslides from which they generated, were responsible for the greatest direct or indirect damages, either in the villages or along the streams.
In conclusion, we regard it significant to remark the role of landslides in increasing the damage of runoff; in fact, they abnormally overloaded rivers of fine and coarse sediments and thousands and thousands of trees. The effects were a. o.: the rising of riverbed elevations (up to 4-5 m in Cardoso and Fornovolasco areas), so reducing the supportable discharge of streams and favouring their flooding; the obstruction of bridge spans, so determining local floods; the temporary damming of channels, on collapse of which flood waves occurred; the increase in destructive capability of streams, because of sediments and trunks of trees.

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Monitoring of the Calderone Glacier (Gran Sasso d'Italia) with Gis technologies

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The study of the variations of the Calderone Glacier is particular and different from the other glaciers; infact the apparatus is confined into a deep mountain valley, with steep walls, and does not show movements along the borders and the front. So every year, during summer season, it is possible to measure the thickness of the snow deposed during the cold season and to evaluate the partial or total melting, and, in this case, the ice ablation in terms of lost equivalent in water (D'Orefice & *alii*, 1996).
Furthemore during the nineties a set of multidisciplinary researches started to evaluate the role of the Glacier, like an indicator of the effects of human activities and finally of regional and global change. These studies included till now (D'Orefice & *alii*, in press) and will perform in next years the measure of ice thickness with geophisical methods (georadar and geoelectric), the collection of meteorologic parameters, rains, snow and temperature (Di Filippo & *alii*, 1996), the realization of an inventory of available ima-

ges, photographs, maps and the data integration and elaboration on Gis, in a context of a full geomorphologic reconstruction of the area. Nowadays the following reports and data sets are available on Gis Arc/Info:
1. Dtm performed starting from a restitution at a scale 1:750 of a topographic survey (Gellatly & *alii*, 1994), used as reference surface and related altimetric zonation;
2. maps elaborated at a scale 1:750 showing winter snow thickness in June 1994, 1995 and difference between the previous years and related variations in terms of water equivalent in mm;
3. maps elaborated at a scale 1:750 showing winter snow thickness in July 1995;
4. historic series of rain fall and temperatures data related to most represented measure points, regularly distributed all around the glacier.
In this paper the authors present the further elaborations related to data surveyed in 1996 and to the informations integration on Gis, starting from new available aerophotographs, images, maps and field and meteoclimatic data.

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Microvariability in Vertisols

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The largest continuous area of Vertisols in Thailand is in the Lob Buri Province. This area receives about 1,400 mm rainfall with a dry season of 5 months. A trench 18 m long and 2 m deep was dug and seven equidistant pedons were sampled. Samples of polygons were taken for detailed physical-chemical analysis, Sem, Tem, X-ray diffiraction, Dta, thin-section, and ^{14}C dating studies. The soils are classified as Pellusterts. The parent material is marl.
Micromorphological studies clearly establish the variations of the carbonates with depth. Carbonates are omnipresent in all the surface horizons due to lateral surface additions. The variations in carbonates is accompanied by variations in Fe and Mn nodules and staining. The secondary carbonate nodules in the solum are finer grained; occasionally, particularly in the surface horizon, fragments of marl are present as nodules.
The marl consists of nodules of large rhombohedral crystals and finer micritic matrices. At the contact zone between the solum and the marl, in addition to fragments of the marl, there are few voids in filled with acicular lublinite crystals[1]. In the carbonate enriched horizons in ped 3,4 and 7, the s-matrix is composed of finely crystallized carbonates giving rise to a calci-phyric related pattern. Sem confirms optical microscope observations. Plasmic fabric are weak. About 75% of the clay fraction is made up of montmorillonite. This is partly due to the low clay content (40-45%) and the high silt and sand contents which buffer the shrink-swell potential of the soil.

[1] Lublinite crystal = acicular crystal = carbonate crystal

ELENA A. DANILCHENKO

Morphostructures and glacial relief of a Chibagalah-Ericit Zone of Cherskiy's Ridge (Republic Saha)

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On data of the geologists Republic Saha according to peculiarities of a geological structure and the expressions in relief, on a parity with ancient structures and character of the newest movements are allocated five basic types of morphostructures: arch and arch-block uplits of a Batholit Main belt (Cherskiy's ridge); horst and block morphostructures of margin uplifts area (Uchchinskiy block of Paleozoic age, Omulevskoe rise); plate like morphostructures of In'yali-Debin sinclinorium area (Nerskoe upland); domes and local arches connected with boss and subvolcanos of Upper Jurassic age: superimposed riftogenous basins of Late Cenozoic Chibagalakh-Ericit system.
Chibagalah-Ericit zone is located in limits of Chersky's ridge, one of the most complex mountain structures of North-East of Russia. In structural-geomorphological terms zone represents an area of interference of square and linear morphostructures of various age and genesis. On the one hand it enters in maximum orogenic and postorogenic uplifts zone, to which Batholit Main belt of Cretaceous age is related. On the other hand this is area of development of late Cenozoic riftogenesis expressing in formation of Chibagalakh-Ericit system of superimposed basins. The first circumstance determines peculiarities of metallogenesis and distribution of regional denudation level, second peculiarity of late Cenozoic sedimentation.
Basic tendencies of a geomorphological stage, the beginning of which is necessary here on Cretaceous time, are primary escalating of contrast relief on a background of which stages of relative alignement are allocated: regional in the end of Cretaceous-Paleogene and local on the boundary Pliocene, Early Pleistocene.
The peculiarities of development separate morphostructures determine distribution of regional and local levels of denudation and precondition of accommodation of plaser forming mineralisation near a day time surface in various circles of relief, and also peculiarities of levels of denudation distribution on separate temporary intervals.
The conditions of formation glacial relief in south-east part of Chibagalah Ericit Zone are considered on an example of basin Bugchanskay. In its limits in Late Quaternary were issued two uncommon site of primary accumulation of glacial and fluvio-glacial deposits. During the maximum development first glaciation in Late Pleistocene more than half of bottom of basin was blocked by glacier. The further history forming of basin' s relief is connected with gradual degradation and partial oscillation of filling it glacier, leaving a complex of adjournment bottom, lateral and final moraines well expressed in modem relief. Degradation of glacier was accompanied by formation of separated files of «dead» ice with chaotic congestion of morain hills, down-

turns and local depressions filled by fluvio-glacial deposits. Apparently, there were the conditions for formation of glacial lakes and zandr plains on sites of backwater. They are expressed in a modern relief as a series of terraces, the number of which three or four achieves. Tracing of deposits and forms of relief created by this glacier (Sartanskiy Glacier) allows to consider that in the specified region glaciation was covered not only valleys. Glaciers are left in a margin part of basin forming a «foot» glacier on the local areas in the basis of slopes of northern exposition and in limits of maximum uplifts.

MARCELO EDUARDO DANTAS, LUIZ GUILHERME DO EIRADO SILVA & ANA LUIZA COELHO NETTO

Sediment storage on hanging valleys of SE Brasil: sedimentation and lowering rates

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The Middle Paraíba do Sul Valley was marked by significant environmental changes on the Late Quaternary, produced by paleo-hydrologic shifts (Coelho Netto & *alii*, 1994), or by the human interference on the landscape (Dantas & Coelho Netto, 1996). The episodic occurrence of erosion-sedimentation cycles in Southeastern Brasil (Meis & Monteiro, 1979; Coelho Netto & *alii*, 1994), lead us to study the spatially and temporally non-uniform fluvial sedimentation, that results of the environmental changes that model the landscape in a regional scale.

Major valley-bottom morphology is caracterized by a sucession of alveolus and gorges in association with local bedrock controlled knickpoints. Bedrock structural discontinuities, such as the joint sets and the main foliation, control 81 % and 67 % of the knickpoints, respectively. The local base-levels lead to a succession of hanging-valleys that operate independently of the regional channel network, resulting in a differential sediment production and storage on the fluvial basins, as indicated by hollow density and channel gradient for each sourcing-area (Dantas & *alii*, 1994).

Geomorphological processes are non-uniform both spatially, and temporally. Coelho Netto & *alii,* (1994), based in stratigraphic profiles and radiocarbon dates, identifyed two erosion-sedimentation periods during the Holocene. The first one, recorded around 10,000-8,000 years B.P., is documented along the fluvial terraces and alluvial fans and is possibly associated to the Pleistocene-Holocene transitional time: paleoenvironmental literature indicates climatic changes toward to warmer and wetter conditions.

The second one, recorded around 200 years B.P., is documented along the floodplains and is associated with the regional deforestation due to coffee plantations, producing a radical regional hydrological changes and generating intense sheet-wash erosion on the slopes.

Taking into account the previous stratigraphic work and dating record, volumetric mensurements of sediment storage were taken by using altimeters and aerial photographs (1:25,000 scale) (Dantas, 1995). During the Pleistocene-Holocene transition, we found sedimentation rates around 38,000 m^3/year, for the Piracema river basin. Major erosion sourcing-areas were within topographic hollows and thus, the total lowering reached 3.0 m^{-1}. Concerning the aggradation within the fluvial system after deforestation, we found a sedimentation rate around 97,000 m^3/year. In this case, the total lowering rates on the sourcing-areas attained 7.5 cm^{-1} during the coffee cycle, that resulted on the erosion of the forested organic horizon

STEPHEN E. DARBY & ANDREW SIMON

Modelling the effects of riparian vegetation on channel morphology: examples from sand and gravel-bed rivers of the S.E. United States

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A deterministic numerical model of channel adjustment, which accounts for specific mechanisms of bank erosion and widening has been calibrated using data from two streams in the Mississippi Embayment physiographic province of the S. E. United States (Goodwin Creek, Mississippi and South Fork Forked Deer River, Tennessee). Goodwin Creek is located in a small (~10 km^2) watershed in the loess hills region of north Mississippi. Model calibration was based on the use of discharge, sediment load, channel cross-section, bed-material, and bank-material data representing the period 1982 to 1989 along a 3.5 km reach of the lowest part of the watershed. For this reach, valley gradient is about 0.002, and bed-material consists of bi-modal sands and gravels (1 mm $\leq D_{50} \leq$ 7 mm). Bank materials are composed principally of silt, with mean effective cohesion and friction angle values of 19.7 kPa and 30.8°, respectively, under ambient conditions. Model calibrations for the sand-bed (D_{50} = 1 mm) South Fork Forked Deer River, West Tennessee, are for a 21.6 km reach (mean valley gradient = 0.0015; drainage area = 2400 km^2) of channel for the period 1969 to 1993. Bank materials are predominantly silt, with mean effective cohesion and friction angle values of 11.4 kPa and 32.0°, respectively, under ambient conditions. Both Goodwin Creek and the South Fork Forked Deer River are unstable channels, having been subjected to base-level lowering and subsequent upstream migrating bed-degradation.

The numerical model used in this study is based on a set of deterministic equations of flow momentum, flow resistance, sediment transport and conservation of sediment mass. The model is solved with a set of specific boundary conditions (discharge and sediment load at the upstream boundary of the modelled reach) to obtain predictions of bed elevation change through time. Channel width adjustment is accounted for through analysis of specific mechanisms of bank erosion, mass failure, and deposition and subsequent entrainment of failed bank-material debris. The effects of riparian vegetation in any discrete time step are accounted for through static analyses of the impacts of specific vegetation types and arrangements on (1) flow resistance, and (2) geotechnical characteristics of the bank materials.
Dynamic interactions between riparian vegetation colonization and growth on re-stabilizing bank surfaces are accounted for through use of idealized, site-specific, vegetation growth functions. Dendrochronology studies along disturbed channels in Mississippi and West Tennessee have been used to develop growth functions for various riparian species. For all woody species combined, mean annual rates of tree diameter and rooting-depth growth were found to be about 1.0 cm/yr. Vegetation parameters (height, diameter, rooting depth) are varied through time according to these empirically-derived growth functions. Riparian vegetation is removed from unstable banklines after mass failure. Vegetation re-growth on stabilizing bank surfaces which failed in previous time steps is simulated using the idealized growth functions. It is recognized that this is a highly simplified representation of geomorphic and vegetative recovery processes.
The effects of riparian vegetation on channel adjustment processes were analyzed in a series of sensitivity analyses, carefully calibrated to reflect the conditions encountered in Goodwin Creek and the South Fork Forked Deer River. To quantify the effects of different types of riparian vegetation on channel adjustment in these streams, simulations were conducted for cases when (1) riparian vegetation is totally absent; (2) riparian vegetation consists of herbaceous vegetation only, and; (3) riparian vegetation consists of woody vegetation only. In the case of woody vegetation, additional simulations were conducted to evaluate the influence of different species on channel dynamics. This was done by using empirically-derived growth functions specific to each of the species analyzed, in conjunction with the use of rooting depth and root tensile strength values representative of, and specific to, those species. Simulations were conducted for the following species (1) river birch (*Betula nigra*); (2) black willow (*Salix nigra*); (3) sycamore (*Platanus occidentalis*), and; (4) alder (*Alnus serrulata*). These are common pioneer species along disturbed channels of Mississippi and Tennessee. Results are presented for both study reaches in terms of comparisons between simulated changes, through time, in channel width, thalweg elevation, channel gradient, and cross-section shape corresponding to each of the specific riparian vegetation types simulated.

SUNIL KUMAR DE

Assessment of soil-loss in the Balasan of the Darjeeling Himalaya

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The Balasan Basin situated in the Darjeeling Himalaya constitutes a fragile and unique ecological system. This basin is frequently devasted by environmental catastrophies. Among such events landslide is perhaps the most rampant environmental hazard threatening the Town of Kalimpong adjoining the basin.
In order to have an in sight into the probable cause of such increased vulnerability, the author in this paper has tried to trace the course of events by drawing together the nature and amount of soils loss calculated on the basis of Fao/Unep, Usle and Usda methods.
Of the five vulnerable zones, the zone falling in between 600 to 1,800 m is considered to be the most unsafe due to high rainfall, fragile geological structure, deforestation and unscientific use of the land by ever growing population. Immediate measures should therefore be taken to stop such menace and restore the natural ecological balance of the basin under consideration.

DIRK H. DE BOER

Using fractal dimensions to quantify changes in the morphology of fluvial suspended sediment particles during baseflow conditions

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The morphology of suspended sediment particles reflects the origin of the suspended load and any modifying processes which may have occurred during transport and storage in the aquatic system. The objective of this study was to evaluate the use of four fractal dimensions to quantify visually observed changes in the morphology of fluvial suspended sediment particles during baseflow conditions. Samples were collected during summer low flow in a small stream on the Canadian prairies. Particle morphology data were obtained with a transmitted light microscope, a Ccd camera, and an image analysis system.
The morphology of the particle population was characterized using four fractal dimensions (D, D_k, D_1, and D_2). D was derived from the area-perimeter relationship and showed an increase from 1.26 ± 0.02 on June 30, to 1.34 ± 0.02 on July 4, to 1.42 ± 0.01 on July 7. Visually, the increase in D represented the formation of large particles with intricate shapes and increased perimeters. D_k was de-

termined from the area-rank relationship and varied from 1.86 ± 0.01 on June 30, to 1.90 ± 0.00 on July 4, to 1.74 ± 0.00 on July 7. The decrease in D_k between July 4 and July 7 would indicate a greater concentration of the particle area over a small number of large particles. Although the decrease in D_k is consistent with observed changes in the particle size distributions, D_k should be used with considerable caution because D_k varied more than one standard error between replicates. D_1 and D_2 were determined from the length-perimeter and length-area relationships, respectively. D_1 proved to be of little value for quantifying changes in particle morphology as it showed little change through time despite considerable visual changes. D_2, however, was useful, despite some variation between replicates. Over the sampling period, D_2 for the composite data sets showed a steady decrease from 1.74 ± 0.02 on June 30, to 1.68 ± 0.02 on July 4, to 1.60 ± 0.01 on July 7. This change in D_2 indicates that through time the larger particles became longer and thinner relative to the smaller ones.
This study shows that temporal changes in D, D_k, and D_2 were consistent with, and allow quantification of, observed changes in particle morphology. D_1 did not reflect observed morphological changes, and is likely of little value for this type of study. The changes in particle morphology coincided with an increase in primary production in the form of algae.

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The floodplains of Northeastern Argentina. Geomorphic components and environmental impacts of flood control projects

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The lower Paraguay and the middle to lower Parana are typical alluvial rivers characterised by extensive floodplains and very low topographic gradients, where channel migration and island development are common features. These characteristics, together with periods of heavy rainfall within their entire watershed (ca. 3 million km^2) cause the recurrence of inundations affecting population and natural systems. The latter are naturally adjusted to this pulsatile regime, but the human occupation of the area causes modifications in natural habitats. Although at the beginning of European occupation in the region (i.e. the Jesuits, since the sixteenth century), the early settlers applied some «common sense» geomorphic criteria by establishing their communities as high as possible, far from the reach of floods, the most recent developments within the present century have not had proper planning criteria. The main urban areas are sited on the floodplains and are periodically exposed to severe damage, both in property and infrastructure. Some housing projects have been developed on inactive meanders. The lack of adequate systems for potable water and for sewarage disposal, as well as the existence of untreated industrial wastes poses a serious threat to human health, particularly when the persistence of a flood is long (several months in 1983). As a consequence of the various flood events, defence works (terreplains, pumping stations, channelisations) were performed during recent emergencies and others are being planned around the main cities within the region. Because all of the planned structures will only have local effects, it is foreseen that minimal impacts will be suffered at a regional scale. However, it must be considered that the creation of artificial landforms (straightened streams, ponds, terreplains) may cause impacts in local systems implying alterations in the flow pattern, destabilization of river islands and stagnation of water around urban centers. The latter will favour the establishment of disease vector fauna. In addition, it must be taken into account that wetlands and gallery forests are typical in the area and host a very rich biodiversity. With the purpose of assessing the impacts of 51 flood control projects, a standard procedure was developed and applied in each case, involving impact identification, vulnerability of the proposed project, and mitigation measures.

SANDRO DE MURO, MICHELE CAMIN & GIOVANNI PAOLO FANZUTTI

Geomorphological map of the coastal and marine area between Punta Sardegna and Culuccia Peninsula. New deglacial sea level records from underwater surveys and dating intergranular cement of beachrock. (North-eastern Sardinia, Italy)

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Geomorphological, sedimentological and chronological studies have been carried out in the sector extending between Punta Sardegna and Culuccia Peninsula in northeastern Sardinia (Strait of Bonifacio and Arcipelago di La Maddalena).
The 1:8,000 geomorphological scale map was compiled on the basis of new data collected during three oceanographic and on-field survey expeditions (in 1994, 1995, 1996). The information contained in the map mainly refers to the more dynamic zone of submarine beaches. The bathymetric strip located between –30 m and the emerged beach, is analysed in detail.

The underwater geomorphologic survey based on 180 scuba diving stations has revealed the existence of several sedimentary formations situated at a depth of –28/–30 m, –6/–8 m, –2 m and –1 m. Following an analysis of rock samples, the surveyed deposits have been classified as beachrock having Holocenic ^{14}C calibrate radiometric age.
The surveyed deposits can be ascribed to a recent coastal geomorphologic evolution affecting the littoral environment and proximal shelf during the late Holocene transgression.

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The Punta Catalina area in post-glacial Magellanic evolution Map N. 4/12 of the Geomorphological Atlas of the Coasts of the Strait of Magellan (Tierra del Fuego, Chile)

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The results of the coastal geomorphological survey on a 1:50,000 scale map mainly concerning marine and transitional terraces of Punta Catalina (Strait of Magellan - Patagonia) are reported. The information mainly concerns mapping and the on-field survey during Italian expeditions (in 1992, 1994 and 1995), co-ordinated by the Dipartimento Scienze Geologiche, Ambientali e Marine of the University of Trieste within the Programma Nazionale di Ricerche in Antartide (Pnra). In the framework of the Pnra, updated studies on the coasts of the Strait of Magellan, have been mainly aimed at the knowledge of the present littoral dynamics and at the detailed cartography of morphological units of the coastal belt (collection of geomorphological, morphostructural, stratigraphic, micropaleontological and sedimentological data, study of active cliffs, paleocliffs, dunes, etc.).
The primary objective of the present research is the mapping of the more recent marine and transitional terraces. The aim is to publish an Atlas accompanied by about 12 geomorphological maps (of which this map is the fifth example) topographically based on 28 Chilean I.G.M. 1:50,000 scale maps of the area between Punta Dungeness and Bah'a Inœtil (De Muro & *alii*, 1996a and 1996b; Di Grande & *alii*, 1996a and 1996b).
The map is mainly focused on the youngest terraces, from which orders starting from the present sea-level have been mapped; they belong mainly to the Holocene.
They are mostly depositional flat bodies; at times, however, they are part of erosion surfaces; on other occasions they are located, either on glacial erosional surfaces, which they modify, or they lie on both morainal and/or glaciflu-vial and Meso-Cenozoic basements. On the whole, they are distributed following the present coastline, being genetically connected to it; in some cases, they present an old configuration that is different from the present Strait.
The First Order, presently located between 18 and 25m, is not well represented along the explored and cartographed coast. Besides, they are difficult to identify, since they link up landwards with continental terraces of different orders and the related hydrography network, which is older (Lower Pleistocene ?). From the textural point of view, they are made up of stratified sands and laminated pelites. Holo-Pleistocenic age is hypothesised according to the stratigraphic position and their relation with analogous deposits of the Strait of Magellan dated by radiocarbon (^{14}C yr B.P.).
The Second Order concerns terraces between 6 and 11 m; they are clearly more evident than the previous order, and even show marine palaeoforms. The deposits are mostly gravelly and sandy, at times clayey or fossiliferous. Their age (Holocene) is presumed from their stratigraphic position, their fauna content and dating by radiocarbon (^{14}C yr. B.P.).
The Third Order (Holocene) is not as clear as in the adjacent areas, although they represent larger single outcrops between 3 and 5 m. There can be spotted fossiliferous gravels and sands.
The genetic similarity of Punta Catalina with the present configuration of cuspate forelands of Punta Dungeness and with those related to the past by Holocene terraces is remarkable. The main aeolian morphology is spread following the dominant Magellanic wind direction especially in high-altitude areas.

MARCELO A.T. DE OLIVEIRA

Regressive alcoves, gully head extension and gully integration

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The extension and integration of gullies on unchannelled valleys had been studied since 1984 on the Southeastern Brazilian Plateau. As a result, a conceptual model for gully erosion evolution was proposed (fig. 1). The model conceives the existence, at the same hillslope, of two types of erosive incision: one connected to the main drainage net (I), the other disconnected (II). With time, both incisions may integrate into a whole channel, creating a unique gully erosion system (III). At the moment of the integration between the distinct incisions, the synergetics of overland

flow and subsurface flow would trigger a stage of accelerated erosion rates.

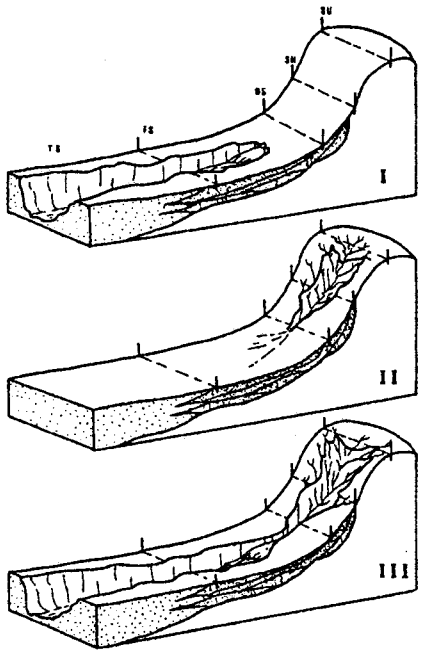

FIG. 1: Gully evolution conceptual model. I: incision connected to the drainage net; II: incision disconnected from the drainage net; III: integration of a connected and a disconnected incision.

The tendency to the integration proposed by the model had been verified in the field through the estimation of erosion rates in a potentially integrative gully erosion system. In order to understand the mechanisms which will act at the moment of the integration, erosive features named «regressive alcoves» had been studied on an experimental field site (fig. 2).

At the experimental site, most of the gully head extension was associated to the retreat of the «regressive alcoves». The main observed mechanisms responsible for the alcove retreat, act on different space-and-time scales. Under low intensity precipitation, overland flow transports material through little «subvertical fillets» adhering to the headcut wall; under high intensity showers, plunge pools undermine the gully head, while «subvertical fillets» promote liquefaction of non-cohesive materials; under low intensity, but long duration precipitation, seepage erosion becomes associated with the previous mechanisms.

The interaction in time, at the same place, of the abovementioned mechanisms, was responsible for the accelerated retreat of the gully head at the experimental site» .Regressive alcoves» seem to be erosive features in which overland flow and subsurface flow tend to reach the synergetic interaction predicted by the above mentioned gully evolution model.

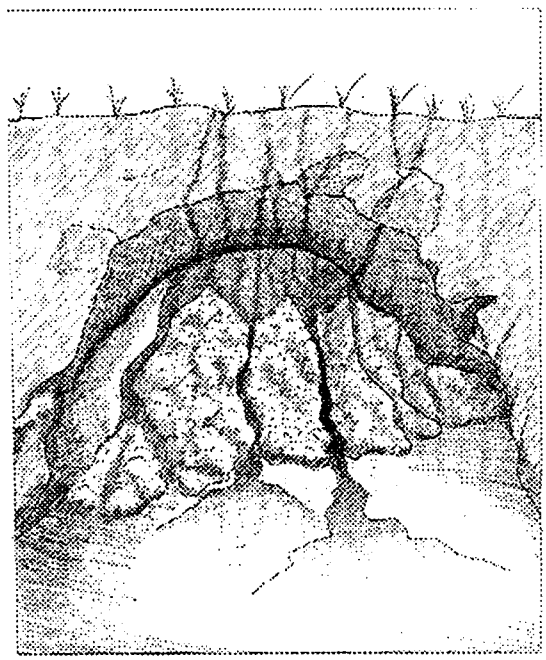

FIG. 2: Illustration of a regressive alcove. Note the subvertical fillets concentrating at the base of the alcove.

TOMMASO DE PIPPO, CARLO DONADIO, MICLA PENNETTA, ALESSIO VALENTE & CARLO VECCHIONE

Morphological evolution of a volcano-tectonic coastal plain in the Western Neapolitan Area

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The coastal plain of Bagnoli-Fuorigrotta, included in the active volcanic district of Phlegrean Fields, joins Naples to Pozzuoli. It is an area with a gentle morphology, modelled into pyroclastic rocks constituting the framework of both cities. The plain is few meters up on the present sea-level, confined eastward by the steep tuff cliff of Posillipo and westward by Mount S. Angelo and Mount Spina volcanic slopes. The coastal area extends from NE to SW for about 4 km with an average slant around 1% until the water's edge of Gulf of Pozzuoli, towards it a sandy beach long 3 km is developed. Today's concave physiography oriented NW-SE is the result of many endogenous and exogenous processes which have taken place during Upper Pleistocene-Holocene. More specifically the area of Bagnoli at present has a morphological evolution strictly connected both to intense pyroclastic eruptions (*Neapolitan Yellow Tuff* and other products of the recent volcanic activity in the western zone of Naples) succeeded in last 14 Kyrs B.P., and to recently modelling processes of volcanic slopes due to weathering and to erosion-deposition action of sea-waves.

This action has been changed by volcano-tectonic events with subsequently submersion or uplifting of large coastal areas in different times as well as Roman Period, Middle Age and last two centuries . The stratigraphy of «La Starza» terrace (11-5 Kyrs B.P.) with its marine and continental deposits results from this events. As well as the roman age ruins of villas and harbours and the middle age handmade (Miseno, Posillipo and Pozzuoli) nowadays submerged or buried under beach deposits. Quite surely those vertical movements have interacted with glacio-eustatic rising of global sea level during Holocene. The soil fluctuation (locally named «bradisismo») has played an important role during the last 2,000 years in this area. In fact the most recent bradiseismic crisis (1970-1972 and 1982-1984) have caused a maximum soil deformations of about 2 m on Rione Terra (Pozzuoli) and the uplifting of the West coastal area of the plain (about 1 m in La Pietra, nearby Pozzuoli; about 0.5 m at Bagnoli and about 0.2 m at Coroglio, towards Naples) as well as the partial emersion of submerged beach, with consequent widening of the emerged beach and seawards prograding of the shoreline.

Stratigraphic reconstruction of the first 20 m depth of plain subsoil, derived by the study of drillings and sedimentological analysis of samples, pointed out a recent regressive-transgressive phase (after N.Y.T. eruption) with deposition of submarine beach sediments (volcanic sands and pebbles) and continental too (pomiceous levels), palustrine (silt and peat levels) and emerged beach sediments (reddish dune sands).

In the central place of the plain has been find two levels of peats lower then the present sea-level, the former one between –0.70/–2.70 m and the latter between –4.50/–7.70 m. Their ages determined with ^{14}C method are fixed respectively at 3700 +/–55 and 1860 +/–50 years B.P. Previous researches have reconstruct the morphological evolution of Bagnoli coastal plain until the uplifting of La Starza terrace and formation of Mount Spina volcano, both related to the last volcanic events (4-:- 3.6 Kyrs B.P.). After Mount Spina eruption took place the post-volcanic collapse of the area with the origin of the coastal plain.

Historical informations and data about the bradeisismic and volcano-tectonic phenomena are known from the Roman Age until today. Therefore the new datings help us to evaluate the time gap between 4 and 2 ky B.P. and also to estimate about 8 m the total subsidence degree in the plain during the last 3.7 Kyrs with an average rate of 2 mm/y.

DAS DEBASHIS

Role of configuration of terrain to determine agricultural landuse in Birbhum district (West Bengal, India)

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A. Terrain configuration is so dominant factor in the Human society and environment that its influence on the pattern and destiny of agriculture is immense.

B. The study possesses following objectives:

i) To examine the nature of relationship between absolute relief and agricultural landuse.

ii) To assess the interrelationship that exist between relative relief and agricultural landuse.

iii) To study the nature of association between disseetion index and agricultural landuse.

iv) To enumerate interdependence between slope of the terrain and agricultural landuse.

C.

i) Analysis of absolute relief has been done by dividing contour map of the study area into units and nothing the mazimum altitude in different units with the help of contours and spat heights.

ii) Relative relief represents the difference in elevation between the highest and the lowest points falling in an unit area.

iii) Dissection index is the ration between relative relief and absolute relief.

iv) Slope analysisis based on the wentworth's method of slope analysis.

v) Composite index of agricultural efficiency is computed

D. In general, altitude of the land is inversely proportional to agricultural development. Therefore, the region with high absolute and relative relief large proportion of dissected land, and with relatively steeper slopes have smaller proportion of net sown area. Most of the farmers of that region cannot practise multiple cropping extensively and therefore, the region achieves lower degree of agricultural development. However, this generalised observations are strictly confined to the macro level studies, but not so at micro level. In developing country at the macro regional level, the physical factors basically determine the nature of cropping pattern, land utilisation and levels of agricultural development to a significant extent. Where appropriate technology and modern infrastructures, facillties are either absent or are located at the small pockets of land. On the other hand, at the micro regional level, the agricultural aspects are influenced largely by the technological, socio-economic and infrastructural factors. As far example at the village level study of Rajnagar and Moyureswar II block the villages with relatively higher slope or higher relative relief also may achieve higher degree of agricultural development, because, here the magnitude of slope or relative relief is not considerably high which can create constraint to agricultural development, as it may be the case in West Bengal and in Birbhum.

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Le creusement plio-quaternaire de la Loire et de l'Allier (Massif Central, France)

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Dans le Massif Central français, le creusement des vallées de l'Allier et de la Loire s'est effectué, durant la période plio-quaternaire, sous l'influence conjointe de la tectonique, du volcanisme et des variations du contexte bioclimatique. Malgré la complexité morphologique qui en résulte, la couverture volcanique (propriétés fossilisantes, possibilités de datations) et les dépôts conservés (nature, contenu en téphras) permettent de reconstituer le fil de cette évolution et d'en caler les étapes.

Dans la vallée de l'Allier, les alluvions fossilisées par les coulées de basanite pliocènes de la bordure orientale du Cézallier (~ 5,5 à 4,2 Ma) fixent le stade de départ du creusement, à plus de 200 m au-dessus des talwegs actuels. Le Pliocène moyen (~ 4 à 3,2 Ma) représente une phase de creusement majeure (encaissement supérieur à 100 m en Limagne) motivée par un contexte bioclimatique favorable et favorisée par les mouvements tectoniques et les contrastes orographiques. Le Pliocène supérieur (~ 3,2 à 2,2-2 Ma) se caractérise par un arrêt de l'encaissement et l'instauration d'un régime de remblaiement visible au travers des successions de Limagne du Sud, de Perrier et du nord de la Grande Limagne. Le réencaissement de l'Allier dans la masse des alluvions à ponces fibreuses de Perrier avant la mise en place des lahars fini-pliocènes du Mont-Dore (~ 2 Ma) marque ensuite le retour progressif à un régime de creusement généralisé dont le caractère climatique s'affirme au cours du Pléistocène inférieur et surtout moyen avec l'apparition des premières terrasses (~ 1,6 - 1,8 Ma).

Dans la vallée de la Loire en amont du Puy-en-Velay, l'inscription du réseau hydrographique s'amorce dès le Miocène supérieur, des coulées datées aux environs de 8 Ma fossilisant les premiers berceaux. Les dynamiques d'incision ne s'affirment cependant qu'à partir du Pliocène supérieur, après une très longue période de stagnation (6 à 2,8 Ma) imputable à la stabilité tectonique des secteurs situés à l'amont du bassin du Puy. Entre 2,8 et 2,5 Ma environ, c'est encore la tectonique qui motive la reprise du creusement dans les secteurs amonts (100 m) dans un contexte bioclimatique cependant plus favorable (Reuvérien). L'influence de ce dernier s'affirme à partir de 2 Ma, la morphologie de la vallée passant du berceau à la gorge. À partir de la charnière plio-pléistocène et jusque vers 1 Ma, l'évolution est bloquée par la mise en place du plateau volcanique du Devès. Le Pléistocène moyen apparaît ensuite comme une période de creusement majeur dans le bassin du Puy (encaissement de 150 à 200 m par rapport au niveau du talweg antérieur, plus épaisseur de la chape volcanique), essentiellement motivée par la nécessité d'un rattrapage du retard d'encaissement accumulé entre 2 et 1 Ma.

Si les similitudes observées dans l'évolution des vallées de l'Allier et de la Loire sont à mettre au compte du contexte bioclimatique, les différences notables reconnues dans la chronologie des phases majeures de creusement indiquent à quel point les perturbations engendrées par le compartimentage tectonique et le volcanisme peuvent être profondes.

SUSANA BEATRIX DEGIOVANNI & M.P. CANTÚ

Neotectonic activity in the La Cruz-Gigena depression, Córdoba, Argentina

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The objective of the present work is to situate in time and space neotectonic movements in the La Cruz-Gigena depression through the analysis of the drainage network and stratigraphy. This depression is located between the parallels 32/ 13' S and 33/ 45' S, and the meridians 64/ 22' W and 64/ 40' W. It is delimited by : Sierras de Comechingones in the West and Sierras Los Condores/Chicas and Las Pe–as in the East; towards the South, it is connected without solution of continuity with the Pampeana Plain.

An outcrop of a quaternary sequence, that stars with fluvial and partially-cemented aeolian sediments which belong to Pampeano Formation (> 25,000 y. B. P., ^{14}C), appears in the area. Fluvial deposits (Chocancharava Formation) of mountains origin, with a moderate to weak cementation, aged 12,000 y. B. P. (^{14}C) or more, are overlying. A layer of loess (La Invernada Formation) aged 12,000-8,700 y. B. P., is deposited over them obliterating the drainage network. The sequence ends with colluvial and alluvial sediments, aged approximately 7,000-5,000 y. B.P.; they are mainly fine, with scarce scattered gravels coming from Chocancharava Formation. In the southern area, aeolian sediments (Laguna Oscura Formation) outcrop, aged approximately 4,000-3,000 y. B.P.

The structural pattern of the area is defined mainly by meridian, inverse and direct faults of regional character. Other faults are associated to them which also exhibit a strike component, among these the most conspicuous are those with E-W, NW-SE and NE-SW directions. This pattern determines a predominance of meridian blocks, differentially raised, segmented and displaced in some cases. This causes a marked asymmetry in the depression, its cross-section profile shows a descending stagger until Sierras Las Peñas, with the exception of the western edge which consists of a group of depressed blocks in the submeridian direction. This asymmetry is lower in the North-South direction, highlighting the Elena block defined by fractures in the E-W direction working as a regional watershed. The maximum throw of the main meridian faults is recorded in the central sector of the area, while the other systems evidence minor displacements.

Two drainage patterns coexist in the area, an old one and a present one, whose differences, considering the available data, allow to place neotectonic movements in space and time. Both patterns belong to two basins, the Tercero river and the Tegua creek, whose watershed is the Elena Block. For both basins the most ancient pattern constitutes a paleonetwork with a mountains origin, a greater drained surface, high drainage density and course frequency, order number between 5 and 6, meandering design of intermediate sinuousity and highly evolutioned valleys. Over the ancient pattern, the current network is being installed, with some basins disconnected from the mountains, constituted by straight courses (rills and gullies) which form sub-basins connected to each other, for certain rainfalls, through depressed areas with slow overland flows. The drainage density and course frequency is much higher and the order number, for some of them, is 3 or 4, with a predominance of first-order courses. This network is in the process of elaboration and extension, at the same time it is being integrated mainly by processes of capture. Confronting the stratigraphy with the morphological, morphometric and morphodynamic characteristics, of both drainage systems, with no consideration of climatic changes, it is possible to state that:

– The disconnection of the mountains and dismemberment of the paleonetwork is related to a significant movement that took place in the Pleistocene-Holocene limit, when Chocancharava, and probably La Invernada Formations had been deposited. In the highest blocks, Pampeano Formation outcrops.

– The compressive effort coming from the West caused a greater reactivation in fractures in a meridian to submeridian direction, while those in other directions suffered less displacement. The former defined the newly-formed subbasins by fragmenting the principal, while the latter only control the location of the streams.

– The regional watershed was not affected in this movement and the Elena Block is a positive area from more ancient times.

– From the principal event until the present time, there is no significant regional, morphological or stratigraphic evidence of neotectonic activity. This period is represented by Las Lajas Formation, whose depositional dynamics is mainly conditioned by the climate

The present tectonic movements only modify the base levels, favoring the processes of network integration, whose reinstallation is mainly due to a more humid climate.

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Assessment of climate change impact on landslide activity

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Most geomorphic processes require climatic parameters such as precipitation, temperature, or wind as important input. While various studies attempt to backcalculate and reconstruct climate and associated processes for the past, there are only few attempts facing potential changing process activity in the future due to an enhanced greenhouse effect. Therefore, in the present study climate change impacts on landslide activity/triggering as one example of geomorphic processes are assessed for the next 50-100 years. While the global picture simulated in general circulation models of the ocean and atmosphere (Oagcm) is widely accepted, confidence in changes in regional and local climate, and its impact on geomorphic processes, remains low. This gap can be filled with various downscaling techniques.

In the present paper an overview of various empirical-statistical downscaling techniques is given along with comparisons between them. These downscaling techniques can be linked either to physically based slope hydrology / slope stability models or to empirical threshold models of landslide triggering. The applicability of the presented methods is discussed with respect to topographical setting, performance, temporal and spatial resolution, seasonal preferences and type of landslide considered.

The interpretation of the resulting scenarios must be carried out with caution, due to various sources of uncertainty in the approach. The results should not to be seen as forecasts but as probabilities of the temporal occurrence of landslides in terms of recurrence intervals. The assumptions, shortcomings and overall performance of the underlying Oagcm, used as climate change information have to be taken into account. Various scenarios based on different Oagcm simulations are compared to show their influence and to clearly identify significant climate change patterns in landslide activity.

MAURIZIO DEL MONTE[1], PAOLA FREDI[1], ELVIDIO LUPIA PALMIERI[1] & ROBERTA MARINI[2]

Contribution of quantitative geomorphic analysis to the evaluation of geomorphological hazards

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The aim of this research is to set up a methodology which can aid the objective evaluation of geomorphological hazards. The study has been carried out considering three drainage basins of Italy (Fiume Orcia, Tuscany; Fiume Mignone, Latium; Fiume Trionto, Calabria) which have various geological and climatical conditions and are affected by geomorphological instability to a different extent.

First of all, the main causes of instability of the studied sample areas have been analyzed through a precise physio-

graphic investigation (about lithological and tectonic characters, topography, drainage extention etc.) supported by a deep examination of human impacts (quarrying, farming, urbanization etc.) Then, the most important morphological effects of destabilizing processes acting in the sample basins have been studied by means of both detailed geomorphological field survey and air photo interpretation as well as through the collection of direct and indirect data about denudation entity. Experimental measures of short time modifications undergone by the related landforms have allowed the quantification of the intensity of present morphogenetic processes; such measures, repeated more times in a period of three years, have been taken on slopes emplaced on easily erodible lithologies where badlands and mass movements are observed.

To make the analysis of the morphological effects of instability as unbiassed as possible, some morphometric parametres have been calculated, which express the main geometric and morphodynamic characteristics of drainage basins.

The results of these investigations have then been interpreted and correlated to single out, within each of the studied basins, what lithologies, slopes, drainage density values and land use are the most frequently existing where a given phenomenon of geomorphological instability is found. Successively the extention of the area affected by the considered morphogenetic processes has been calculated within each class of lithology, slope, drainage density and soil use; such classes have been considered more or less prone to undergo a given destabilizing phenomenon in consequence of the actual spread of the same phenomenon, as surveyed on field.

Once the predisposition of the different classes to undergo a given phenomenon has been established, many areas have been singled out, by overlapping, which are characterized by the concomitant presence of given classes of the four considered causes of instability (lithology, slope, drainage density and land use). The higher or lower probability for a given geomorphological destabilizing process to happen in one of these areas is given by the values of the following products:

$P = a_1/L \times a_2/A \times a_3/D \times a_4/U$, where

P = «hazard index»;

a_1, a_2, a_3, a_4 = surface affected by a given process within each class;

L = surface covered by a given class of lithology; A = surface of a given class of slope; D = surface of a given class of drainage density; U = surface of a given class of land use.

In this way it has been possible to order the hazard classes according to the probability that the described phenomena really happen; the class definition derives from the compared analysis of causes/effects of the phenomena themselves and is not based on «a priori» standards. The hazard scale, although variable as function of their peculiar characters, allows a comparison among the geomorphological hazards in the drainage basins considered.

The methodology set up in this study makes it possible the automatic preparation of effective and exact maps of geomorphological hazard which are a useful practical tool. It is based on quantitative data which derive from field survey, from the systematic observation of the evolution with time of geomorphological instability phenomena , from indirect and experimental measures of denudation process entity and from the analysis of cartographic stand through informatic devices. Moreover the proposed methodology is «open» to any integration which can improve the definition level of areas with different geomorphological hazards; therefore, it intends to be a preliminary contribution of Quantitative Geomorphology to the unbiassed evaluation of hazardous denudational processes, both present and potential, in a given territory.

MAURIZIO DEL MONTE[1], PAOLA FREDI[1],
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Fractal characterization of drainage network geometry

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Studies which have been carried out since many decades on a large number of drainage basins have shown that drainage networks, although seemingly irregular from a geometrical point of view, have some order degree which increases with increasing homogeneity of morphological and structural conditions.

The aims of this study are: to examine the possibility that the drainage networks can be described as fractal objects, to measure the «dimension» of such objects and to evaluate quantitatively their geomorphological significance.

A set of Italian networks with different patterns has been considered and the distribution exponential curves of stream channel length have been elaborated. The curve trends resulted to be influenced by the different drainage patterns (denditric, rectangular, pinned, angular etc...). The observed variations - expressed by the parameters of the fractal distribution - have allowed the quantitative characterization of the different drainage network patterns. The same kind of analysis has been performed by subdividing the drainage network by stream orders and ascribing to each order its mean cumulative length.

Results have been compared with a synthetically generated drainage network following the Horton's laws and using the bifurcatio ratio of a «conservative» network ($Rb = 2$) and the mean length ratio $Rl = 2$. The ideal network so defined has the configuration of a fractal object. Shifting between graphs relevant to theoretical and real drainage networks has been translated into «index values» which may quantitatively represent the degree of control exerted on the drainage networks by external factors (tectonics,

lithology etc....) that interfere with their theoretical emplacement and evolution.
Preliminary results shows the usefulness of the proposed methodology for the automated unbiassed interpretation of drainage network arrangement.
The following figures illustrate the fractal distributions of some examples of real drainage networks compared with the theoretical one; they have been obtained through the analysis by length classes (fig. 1) and by cumulative length of each stream order (fig. 2).

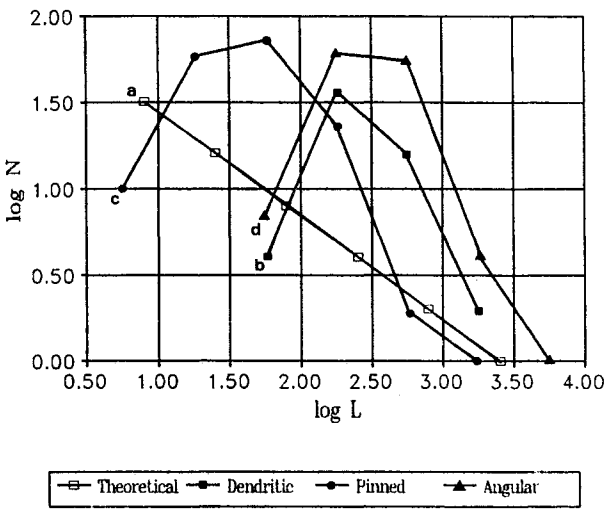

FIG. 1 - L = stream length; N = number of channels.

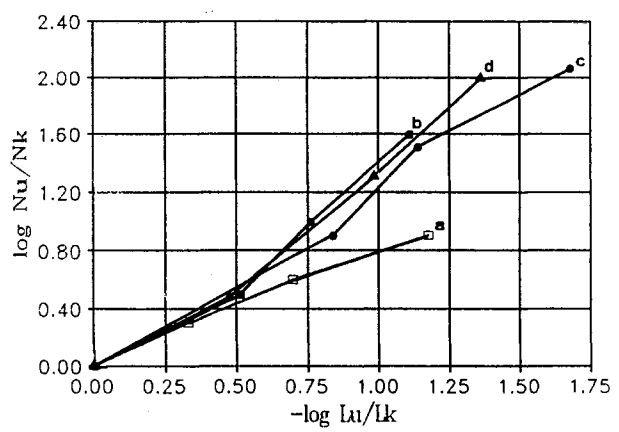

FIG. 2 - Lu = mean length of channels of order *u*; Lk = mean length of maximum order channels; Nu = number of *u* order channels; Nk = number of maximum order channels.

a) Theoretical pattern (Rb=2; Rl=2); b) Dendritic pattern within the Fiume Tevere network; c) Pinned pattern within the Fiume Cavone network; d) Angular pattern within the Fiume Garigliano network.

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Topographic evolution in the Basin and Range Province, Western U.S.A.

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The extensional Basin and Range province, Western US, contains numerous examples of normal fault-bounded rangefronts. A lively scholarly debate over the origin of these rangefronts was silenced by the death of G.K. Gilbert in 1918, and little attention has since been paid to the geomorphology of the region. The Basin and Range has undergone late Cenozoic extension of between 30 and 200%, and is currently marked by both active and inactive normal faults. A number of characteristic geomorphic features are associated with the rangefronts bounded by these faults, including linear catchments, wineglass canyons, and triangular facets. Pediments, in various stages of dissection, are developed at the feet of several ranges. Despite the often spectacular development of these features, and despite the expectation that they record the tectonic and climatic history of the mountain range, few studies have attempted to understand the evolution of topography along these fault-bounded ranges. We use a numeric model of landscape evolution to explore the roles of geomorphic and tectonic processes in shaping these rangefronts. By varying the relative rates of different processes, we can determine the sensitivity of the landscape to those processes and thereby guide both our understanding of the landscape and our efforts to measure those processes in the field.
The tectonic component of the model is composed of planar dislocations in an elastic half-space that are allowed to slip freely in response to a uniform displacement field. We thus generate three-dimensional displacements at each point in the model space, equivalent to a M_w 7.0 normal-faulting earthquake. Repeated application of this displacement field creates a topographic envelope that is acted upon by a set of geomorphic processes. These include regolith production and diffusion, bedrock landslides, fluvial sediment transport, and fluvial bedrock incision. The model produces regolith, or erodible material, at a rate that depends upon the existing thickness of regolith cover. That regolith is transported downslope by linear, weathering-limited diffusion. A bedrock landsliding algorithm simulates discrete bedrock landslides that start near the toes of the model hillslopes; the probability of landslide occurrence is a function of the rock strength, the local topographic gradient, and the height of the hillslope. Finally, we define a channel network on the basis of a threshold value for stream power, approximated by the product of the contributing drainage area at a point, the precipitation, and the local slope. The available stream power determines both the rate of fluvial sediment transport and the rate of

bedrock incision. Finally, additional footwall uplift is driven by flexure, modelled as the sum of a set of line loads due to erosion and deposition.
We apply the model to a variety of tectonic and geomorphic problems in the Basin and Range, and compare the resulting topographies with Dem data of particular ranges. Particular problems that we address include (1) the evolution of simple fault-block ranges, (2) the evolution of horsts, (3) the effects of temporal variations in fault activity, (4) the effects of temporal changes in climate, and (5) the evolution of steps or discontinuities in fault traces. We find that topographic evolution is most strongly controlled by channel incision and bedrock landsliding, suggesting that those processes deserve the most field attention. We also find that the form of the channel network is very sensitive to the imposed tectonic displacement field. We use the channel network to constrain long-term estimates of tectonic displacement patterns near fault steps. We suggest that pediment formation may be dominated by expansion of drainage basins within the mountain mass during periods of static baselevel, rather than by lateral erosion of streams or backwearing of the mountain front. Baselevel may remain static due to tectonic quiescence, low climatic rates, or changes in the connectivity between the hangingwall block and neighboring basins. Finally, we caution that initial topography exerts a strong control on the final morphology of a landscape, although we may insulate ourselves from this somewhat by employing statistical measures of the landscape.

ANGELO DI GRANDE[2], SANDRO DE MURO[1], ANTONIO BRAMBATI[1] & ALBERTO MARINI[3]

Holocenic evolution of the Primera Angostura based on a 1:50,000 scale map (S. 5/12) of the Geomorphological Atlas of the Coasts of the Strait of Magellan - Southern Chile

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Previous studies, carried out by the Department of Geological, Environmental and Marine Sciences of the University of Trieste within the Programma Nazionale di Ricerche in Antartide (Pnra) on the Strait of Magellan were mainly directed at a sedimentological research of the sea bottoms and coastal belt of the eastern section (Atlantic opening). A similar wide ranging research was also carried out from vessels on the coastal belt of the western section of the Strait (Pacific opening). The first coastal studies were limited to a regional definition of morphostructural units. Later, research was carried out in detail during this second phase, and greater attention was dedicated to the study of palaeo-shorelines and different terrace orders of presumed marine and transitional origin (Brambati & *alii*, 1993 a; Brambati & *alii*, 1993b). On the basis of the geomorphological, geological and sedimentological results, we made a zoning of the coastal belts along the Atlantic opening of the Strait and three sheets on a 1:200,000 scale were printed (De Muro & *alii*, 1995, Brambati & *alii*, 1995a, Brambati & *alii*, 1995b, Di Grande & *alii*, 1995). Detailed studies and maps (scale 1:50,000) of the terraced sequences linked to Holo-Pleistocene glacio-eustatic variations are in progress. The aim is to publish an Atlas accompanied by about 12 geomorphological maps (of which this map is the fourth example) topographically based on 28 Chilean I.G.M. 1:50,000 scale maps of the area between Punta Dungeness and Bahía Inútil (De Muro & *alii*, 1996a and 1996b; Di Grande & *alii* 1996a and 1996b). The coastal area between the Atlantic Ocean and Paso Ancho since the Lower Holocene, has been an important morphodynamic unit in the history of the Strait of Magellan. Its recent evolution can be easily inferred upon examination of the geomorphological map of the coastal strip. Its origin is prevalently linked to the last glaciations and their deposits (drumlins, morains, etc). The Western area like the remaining eastern Magellanic area, shows a regular sequence of mainly marine terraced deposits, located in three orders at elevations of 18-25 m, 6-11 m and 3-5 m. Due to its stratigraphic position and from radiocarbon dating, the age of the oldest order can be attributed to the Lower Holocene. The environment seems to be lacustrine and marine-transitional. The second Order of marine environment, is also Holocene and is on average attributable to 6,000-7,000 years B.P. The third Order, with an average age of 4,000-5,000 years B.P., can be referred to the same environment. In addition other terraced surfaces are present, located above 25 meters and of fluvial and/or glacifluvial origin. On the coastal strip another order of marine environment, is locally present at less than 3 meters a.s.l.

SILVIO DI NOCERA[1] & FABIO MATANO[1]

Weathering surveys in Geomorphology: mapping examples from Sila Massif (Calabria, Italy)

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The evolution of the slopes, and particularly the characteristics of the instability phenomena, are controlled prevalently by the features, the type and the thickness of the weathering profile in the areas where deeply weathered rocks outcrop (Ollier, 1984). The classification and the mapping of the weathering grade of the crystalline rocks

therefore result very useful tools in both general geomorphological and engineering-morphological studies. Some examples can be found in literature with regard to the geomorphological problems, like at regional scale in Hall (1986), and with regard to the engineering problems, like at a detailed scale in Knill & Jones (1965) and in Anonimous (1981).

A such approach has been made in a research about the gneiss of the Sila Massif (Calabria, Sothern Italy), where the crystalline rock mass is deeply weathered (Guzzetta, 1974). The study has allowed to fit the data concerning the different landslide typologies and the landsliding evolution into the pregnant context of the morphological evolution of the slopes, also in relation to climate and tectonics. Six weathering classes have been adopted for the studied gneiss: fresh gneiss (class I), slightly weathered gneiss (class II), moderately weathered gneiss (class III), highly weathered gneiss (class IV), completely weathered gneiss or saprolite (class V), and residual and colluvial gneissic soils (class VI) (Cascini & *alii*, 1992).

The importance of a comprehensive outlook of the weathering processes patterns, also in order to have a correct territorial plannning and natural resources management, needs a cartographical representation of the weathering profile. This requirement suggested us to define a methodology for the survey and the mapping of the gneiss weathering grade, which applies to various scale and also to different types of crystalline rocks. It consists of a detailed survey on the field, which is based on a careful analysis of the outcropping rocks and soils through observations about consistency, discolouration and texture of the regolith and through the Schmidt Hammer test results on the weathered rock. The gneiss weathering grade has been estimated both at the rock specimen scale both at the rock mass scale. The weathering grade survey on cutslopes (Gullà & Matano, 1994) and the analysis of borehole cuttings has resulted useful in order to have data about the thickness and the features of the weathering horizons of the profile.

Some weathering grade maps at various scale have been compiled with reference to a study area located along the western slope of the Sila Massif. After a preliminary study about the weathering conditions along the slope and on the plateau of the massif, detailed weathering surveys of some sectors of the slope have been performed and various weathering maps with a scale among 1:5,000 and 1,200 have been produced. The scale 1:5,000 has been utilized for basic geomorphological studies about minor slopes and drainage basins or for landsliding studies with reference to a municipal territory. The scales among 1:2,000 and 1:1,000 have resulted useful for the morphological analysis of particular sectors of the slopes, for the study of the landsliding phenomena involving inhabited areas and for the arrangment of engineering-geological and geomorphological problems, such as those related to the planning of works and structures. The most detailed scale among 1:1,000 and 1,200 have been used for the study of single landslide phenomena.

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The North Fork Calawah watershed: dynamics of geomorphically complex landforms and salmonid fish production

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Although it drains a basin in one of the world's wettest climates, receiving about 280 cm of precipitation in a average year, seven miles of the North Fork Calawah River go subsurface every summer, and long reaches may go subsurface even in the wet winter season. This hydrologic regime has important ramifications for salmonid populations and can only be understood in light of the wathershed's glacial history. A formal process of environmental evaluation, called Wathershed Analysis, has led to better understanding of the complex landforrns and processes that have created this unique watershed.

The North Fork Calawah River drains 30.000 acres of the Olympic Peninsula, North America, and lies on the boundary between the stable northern edge of the peninsula and the Olympic Mountains. The Calawah Fault trends west southwest across the northern third ol the watershed; it has accomodated much of the uplift of the core of the Olympic Mountains. North of the fault are peripheral rocks of the Needles-Gray Wolf lithic assemblage and south of the fault are core rocks of the Western Olympic lithic assemblage (Tabor & Cady, 1978). Both assemblages contain poorly-indurated Tertiary lithic sandstone and siltstone derived from island are volcanics. High uplift rates ot the Olympic Mountains have led to oversteepened topography, and this, coupled with the soft bedrock has resulted in hillslopes shaped by mass wasting events, principally debris flows. The northern edge and northwest corner of the Olympic Peninsula have been overridden by continental glacial lobes that have advanced across the Strait of Juan de Fuca. During the last glacial advance, ice breached the northern boundary of the North Fork Calawah watershed at three low divides. The mainstem of the North Fork Calawah received large volumes of melt water and outwash, partially filling the entire length of the valley. The river has reclaimed much of its pre-glacial floodplain, but remnant terraces of outwash still remain.

Several river miles of the mainstem go subsurface during the dry summer months, and certain segments go subsurface between storms during the wet winters. Standpipes as deep as 40 feet have been driven into the channel and have gone dry during the summer (Larsen, 1987). Hydrologic calculations and geomorphic interpretations of hillslope profiles indicate that the drying reach must contain at least 150 feet of porous gravel and sand deposits. The presence of faceted spurs and small remnants of lateral moraines along the mainstem valley walls suggests that during some previous glacial episode an ice lobe in the eastern divide extended a considerable distance down the mainstem val-

ley. We hypothesize that this ice lobe eroded a wider and deeper valley than had existed under a purely fluvial regime, then filled the valley with recessional outwash as it retreated.
The variety of glacial landforms and phenomena in the North Fork Calawah Watershed have had both positive and negative impacts on the productivity of salmonid fish. The quantity of coho salmon and steelhead summer rearing habitat, very important to the productivity of these species, is unusually low in this watershed, limited by the drying reach. However, subsurface water flow through the drying reach provides cool water downstream, lowering thermal stresses on young fish rearing below the drying reach. The lower mainstem is protected from the direct delivery of debris flows from adjacent hillslopes by tbe wide outwash terraces which provide adequate run-out distances for complete deposition. Furthermore, evaluation of historic aerial photos suggests that the drying reach buffers sediment pulses derived from landslide events in the headwaters of the watershed. Sediment pulses from storm-triggered debris flows cause large channel disturbances, such as braiding of the channel, in the drying reach. These pulses do not continue down the mainstem channel, perhaps because winter flows in the drying reach are insufficient to propagate the pulses. It appears that sediment is metered into the lower mainstem. The protection from direct delivery of debris flows and the attenuation of sediment waves as they pass through the drying reach provide for a more stable channel, and, thus, more stable salmonid habitat below the drying reach.

TATIANA V. DIKAREVA

Transformation of fluvial relief as the result of irrigation (valleys and ancient deltas of the Rivers Murgab and Tedgen in the Central Asia)

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Oases of the Central Asia are the hotbeds of civilization. Irrigational activity in the Tedgen and Murgab oases began from the IVth millennium BC and goes on till our days. That's why the relief of valleys and ancient deltas of these rivers is significantly transformed. One can observe traces of ancient irrigational buildings together with modern canals, bars, dams and embankments.
In the relief of Murgab oasis there are a lot of ramparts, irrigational canals and collectors. All them are of anthropogenic origin. Some of them, for example, canals Sultan-Yab, Khurmuz-Fary, collectors Dgar and Kese-Yab are cleared and straightened branches of Murgab. These branches had natural levees which became higher thanks to reconstruction of river bed. These levees are several kilometers long and 0,5-30 meters wide at the tops. At the bottom their width is 300-500 m. Between these levees there are shallow depressions with gentle slopes (0,003-0,001) and flat bottoms. Dimensions of these depressions may reach 103 km^2. In spring the salinized lakes are in these depressions.
Initial alluvial-deltaic relief is only on the north-western edge of the Murgab delta. Here one can see low (up to 1 m) flat ramparts and shallow interstream depressions, opened to the north. Irrigational relief is clearly expressed in central and southern regions, where ramparts have maximum heights and interstream depressions are closed.
Along Murgab there are ravines. Young ravines have depth of 3-4 m and vertical slopes. Width of their bottoms in the mouth is sometimes 40-50 m. In the belt 150-200 m wide along the floodplain of Murgab there are suffosion craters 1-1,5 m in diameter.
The Tedgen delta has typical deltaic relief-fan-shaped branches (most of them are transformed into canals), natural levees, composed by light material. Many branches are filled up, but they are well seen on the cosmic photos. Sometimes one can meet lake depressions, filled with clay sediments. Today they are solonchaks. At the borders of the modern delta there are a lot of barkhans and aeolian sand hills. There are a lot of anthropogenic relief forms in the Tedgen delta-natural levees, «depes» and others.
Today the new agroirrigational relief is being formed on the ancient delta.

RICHARD DIKAU & LOTHAR SCHROTT

The temporal stability and activity of landslides in Europe with respect to climatic change (Teslec)

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«The Temporal Stability and Activity of Landslides in Europe with Respect to Climatic Change (Teslec)» was a research project supported by the European Commission which investigated from 1994 - 1996 the interrelationship between landslides, climate and time.
The project started working as a cooperation network of scientific institutions from six member states of the European Community (Germany, France, Italy, Spain, the Netherlands, United Kingdom). In the talk the project conception and the main project tasks and objectives will be presented. The project was based upon the fact, that available information on existing or relict landslides does not normally give either the quantitative characteristics or the physical background of the previous temporal patterns of behaviour. It is, therefore, difficult to indicate in a reliable way future patterns of actvities as a function of the past. Therefore, a more detailed diagnoses of activity requires

better historical data and field observation, whilst methods of modelling and analysis are required to improve the understanding of the processes and mechanisms involved.
The research objectives are focused on:
1. the development of criteria for the recognition of landslides including the publication of the book «Landslide Recognition»;
2. the reconstruction of past distributions of landslide incidents related to the change of various climate parameters;
3. the development of qualitative landslide evolution models and a hydrological and slope stability framework for the prediction of landslide activity evolved at test sites.
After the presentation of the main contents of the publication «Landslide Recognition», results and remaining problems of climatic and dynamic inferences from dated landslides and relationships between landslides and climatic conditions are discussed for different regions in Europe. Special emphasis will be given to the reliability of historical information from dated landslides and to the holocene landslide time series in relation to the question if the landslide carry a clear climatic signal.
In a second part the use of hydrological and slope stability models are discussed in terms of their contribution to a better understanding of the relationship between the frequency of the occurrence of landslides and precipitation patterns in the past. The project results show that this depends strongly on the landslide type and the frequency spectrum through time.
In the third part selected test sites are presented to evaluate the stability of future climatic change scenarios using coupled hydrological and slopes stability models. The results are related (1) to the evaluation of several hydrological and slopes stability models, (2) to the selection of specific hydrological and stability models and (3) to the discussion of downscaled results of global circulation models (Gcm) (see contribution of Dehn and Buma).
The results presented are related to different test sites in France, Italy and Britain. In a final statement a summary of the results and outstanding problems will be given.

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Neotectonics and geomorphology of South-Central Turkey: effects of orogenic collapse in an alpine collision zone

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The neotectonic evolution of south-central Turkey represents a classic example of orogenic collapse of tectonically thickened continental crust, and is controlled by an interplay of tectonic extension and strike-slip faulting starting in Oligo-Miocene time. The current geomorphology of this region is characterized by an «ova» regime, which consists of large, roughly equant complex basins (ovas) and a number of dispersed volcanic cones. Emplacement of Neo-Tethyan ophiolite nappes onto platform carbonates in the Late Cretaceous and subsequent crustal imbrication and S-vergent thrusting within the Anatolide-Tauride realm in the Early Tertiary were responsible for crustal thickening, high T/P metamorphism, and topographic build-up prior to the onset of the neotectonic phase in the region. The Nigde metamorphic massif (Nmm), north of the Inner-Tauride suture zone, is an isolated crystalline dome with a plastically deformed high-grade metamorphic and plutonic basement overlain by an unmetamorphosed sedimentary lid, and represents a Cordilleran-type metamorphic core complex. Unroofing of Nmm as a core complex was facilitated by erosional and tectonic exhumation in the upper plate of a N-dipping subduction zone in Cenozoic time. The Bolkar massif in the south is part of the parautochthonous Tauride carbonate platform and has experienced asymmetric uplift along a steeply N-dipping frontal normal fault in the northern foothills of the Bolkar Mountains. The fault zone is marked by a several-m-thick mylonitic breccia which contains ophiolite and carbonate material and down-to-the-north shear sense indicators. The rugged topography of the Bolkar Mountain range, with a high elevation of >3.5 km, is a manifestation of this rapid uplift in the Oligo-Miocene and subsequent glaciation in the Plio-Pleistocene epoch. The Ulukisla basin between the Nmm and the Bolkar massif represents a peripheral foreland basin developed along the Inner-Tauride suture zone during and after the closure of the Inner-Tauride branch of the Neo-Tethys and contains U. Cretaceous-U. Eocene marine strata overlain by Oligo-Miocene lacustrine and Miocene-Pliocene terrestrial deposits. The presence of several unconformities and distal depocenters in the Oligo-Miocene and younger strata and a corrugated backshed topography along the Nigde detachment fault suggests a supra-detachment evolution of the Ulukisla sedimentary basin in the late stage. The sinistral Tertiary Ecemis fault zone truncates the Bolkar massif and the Ulukisla basin on the east and contains Oligo-Miocene and younger fluvial and lacustrine deposits. The left-lateral slip along the Ecemis fault zone has accommodated both tectonic extension in the upper plate of the detachment fault along Nmm and internal deformation within the westward moving Anatolian wedge. Crustal deformation and orogenic collapse along the southern margin of the central Anatolian crystalline complex further north in the detachment hinterland was taken up mainly by strike-slip faulting along NW-(dextral) and NE-(sinistral) trending lineaments. A number of historically active composite volcanoes (i.e., Hasan, Erciyes) that consist of alkaline to calcalkaline lavas and pyroclastic rocks evolved along and/or at the intersections of transtensional strike-slip fault systems in this regime during the La-

te Tertiary-Quaternary. In summary, tectonic extension and strike-slip faulting during the neotectonic evolution of south-central Turkey are the consequences of orogenic collapse of thermally weakened and overthickened continental crust in the upper plate of a north-dipping subduction zone and the westward tectonic escape of the Anatolian block following the collision of Arabia with Eurasia in the Middle Miocene. The Central Anatolian «ova» province and its unique geomorphology are thus an artifact of this complex neotectonic evolution of an Alpine-style collision orogen in south-central Turkey.

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Morphogenetic effects of relative Holocene sea level changes in Southern Apulia (Italy)

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Along the coast of Southern Apulia many marine and aeolian landforms and deposits of Holocene age have been recognized. Their study can allow to reconstruct the Holocene evolution of the coastal area and to point out its tectonic trend in recent times.
Apulia region represents part of the Apenninic foreland and it is characterized by a 6 km thick Mesozoic carbonate platform sequence overlaid by thin discontinuous Tertiary and Quaternary deposits. The region was affected by uplift since Middle Pleistocene (after Pliocene - Early Pleistocene subsidence) probably due to the arrival of the Apulian thick continental crust to the Apenninc hinge. However, the rate of uplift is not uniform as transfer faults striking oblique or perpendicular to the main WNW trending normal faults break Apulia region in three main blocks with different rate of uplift (Gargano, Murge & Salento) divided by areas characterized by relative subsidence (Tavoliere and Brindisi-Taranto plain).
The coastal landscape of Southern Apulia is characterized by a straircase of marine terraces, more or less evident. Along the area close to present coastline the effects of relative Holocene sea level changes are detectable both on rocky coasts and on main beaches.
Some tracts of rocky coasts modelled on weak calcarenitic deposits are characterized by raised shore platforms of impressive width (up to 40 m), placed at altitude ranging between 1 and 3 m above sea level in same places bordered landward by a well-developed notch. Furthermore, submarine survey revealed the presence at about 4 m below sea level of either a submerged platform or openings of submerged sea caves. Good examples of these forms can be recognized near Monopoli, Otranto and on the Cheradi islands (Taranto).
The age of the emerged platforms can be inferred by morphological considerations and from the regional geological context. In fact, small patches of *travertino* and quarried blocks encrusted by Vermetidae coming from the edge of the present intertidal platform have been found on their surface. The former yielded a radiocarbon age of 1,350±80 years B.P. and the latter dated a catastrophic wave event occurred 2,060±50 years B.P. Furthermore, ancient pottery encrusted by red algae was detected on the Cheradi islands platform. On the other hand, the effects of the youngest Tyrrhenian sea level stand are recognizable along the coast of Southern Apulia at an altitude of about 8/10 m so that it seems reasonable to attribute the modelling of the raised platforms to the Holocene.
Several tracts of coast shelter pocket beaches or are represented by long beaches (i.e. along adriatic side from Torre Canne to Rosa Marina, from San Cataldo to San Foca, and near Alimini Lakes and along the Ionian side from Torre Sgarrata to Torre Lapillo and from Torre San Giovanni to Torre Vado). Their landward border is often characterized by two main aeolian units represented by dune belts behind the main long beaches or by small dune fields fed by pocket beaches. Both the aeolian units are characterized by pulmonate Gastropods (mainly Helix sp., Pomatia sp., Rumina sp.) which have been the object of numerous radiocarbon age determinations.
The older aeolian unit is represented by grey or pale reddish sands, partly cemented and showing a well-developed high-angle cross lamination, which in Rosa marina locality grades downward to beach deposits characterized by bioturbation of Echinoids and placed at about 1 m above sea level. Along the Adriatic side of southern Apulia this unit constitutes the core of present dune belt and outcrops along coastal tracts in severe erosion. On the contrary, along the Ionian shoreline this aeolian dune shows the foot 1 m below present sea level and it is often cut by present cliff. Several radiocarbon age determinations carried out on samples coming from both the Adriatic and the Ionian side of southern Apulia point out for this unit an age of about 6,000 years.
The younger aeolian unit is made by brownish or greyish loose sands characterized by the presence of numerous decimetric levels of brownish soil. This unit often covers the older Holocene aeolian unit by a thin brown paleosoil. Radiocarbon age determinations yielded an age of about 2,500 years B.P. Small patches of younger aeolian deposits have been recognized along several coastal tracts and radiometrically aged to 500-800 y B.P.
The collected data suggest a relative high sea level stand in mid-Holocene times. The altimetric position of forms genetically linked to this sea level stand stresses the different rates of uplift which characterize the four main structural blocks recognized in southern Apulia, i.e. the Murge, the Taranto and Brindisi plains, and the Salento peninsula.

MIHAELA DINU

Geomorphological hazards in the Getic Subcarpathians and Piedmont

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The Subcarpathians are recognized as being one of the regions in Romania most affected by intense geomorphological hazards.
The Getic Subcarpathians, (the south-western part of the Subcarpathians) and the Getic Piedmont, are hilly regions in the South of the Southern Carpathians which have a common and unique Quaternary and present-day evolution. Built of folded and faulted Neogene molasse (Getic Subcarpathians) and Quaternary deposits (Getic Piemont), associated with a continental type of precipitation and specific land-use (forest, pasture, orchard, arabil land) the regions have very large areas affected by landslides and slumps and intensive erosion. Many of the landslides and debris-flow deposits exist in a fragile equilibrium, ready to becoming destabilized by intense precipitation or seismic activity. After a humid period (specialy May-June) associated with snow melting, some catastrophic events happened. Large areas are covered by mass movements and gully erosion. Some of them are affected villages, routes, railways, because the regions are also very old and well populated.
From the diversity of geomorphological hazards some case-studies are presented herein.

NELSO C. DOFFO & GUILLERMO SAGRIPANTI

Modification in recent dynamics of hydric and fluvial processes as indicators of neotectonic activity in Sampacho, Cordoba, Argentina

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The structural pattern for the perimountain area that drains the eastern slope of the plutonic-metamorphic complex called Sierra de Comechingones, consists of differentially thrusted and tilted blocks, mainly towards the East and South East with asymetric profiles of steeper slope on its western front. These profiles, at regional level, constitute the most important factor in relief control, defining in depressed sectors, alluvial accumulations and basin divisions in structural hills, some of the them with base outcroppings. The superficial drainage, besides presenting a marked structural control, shows evidence of neotectonic activity favoring the development of new processes and intensifying the increase in vertical crack rate, piracy and drainage network hierarchy, among others. The dynamics of undergroud water is greatly influenced by the structure, as shown by the presence of marshes and lacoons along the failure scarpment. Most of the zone is covered by holocenic deposits of eolic and alluvial origin, with slopes ranging from 1 to 3 %.
The seismological history, the remarkable seismic activity rate and the geological and geometric characteristics of the existing structures define the region as seismically active with an effect on the neotectonic dynamics.
The antagonic response of exogenous agents masked, as in this case, by climatic variations and by the farming activities developed on this soil, shows however qualitative and quantitative differences in those tectonically active sectors.
The purpose of this paper is to propose a methodology that would allow on the one hand to define from the analysis of exogenous dynamics, the presence and activity of potential earthquake generating structures, and on the other, to be used as a tool for the prediction and estimation of earthquake recurrence in failures of interplate regions considered nowadays to be aseismic.

WALTER DRAGONI & DANIELA VALIGI

Some considerations regarding climatic change and specific erosion in Central Italy

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Global Circulation Models (Gcms) predict a rise of between 0.5 to 3 °C in the average atmospheric temperature in the Mediterranean area over the next fifty years, based on the increase in the amount of CO_2 in the atmosphere. The predictions for precipitation in the Mediterranean area are less certain: according to the different models, it could vary between +30 % and –30 % of the current mean values (Wigley, 1992; Ipcc, 1995). This variation will undoubtedly have an effect on the hydrological cycle. The analysis of the longest and most reliable time series for central Italy (Perugia and Rome) indicate that a rise in temperature of approximately 0.5 ÷ 1°C/100 years and a decrease in rainfall of about 2 mm/year are now taking place. These climatic variations, regardless of their causes, involve significant geomorphological consequences, the most evident being the phenomenon of soil erosion. In the absence of measurements, soil erosion can be estimated using empirical formulas. That which is most commonly used, although it is not very recent, is the Fournier formula (1960):

$$\log D.S. = 2.65 * \log (p^2/P) + 0.46 * \log (\overline{H} * tg\ \alpha) - 1.56$$

where:
D.S. = specific erosion ($t/km^2/yr$); p = rainfall in the rai-

niest month of each year (mm); P = annual rainfall (mm); ($\overline{H}$ *tg α) = orographic coefficient (m).
The analysis of monthly rainfall data for Rome time series indicates that the p^2/P ratio tends to decrease. In order to have an idea of the effects of such decrease, the Fournier formula was applied to the data of Rome (tab. 1), with an orographic coefficient of 16.50, as in the Fournier work.

TABLE 1 - Variations in p^2/P and D.S. in the basin of the Tiber River

Station	Period	p^2/P	D.S. (t/km^2/yr)	D.S. variation (%)
Rome	1882 - 1938	47.9	2837	—
	1939 - 1995	42.0	2003	– 29

Actually in the last few decades in Italy there has been a considerable decrease in solid transport, with serious damage to structures (bridges) taking place and erosion at most beaches (Martinis, 1988). These are attributed in general to man's activities (dams, excavating of inert materials from river beds, etc.). Man's activities are certainly the major cause of these phenomena; however in light of the data given in Table 1, perhaps it is necessary to consider whether the variations found in the p^2/P ratio might not contribute in some way to the actual decrease in solid transport.

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Runoff and sediment loss following bushfires in eucalypt forest, Australia

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Bushfires are an integral part of the Australian environment and vegetation has largely adapted to this by developing mechanisms for rapid regeneration. Woodlands and forests of *Eucayptus spp* occur within the Sydney metropolitan region, and in the nearby Blue Mountains. Bushfire activity was widespread in eastern Australia during 1994 when much of the region was affected by drought. Fires are common in the Blue Mountains: more than 400 bushfires have been documented over a 28-year period. The eucalypt vegetation, mild climatic conditions and rugged terrain contribute to a high fire susceptibility.
Increases in soil erosion following fire have been reported previously in eastern Australia. Rates of sediment loss in the post-fire landscape are affected by fire intensity. This study compared runoff and sediment movement on land which had been subjected to high, moderate and low (unburnt in the last fire) intensity burns. A total of 12 sediment plots were sited in upper and lower slope positions with gradients ranging from 11 to 13 degrees. Plot design followed that of Riley & *alii,* (1981) and each plot measured runoff and sediment yield from an area of 8m^2. A total of 4 closed and 4 open plots were installed on high and medium intensity burn sites in upper and lower slope positions. On the low intensity burn site, 2 open plots were constructed in each of the upper and lower slope positions. Monitoring of runoff plots extended over a six-month period during which 11 collections were made. Rainfall for the first eight months in 1994 was only 423 mm, less than half the long-term average.
Combined cumulative runoff for the 4 plots in upper and the 4 in lower slope positions was 250.5L and 250.9L respectively. Runoff from the high intensity burn plots had a mean value of 11.8L for the 11 collections, the moderate intensity burn plots 7.1L, and the unburnt plots 2.9L.
Sediment yield included surface wash, bioturbation, and organic matter. Surface wash averaged 111.5g from plots on slopes with a high intensity fire; 60.5g for slopes with a moderate intensity burn; and 6.8g for the unburnt slope. Large variation occurred between the 12 plots on all collection days. Total surface wash was 4906g for the high intensity burn slope, 2660g for the moderate intensity, and 299g for the unburnt slope. The lowest leaf material addition occurred on the unburnt slope, and the highest on the slope with a moderate intensity fire. Bioturbation, involving mainly ants and animal scratchings, was identified in 33 % of the sediment collections. The highest contribution of bioturbation to total sediment movement occurred on the moderately burnt slope.
Fire intensity influenced the amount of total downhill sediment movement, with the greatest amount being collected from the plots on the moderately burnt slope. However, no significant difference occurred between total sediment collected from the high and the moderate intensity burns. Significantly more sediment was collected on both of the burnt slopes compared with the unburnt slope. Both runoff and surface wash were greatest on slopes with high intensity fires, and lowest on unburnt areas. When bioturbation and organic matter were included in total downhill movement, losses were highest on the moderately burnt slope and least on the unburnt slope.

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Influence of climatic changes on travertine deposition during Holocene: a new hypothesis

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Observations made in different parts of the world (Goudie & *alii*, 1993; Berakhi & *alii*, in press; Calderoni & *alii*, in

press) show that, during the Holocene, travertine has been deposited by spring waters fed by limestone aquifers. The production of travertine generally started in the Early Holocene and ended (or underwent a strong decline) after 4,000 yr. B.P.

A satisfactory explanation of that is not yet available though different hypotheses have been proposed by several authors (see Goudie & *alii*, 1993): some of them point out the influence of climatic changes, while others invoke the effects of human impact. However, no specific reference has been made to a possible role of spring water temperature changes, notwithstanding their well known influence on calcium carbonate dissolution equilibria. In particular, differences between lower temperature of ground waters (influenced by deep penetration into the limestone bedrock of Late Pleistocene surficial temperatures) and higher external temperature at the spring may have played an important role.

The infiltrating waters, enriched in CO_2 by percolating through the new formed soils, acquired higher $CaCO_3$ dissolution capacity because of underground temperatures colder by several °C. The higher temperatures at the emergence, in connection with algal-bacterial activity, may have caused loss of CO_2 and travertine deposition.

This process may have continued for a long time because of the low thermal capacity of limestone, the ground water circulation through a wide network of fissures within large volumes of dry rock, and the progressive increase of athmosphere temperature during Lower-Middle Holocene.

KEVIN G. DRISCOLL & JOSELITO M. AROCENA

Classification and genesis of selected pedons in the Central Interior of British Columbia, Canada

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Fifteen selected pedons were sampled from the very wet, cool Sub-boreal Spruce biogeoclimatic zone in the central interior of British Columbia, Canada. The study area, which was deglaciated ca. 10,000 BP, is located west of the Rocky Mountains. The surficial materials are sediments and till laid down at the close of the Fraser Glaciation. Glacial fluvial, glacial lacustrine and colluvial processes were the predominant forces involved in laying out the parent material for the current soils. The primary sources of this material were the Rocky and Mackenzie Mountains to the east and north of our study sites. Elevations range from 820 to 1070 metres above sea level with slopes between 5% and 63%. Mean annual soil temperatures range between 1.2° and 2.5°C. Over 960 mm of precipitation falls annually, including over 328 cm of snow with levels increasing with altitude. The vegetation of this region is dominated by hybrid white spruce (*Picea engelmannii x glauca*) with lesser amounts of subalpine fir (*Abies lasiocarpa*) and an understorey of devil's club (*Oplopanax horridus*), thimbleberry (*Rubus parviflorus*), huckleberry (*Vaccinium spp.*), fireweed (*Epilobium angustifolium*) as well as other herbaceous shrubs and grasses.

Six of the pedons were classified as Eluviated Dystric Brunisols (Typic Cryochrept and Typic Haplocryod), one pedon as a Gleyed Eluviated Dystric Brunisol (Typic Cryaquod), five as Orthic Humo-Ferric Podzols (Typic Haplocryod), two as Orthic Gray Luvisols (Typic Cryoboralf), and one as Rego Humic Gleysol (Oxyaquic Cryoboroll). Sodium pyrophosphate extractable Fe (Fe_p) and Al (Al_p) was noted in one of the Luvisols, however, the eluviation of clay (A horizon = 5% clay and B horizon = 12.4% clay) superseded the podzolic soil (Bt1 horizon: (Fe_p+Al_p) = 0.89%; Bt2 horizon: (Fe_p+Al_p) = 1.1%) in the Canadian System of Soil Classification. The Eluviated Dystric Brunisols showed signs of Fe and Al movement, though not enough to satisfy the requirements of Orthic Humo-Ferric Podzols. Levels of Fe_p for the Brunisols ranged between 0.12-0.36% and the podzolic B horizons in the Orthic Humo-Ferric Podzols were 0.41-0.63%. The (Fe_p+Al_p) levels were 0.30-0.47% for the Brunisols compared with 0.54-0.95% for the Podzols. Similarly, the (Fe_p+Al_p)/clay levels in the Brunisols ranged from 0.014-0.24% compared with 0.072-0.36% in the Podzols. The Luvisols seemed to have formed from different parent compared to the Brunisols and Podzols. With the exception of the Rego Humic Gleysol, all the pedons were believed to be zonal soils.

Incipient podzolization seems to be the dominant pedogenic process in the area. The sandy parent materials, cool temperatures and high precipitation rates provide a mechanism conducive to the translocation of organic acids with or without Fe and Al into the B horizon. With time, it is anticipated that the Eluviated Dystric Brunisols will develop into Orthic Humo-Ferric Podzols. The Gleyed Eluviated Dystric Brunisol will probably develop into a Luvisol as it has been formed on different parent material and showed some degree of clay eluviation.

Lessivage is also an active process within the region. Increases in clay content with depth for the two Luvisols ranged from 5-7.9% in the Ae horizons to 12.6-13.4% in the Bt. Four of the Brunisols (A horizons ranged from 4.8-15.2%, B horizons ranged from 5.4-16.4%) and two of the Podzols (A horizons ranged from 2.8-9.2%, B horizons ranged from 5.2-9.6%) showed lower increases in clay content from the A to B horizons.

Gleyed features in pedons resulted from changes in microtopography. The Rego Humic Gleysol was formed on colluvium at the base of a relict avalanche which explained the poor drainage and high level of organic matter found in this pedon. Water seepage was found within a sand layer at a depth of 59 cm in the Gleyed Eluviated Dystric Brunisol.

VALENTINA A. DROUCHITS

Formation of the Issyk-Kul Lake bottom relief

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From the geological point of view the Issyk-Kul lake depression can be divided into four parts (west, north, east and south). These distinctions are inherited by lake geomorfology. All these parts have general features of relief and differences have local character. On the base of bathymetric map, serie of seismogeological sections and coastal drilling materials the geomorphological scheme for Issyk-Kul lake depression was compiled. It was distinguished four major stages for relief formation:

1. stage. Eopleistocene - Early Pleistocene

a) Formation of bottom and slope (700-300m), Eopleistocene

b) Formation of ancient submerged lacustrine plain (300-200m), Eopleistocene-Early Pleistocene.

c) Formation of deepwater wedge and canyons, Eopleistocene-Early Pleistocene.

2. stage. Middle Pleistocene-Late Pleistocene (first part). Formation of gently sloping surfase (200-100 m)

3. stage. Second part of Late Pleistocene

a) Formation of submerged alluvial-lacustrine plain (100 m - recent level)

b) Formation of submarine valleys (recent level - 100 m).

4. stage. Holocene

a) Formation of coastal area relief (+15 - –20m)

b) Formation of bottom microrelief

The first stage of relief evolution is caused by global event such as Naryn phase of Late Alpine orogenic epoch. The glacial epoch is respondent for the second stage genesis. The third is associated with regional falls of lake levels in arid zone in the North Hemisphere. The last stage is conditioned by complex of local processes.

At the base of seismoacoustic profiles it is possible to determine the relief genesis for Late Pleistocene. It was not revealed clear features of glacial relief. Probably the present lacustrine shelf was aggradation plain. Its west part developed under of subsidence conditions, but east part tested intensive raising. Western cutting valley system is rather shallow, there are burried valleys. The facial replacement could be to observe from thin to coarse ones from submerged valley to coastal area on seismogeological sections.

At present on satellite photos the block structure of lake depression is very good displaied, but on the seismic profiles only the large blocks can be mark out. The Holocene stage also can be characterized by different types of microrelief. In the north and east parts hemogenic microrelief is predominated, while the central shelf area is recognized by biogenic and hydrogenic microrelief. For the north slope and whole south part the slumps are typical forms.

There are clear changes between all environment stages despite of palimpsest character for some ancient surfase relief. For Late Pleistocene and Holocene in amplitude and distribution of relief and also in correponding deposit thickness particularly it is noticeable. Naturally the formation of meso-and microrelief during all these stages depended on local endogenius and exogenic processes, but general features of lake bottom relief are related to global changes.

RUSSELL DRYSDALE

The Biogeomorphology of meteogene travertines from a tropical karst: the role of hydrodynamics and some implications for interpreting travertine fabrics

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Louie Creek is a karst spring-fed creek which drains the northeastern Barkly karst, tropical northern Australia. The stream deposits travertine along a reach of approximately 1.5 km. The travertines occur primarily as a series of barrages; waterholes of up to several hundred metres in length separate sets of barrages, act as sediment traps and host stromatolitic travertines. All travertines are composed primarily of calcite with traces of aragonite and insoluble material. Carbonate precipitation commences once the source waters reach approximately 3 to 5 times supersaturation with respect to calcite.

Although physico-chemical processes dominate the downstream evolution of the bulk solution, biota play both a direct and an indirect role in travertine deposition at the microenvironment level. The two most significant biotic groups at Louie Creek are aquatic insect larvae and microbes. By far the most important insect order is Trichoptera (caddis flies), which is dominated by genera of the superfamily Hydropsychoidea. Several hydropsychid genera construct cylindrical cases and silk nets on the travertine surfaces. The cases consist of local materials, including travertine quarried from the stream bed. The nets are usually erected between cases or constructed over the case opening and serve to trap food carried downstream in suspension. Nets and retreats are usually aligned ~normal to stream flow in successive linear arrays, which protrude up to 10 mm above the travertine substrate. Microrelief of this magnitude probably enhances turbulence, giving rise to increased carbon dioxide outgassing; such a phenomenon may explain why the nets and cases become heavily encrusted with calcite, even where 'background' rates of travertine deposition are low. Larval activity may also be used as a palaeoenvironmental indicator: many larvae at Louie Creek, such as hydropsychids, tolerate a relatively narrow range of hydrodynamic conditions, and their activities (such as case-building) produce distinctive sedimentary fabrics.

As with meteogene travertines elsewhere in the world, the dominant microbes associated with the Louie Creek tra-

vertines are cyanobacteria. The precise role of microbes in travertine deposition is still in dispute, especially in meteogene environments. However, travertine fabric and microstructure are unquestionably related to microbial activity. In the tropical environment of Louie Creek, variations in microbially-controlled fabrics appear to be related to local hydrodynamic changes rather than climatically-induced constraints on microbial communities, which is largely the case with meteogene travertines from temperate regions. Travertines showing alternating microbial and larvae fabrics are similarly the result of hydrodynamic changes. Such hydrodynamic control has implications for palaeoenvironmental interpretations of fossil travertines.

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Fluvial changes in the Calore River watershed during the last century (Southern Italy)

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The Calore River is a left hand tributary of the Sele River which flows into the Salerno Gulf (Thyrrenian Sea - Southern Italy), The main water course stretches 82 km, with an average profile slope of 1,4%, draining a watershed of about 680 km^2 with an average altitude a.s.l. of 650 m. The Calore River watershed has been chosen for the evaluation of recent fluvial changes because of the scarcity of river control manufacts until today: since 1994 it belongs to the Cilento «National Park». Moreover this watershed shows most of the peculiar features of the Southern Italy landscape: - the mountain relief, forming the major drainage divide, consists of carbonate massifs (Mts. Alburni - 1742 m , Mt. Cervati - 1899 m, Mt. Motola - 1745 m, Mts. Soprano-Chiaianello - 1318 m) with a coarse drainage network (1-2 km/km^2) and several endoreic areas of karst origin; - the hilly central part of the watershed is characterised by flysch terrain where both landslides and fluvio-denudation take place and originate a medium density drainage network, strongly influenced by local lithological variations; - the terraced alluvial plain constitutes a small portion of the watershed and is partitioned in 3 major terraces, an older dissected Pleistocene coarse debris (Persano group Auct.) terrace, and two Olocene terraces, which are crosscut by the last 30 km of the meandering Calore River.

In order to evaluate the influence of the climate, and hence the hydrologic regime, on fluvial geomorphologic changes, data since 1920 concerning temperature, precipitation, fluvial and spring discharge, as well as man made water catchments, have been used to calculate the time variations of the water balance and the recurrence time of major floods. The fluctuations of the water balance have been analysed on the basis of the most widespread evapotranspiration formulas, used in literature, looking at the monthly data and applying a Gis regionalization of point data. As far as the springs regime is concerned, both direct measurements and estimates based on summer fluvial discharges have been analysed, showing the increase in underground water exploitation during the last decades. The floods have been studied on the basis of both large events, followed in the field, and historical hydrological record, looking at the hydrometric levels associated to the bankfull stages and overbank discharges, furthermore an estimation of the long term variations of peak discharges has been attempted starting from the yearly maxims.

The erosion regime has been evaluated, according to a quantitative geomorphology approach, by digitising the whole drainage network and calculating drainage density and Strahler's ordering parameters. The estimated total yearly solid discharge for each III order drainage subbasin has been hence attributed to its confluence with the main river talweg. So the effect of these confluences upon the Calore River path has been studied and the possible relations between sediment yeld fluctuations, associated with climate and landuse, and the evolutionary trend of the main water course have been evaluated.

The analysis of the fluvial bed variations in the alluvial plain has been carried out by: geomorphologic mapping at 1: 10,000 scale, multitemporal comparison of topographic maps drawn from 1745 to 1994, overlapping of about hundred cross-sections of the river bed at gauging sites. On the whole the river bed shows neither vertical erosion nor deposition. As demonstrated by the study of the fluvial sections and by the geomorphologic mapping, only 1 m scour and fill yearly fluctuations, related with floods and summer low levels, have been observed. The river path, instead, varied from anastomozing to meandering, with a width decrease reaching 50% and a sinuosity increase to about 1.6, associated with a lengthening of the water course of about 9 km in a century.

At present, in these geomorphic processes a key factor seems to be the agricultural exploitation of the alluvial plain, with the machinery flattening and compacting of the river bank zones and the abandoning of the bankfull stage slopes. This kind of landuse strengthens the natural tendency of the river toward meandrification because the abandoned zones are covered by a composite vegetation (also with large trees), which protects the slopes from erosion during floods. In fact, looking at large floods in the field (December 1993, November 1996), in the flooded Holocene terraces, with a depth of water over 2 m, marked discharge and erosion processes were confined to a few sites, showing a peculiar water flux regime, mostly due to obstacles (i.e. trees, guard-rails, etc.).

In conclusion the recent evolution of the Calore River can be depicted as a slow fluctuating tendency toward meandrification, in relation to the present day climate and lan-

duse. The human activities, although not interacting directly with the river bed, influence this evolution as far as the summer discharge and the landuse are concerned and probably mask the effect of the global climate change upon the fluvial evolution.

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Corrélation entre les paléorivages étagés de Calabre méridionale et les variations climatiques rapides enregistrées entre ~130 et ~60 ka

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La découverte de nouvelles lignes de rivage en Calabre méridionale aboutit à menre en évidence une série d'au moins 13 paléorivages étagés entre 43 et 157 m. Ce dispositif géomorphologique étant observé sans changement significatif sur une fa ade côtière de près d'une cinquantaine de kilomètres permet d'écarter la séismicité pour expliquer un tel étagement. Les paléorivages sont l'expression géomorphologique de maxima glacio-eustatiques. Le plus élevé à 157 m (cf. Dumas & *alii*, 1987, B. Dumas & *alii,* 1988) correspond à la plus haute ligne de rivage à *Strombus bubonius* attribuée au stade 5e (130 ka). On en déduit une vitesse de soulèvement de l'ordre de 1,20 m/ka. Le plus bas (43 m) est daté de 59 ± 5 ka par thermoluminescence (S. Balescu & *alii,* sous presse).
Dans cette tranche d'altitude, des mesures précises montrent que la dénivellation entre deux paléorivages successifs est le plus souvent inférieure à 10 m. A vitesse de soulèvement supposée constante, l'écart d'altitude entre deux paléorivages dépend du laps de temps qui sépare deux maxima glacio-eustatiques successifs et de l'altitude relative des paléoniveaux marins correspondants. Il existe donc une relation entre ce faible écart d'altitude et la rapidité des oscillations climatiques responsables des transgressions.
Dans cet intervalle de temps, des lignes de rivages peuvent être corrélées avec des pics climatiques chauds de courbes isotopiques obtenues à partir des inlandsis groenlandais et antarctique (Grip, Gisp2, Vostok). La ligne de rivage soulevée à 117 m peut être attribuée au pic isotopique de stade 5c dont l'âge est estimé à 106 ka (IS24), le paléoniveau marin correspondant étant à -10 m. Sachant qu'il existe trois lignes de rivage entre 157 m et 117 m, quatre lignes de rivage ont été fa onnées pendant le stade 5e. Les divergences qui existent entre les courbes à propos du nombre et de l'âge des pics ne permettent pas de préciser davantage les corrélations. A titre purement hypothétique le rivage de 145 m pourrait etre rapporté au pic de 118-120 ka, celui de 129 m au pic de 112 ka.
Toutes les courbes comportent un pic très net à 81 ka (IS21). La transgression correspondante s'est inscrite sous la forme d'un rivage porté à 85 m, le paléoniveau marin étant à -12 m. Comme il existe deux lignes de rivage à 106 m et 95 m entre 117 m et 85 m, on en déduit que le stade 5c est représenté par trois 1ignes de rivage, celle de 106 m étant corrélée avec le pic de 103 ka (IS23) et celle de 95 m avec un pic à 96 ka. Il existe un pic à 87-9Oka (IS22) mais le rivage correspondant n'a pas été repéré sur le terrain. Dans l'intervalle 81-60 ka, Dansgaard & *alii* (1993) ont identifié deux interstades, IS20 et IS19, respectivement à 72 et 68 ka. Or entre 85 m et 43 m il existe au moins quatre paléorivages. Cela signifie que la Calabre a enregistré non seulement les transgressions majeures mais également de plus faibles pulsations, visibles sur les courbes isotopiques à 79 et 65 ka (Grip, Gisp2).
Au total l'écart moyen entre les maxima transgressifs est de 6,4 ka mais s'il peut s'étendre jusqu'à 10-12 ka, et s'abaisser jusqu'à 2 ka. Ainsi le soulèvement de l'extrémité de la Calabre méridionale a permis à cette région d'enregistrer un grand nombre de variations glacio-eustatiques qui reflètent les oscillations climatiques déduites des courbes isotopiques tirées des inlandsis. L'ensemble des paléorivages étagés est l'expression géomorphologique à haute résolution des oscillations climatiques rapides.

JEAN F. DUMONT

Fluvial mobility in tectonic basins: respective effect of tectonic control and paleoclimatic rhythms

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The surface of flexural basins are prone with abandoned river traces. The reconstitution of successive river occupation using radar and Spot images provides evidences of multi-staged directional shifts over more than one hundred of kilometers, longitudinally as well as laterally to river courses. Upstream and downstream connections with the present rivers give evidence of the successive shift of the main position of the drainage during recent times (Late Pleistocene to Holocene).
The position of the successive stages of fluvial traces (data set 1) is analyzed in relation to subsurface structures (data set 2) and recent tectonics (neotectonics and seismotectonics) of the basin and its margins (data set 3). The superimposition of the three sets of data shows spatial and timing correlation suggesting a structural control of river setting by active deformation. Examples are presented from the Marañón and Beni Subandean Basins (Peruvian and Bolivian Subandes), as well as from the Pannonian Basin (Hungarian foreland basin). In the Subandean Basins

the shifts and deflections of the Marañón, Ucayali and Beni rivers are controlled by faults issued from the foothills margin. Shifts of the Tisza River in the Pannonian Basin are related to the change from extensive to compressive tectonics during the Holocene, that result in jumps from graben to strike slip fault controlled positions.

Meanwhile, the tectonic related setting of river traces does not explain completely the process of major river shift. In most cases the well preservation of abandoned traces suggests that the process of abandonment was probably very sudden. But the rate of tectonic deformations in subsiding basins is probably not enough to give account of the phenomenon, except in some cases where river shift is correlated with a precise and morphologically identified tectonic event. A study of the lower Ucayali River near Jenaro Herrera (East Marañón Basin, Peru) shows a directional migration of the river related to quaternary faulting. A detailed study of the sequences of meander construction in the area of asymmetrical migration of the river belt toward the faulted margin of the basin shows a correlation with the periods of wet paleoclimate.

Position and timing of large river shifts suggest the following interpretation. During periods of relatively dry climate, a lower discharge produces underfit channel patterns, and the river is stable inside his traces despite the continuation of tectonic deformation. At the onset of a wet period the increase of discharge favors river mobility and overpassing of the previous underfit traces. The new channel will move toward the new area of active subsidence and deposition where a new meander belt is progressively built.

HELEN M. DUNSFORD & DAVID L. HIGGITT

Sediment supply as a control on alluvial and debris cone development, Scotland

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A number of studies in upland Britain have demonstrated that alluvial fans and debris cones, formed and stabilised during early de-glaciation, show evidence of recent aggradation and incision. Renewed activity is particularly evident during the last 300 years and a key issue is whether these changes relate to increased storminess or anthropogenic activity. As part of a wider study of regional variation of fan morphology and sediment dynamics, the role of catchment sediment availability as a control on supply to fans and cones has been investigated. It is suggested that the removal of paraglacial sediments from slope storage leads to an exhaustion effect in which sediment production becomes insufficient to maintain active fan aggradation. In the paper, two catchment reaches in Scotland (Glen Etive, in the Western Highlands and Yarrow Water in the Southern Uplands) are selected for detailed examination because of the differences in their glacial history and a potential variation in sediment availability.

The distribution, type and form of fans and cones and the morphological characteristics of their supplying basins have been evaluated using a combination of aerial photography, map analysis and field investigation. Differences in lithologic erodibility, sediment storage within a drainage basin and main reach characteristics, such as valley width and valley gradient, were examined to investigate fan-basin area relationships at each site and determine the relative importance of spatial variation in sediment supply. Radiocarbon dates taken from two sections at each site has established the time scale of fan formation. Mineral magnetic, heavy metal, and particle size analysis has been used to characterise the source of sediment, its mode of deposition and their sequential change. As sediment supply is depleted within the contributing basin, a switch from till as a source to bedrock-derived sediment will occur. Whereas much previous research has focused on individual stratigraphic sections, the current project is concerned with variability within and between catchments. An integrated approach, using a combination of morphologic and sedimentologic techniques, can help decipher the changing nature of alluvial fan and debris cone dynamics in upland Britain.

JUDY EHLEN

Fracture characteristics in weathered granites

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The variability of weathered materials is an important factor in the geotechnical characterization of rock for engineering purposes. Most engineering classifications include weathering schemes that separate the weathering profile into zones or grades that depend upon the engineering and geological properties of the rock. Many geotechnical characteristics, including weathering, are controlled by the density and arrangement of fractures within the rock, but the relationships between fracture patterns and weathering grades are typically not addressed.
Fracture characteristics were investigated in 13 exposures in 5 study areas in weathered Daebo granite in South Korea. All weathering grades were present, but never in the same exposure. Two approaches were used to evaluate the field data: (1) joint spacings were tabulated and examined within each weathering grade (tabulated classification); and (2) each exposure was classified according to the dominant weathering grade (visual classification). Mean joint spacings and joint spacing frequency distributions were analyzed and compared statistically for each approach. The effects of aspect and topographic position on weathering grade were qualitatively evaluated, and fractal dimensions were calculated for exposures classified visually in each weathering grade.
The tabulated classification scheme produced realistic results whereas the visual scheme did not. Mean joint spacing is about 25% closer in weathered granite than it is in fresh granite, but the difference is not statistically significant. The joint spacing distributions, however, are statistically significantly different between weathered granite and fresh granite, but there are no significant differences among the joint spacing frequency distributions for the different grades of weathered granite. In an engineering context, jointing spacing relationships in the various grades of weathered granite can thus be treated as the same regardless of weathering grade; joint patterns in fresh granite must be evaluated separately. This knowledge could result in significant time and cost savings in the geotechnical characterization of these materials.

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Late Quaternary shorelines in the Central Adriatic coast (Italy)

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The late Quaternary shorelines between the Po River Delta and the Tronto River (Central Adriatic coast) have been reconstructed on the basis of geomorphologic features and subbottom data. Their evolution has been controlled both by glacio-eustatic variations and tectonic movements.
The coast line north of Rimini corresponds to the subsiding zones of the Po plain, with a subsiding rate of 1 to 2 mm/year ; the coast is generally rectilinear and sandy. The southern tract corresponds to the North Marchean arcs, generally stable or involved in a slow uplift (less than 0.1 mm/y). The coast is more irregular with wave-cut cliffs and narrow coastal plains, intersected by large river plains.
In the northern zone, the depositional sequences and the Flandrian transgression surface have been detected by drillings data. A Flandrian shoreline, the highest one, is located inland 12 to 2 km far from the present shore, at heights ranging from –21 to –9 m. A drowned barrier coast dating back to 8,000 y B.P lies at about 30 km far from the present coast, at 40 m depth. The Roman shoreline (about 2,100 - 1,900 y B.P.) is located 6 to 1 km inland.
In the southern areas, two conditions occur: where the coast is cut in hard rocks (i.e. in the Pesaro and Ancona promontories) the two shorelines (Flandrian and Roman), are external to the present one. Where soft sediments are present, the coast is straightened and the two lines are internal to the present shoreline, marked by continuous scarps. An older wave-cut cliff and a platform is present at about 19-25 m depth, clearly produced by a standing interval during the Late Postglacial rise (Boreal?). The coast line in all likelihood corresponds to the drowned barrier island above described in the northern subsiding zone. Between Ancona and Tronto rivers mouth an higher submerged wave-cut cliff is present at depth of 6-10 m, probably related to the Atlantic Period.

BERND ETZELMÜLLER [1] & JOHAN LUDVIG SOLLID [1]

The use of geomorphometry on glacier surfaces. Examples from Spitsbergen

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The importance of relief as a governing factor for geomorphological processes such as mass movements and runoff generation has been recognized in geomorphology. In geomorphometry a quantitative description of the relief is achived by adapting a surface function to the topography. From the surface function and its derivatives, a variety of relief parameters can be derived: the surface elevation (*altitude*), the surface gradient (*slope*), the exposure of the slope (*aspect*) and the slope form (*curvature*).
A glacier is a dynamic feature, with a constantly changing surface. During a glacier's advance or retreat the surface topography, such as elevation, slope, surface texture and surface curvature, changes. As the surface topography can

be mapped by photogrammetric methods based on terrestrial or aerial stereo photographs, one gets a tool to quantify long-term glacier surface changes. This has been done in many years, mainly for analysis of the mass balance (analysis of surface elevation change) or to measure surface flow velocities. In the latest years geographical information technology (Git) has been applied for this purpose.
This presentation presents an integrated approach to long-term glacier analysis, considering both the surface function and its derivates. The main aim is:
– to demonstrate how mathematical surface descriptors calculated from grid-based Dems can be applied to classify and to quantify glacier surface changes over a period of time
– to demostrate how changing surfaces can be quantified depending on scale, accuracy and noise in the data material.
The concept was tested on five Svalbard valley glaciers. The geomorphometric analysis reflects the different dynamics of these glaciers. The method seems suitable to give a first impression of changes in the glaciers surface morphology. Such observations can further be related to changes in the glacier dynamics. This is important, especially for non-monitored glaciers.

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Littoral dynamics of the Circeo-Terracina coastal system (Lazio, Italia)

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The littoral dynamics was modeled from wave climate data across the bottom topography within the Circeo-Terracina coastal area (100 km SE of Roma). Wave data were obtained from a previous study conducted by Delft Hydraulics in 1991. The wave height, period, direction and frequency of occurrence were transformed into fully developed sea wave spectra using classic methods of Pierson and Moskowitz. The bottom topography was obtained from the Istituto Idrografico della Marina as unpublished bathymetric survey maps at scale of 1:25,000 and were hand digitized. The depth data were interpolated to generate a 125 m square grid using kriging techniques. The effects of wave refraction, diffraction and height modification, upon waves approaching the coast, were calculated using a program that considers spectra of wave heights, spectra of wave periods and spectra of wave directions. The program utilizes a finite difference model of differential equations for velocity potential assuming first order waves traversing slopes that approximate the tangent of the slope. The potential sediment transport was calculated at 24 shore perpendicular profiles distributed along 16 km of coastline. Breaking wave dynamics, longshore current velocity and sediment transport were modeled using formulations of Longuet-Higgins, Guza, Inman, Thornton, Wright and Short. The values of longshore transport, current velocity, maximum orbital velocity at the sea floor, shear stress, significant breaker height and percent of breaking waves were calculated along each profile from about 18 meters of depth to the shore. The longshore sediment transport was calculated incrementally along the profiles to allow observations of the spatial variations in the sediment transport along each profile and between profiles. Computations were done for a combination of periods and directions of wave approach. These were chosen from available wave frequency data by multiplying the frequency of occurrence by the square of the significant wave height. Wave conditions corresponding to high values were used. This does not represent all the sediment transport but yields a view of the major transport in the area. The sea from 150 and 180 and the swell from 180 and 210 have been analyzed. The values of periods are about 5 seconds and the wave height about 1 meter.
The results of the analysis shows modest values of longshore currents. In particular the sea from 150 produces a current from Terracina toward the west, whereas the current produced by a sea from 180 is directed, toward the east starting from Circeo. For both directions, the current decreases proceeding alongshore. The shear stress on the bottom is similar for the two directions for each profile, but has higher values for the sea from 150. The swell with periods of 5.5 sec and wave height of about 1 m either from 180 or from 210 induces a current from Circeo towards Terracina. With respect to swell coming from the south, swell from 210 shows an increase in values 1 km west of the harbour of Terracina. From this point both decay towards east. The shear stress on the sea floor is always higher for the swell coming from 180 than for swell coming from 210.

DAVID J.A. EVANS[1] & BRICE R. REA[2]

The geomorphology and sedimentology of surging glaciers: a landsystems approach

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The surging glacier landsystem can be reconstructed by utilizing observations on contemporary surging glacier snouts in Iceland and Spitsbergen. This landsystem is critical to the identification of ancient surging margins and their differentiation from fast flowing palaeo-ice streams. Examples of the geomorphology and sedimentary structures of possible ancient surge margins in western Canada

and eastern England are assessed using the landsystems model.

Landforms produced during surging include thrust and push moraines, concertina eskers and subglacial crevasse-squeeze ridges. Sedimentary sequences are usually characterized by multiple stacked diamictons and stratified interbeds, which display severe glacitectonic contortion and faulting. Hummocky moraine comprising interbedded stratified sediments and mass flow diamictons has also been associated with surge margins where large quantities of englacial debris entrained during the surge event has melted out in situ. Similar landform/sediment associations appear to have been produced at the margins of fast flowing palaeo-ice streams. In southern Alberta, western Canada, a palaeo-ice stream within the southwest Laurentide Ice Sheet has been identified from a mega-fluting complex and an associated terminal moraine arc of glacitectonically distorted and thrust bedrock. Thrust moraines are common also at slow moving sub-polar glacier snouts where surging is extremely rare. Complex stratigraphies of glacitectonized diamicton and stratified interbeds have been widely reported from palaeo-glacier margins in Britain and northwest Europe where they are interpreted as the products of glacitectonic thickening of deformable sediments and are not necessarily associated with abnormal glacier velocities.

Only concertina eskers and extensive networks of subglacial crevasse-squeeze ridges can really be associated exclusively with surging glacier margins. Contorted medial moraines are also good indicators of surge behaviour but have a very poor preservation record. In the absence of such features (eg. East Yorkshire) the local and regional aspects of the palaeogeography that are conducive to surge behaviour (eg. former deep ice-contact water bodies) should be assessed in conjunction with the glacial landsystem.

IAN S. EVANS[1] & NICHOLAS J. COX[1]

Analysis, presentation and interrelation of directional data as applied to glaciers and glacial cirques

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Linear statistics are still frequently applied to 2-D directional data (azimuths, data on the circle), although it is well known that the results can be very misleading because the point at which the circle is divided is arbitrary. One problem is that most statistical program suites do not have routines which address the special properties of data on the circle, and users are tempted to use ordinary linear routines especially when their data sets include both linear and circular variables. Here the use of a number of routines for circular data, available from the authors, is exemplified for data sets for whole mountain ranges specifying the aspect, position, size and form of glaciers and glacial cirques. Other applications include hillslope analyses, river channel and network analyses, wind direction and bedform analyses (dunes, bars, drumlins)

Univariate data presentation is not a trivial matter and three different approaches all have their strong points: a cumulative vector diagram, a histogram wrapped around a circle, and a linear histogram with repetition either side of the division point. For a linear histogram, repetition of a quarter-circle on the left and the right usually permits modes and minima to be properly appreciated. Alternatively, for unimodal distributions a linear histogram can be recentred so that the circle is divided opposite the mean resultant vector. Smoothing by a moving kernel on the circle can remove minor sampling or rounding fluctuations, but the number of 'real' modes remains a subjective interpretation. For bivariate scatter plots, the best solution is lateral repetition so that every data point plots four times; this ensures that the whole of a band or cluster of data points can be appreciated, whatever its shape or position.

A special version of the correlation coefficient is available to interrelate paired values of aspect or azimuth. For example the correlation between axial aspect and headwall aspect is +0.873 for 158 cirques in the English Lake District, and +0.838 for 198 cirques in the Cayoosh Range, British Columbia. Circular variables are related to linear variables by Fourier regression, which can be summarised by another version of the correlation coefficient. Further tests deal with the randomness of a data set, compared with different alternative hypotheses, and the difference between two or more distributions.

Both glaciers and cirques in the southern Coast Mountains, British Columbia show a landward trend to increased azimuthal concentration in the drier, more continental climate with higher snowline. Differences are significant in concentration but not in vector mean azimuth. The strong asymmetry is related to wind and solar radiation effects which reinforce eachother. Cirques are less azimuthally concentrated than glaciers in the same range; the climates in which they developed were colder than present, with a snowline about 400 m lower, but with no discernible difference in snow-bearing winds. They are believed to have developed before glacial maxima, at which they were inundated in the Cordilleran Ice Sheet.

MARTIN EVANS

The geomorphic sensitivity of alpine-subalpine basins in the Cascade Mountains, British Columbia, Canada

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Concerns over global change have highlighted the importance of understanding the sensitivity of geomorphic sy-

stems to external forcing, and in particular to climatic change. The ecotonal nature of alpine/subalpine systems suggests a particular sensitivity to climatic change. In contrast, the sediment system in such basins is characteristically poorly linked (Caine, 1986) suggesting that impulses of change may not be efficiently transmitted through the sediment system. Therefore, *a priori* the extent to which alpine/subalpine geomorphic systems will be sensitive to climate change remains unclear.

This paper describes research on four alpine/subalpine basins in the Cascade Mountains of southern British Columbia. The study aims to empirically illustrate the sensitivity of the basins to external climatic forcing by comparison of Holocene sediment stratigraphy with the palaeoclimate record. Lake sediment derived estimates of sediment yield provide an integrated measure of geomorphic activity within the basins during the Holocene. Sediment yield to the basins increased significantly in the second half of the Holocene. Comparison of the sediment yield changes with the local and regional palaeoclimate records indicate that long term changes in sediment delivery to the lakes are correlated with the pattern of Holocene climate changes. Approaches to establishing the process basis of this relation are discussed.

EZE BASSEY EZE & ADETOYE FANIRAN

Rainsplash detachement on different landuse surfaces in sub-urban Ibadan, Nigeria

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Splash erosion on forested surfaces has been relatively neglected in geomorphological studies: the assumption seems to be that splash takes place mainly on bare surfaces. The neglect is particularly pronounced in the humid tropics. This study is part of a recently completed Ph.D. work in the Department of Geography, University of Ibadan (Eze, 1996) aimed at filling the recognized gap. The specific aims of this study included:

a) measuring and analysing the quantity of splashed soil on different landuse surfaces-bare, cropped, teak plantation, grass and natural forest;

b) relating the splash data to the environmental (controlling) factors of erosivity and erodibility;

c) build models capable of predicting splash on the studied surfaces in particular and similar surfaces in general.

The modified Morgan's splash cup was used in the field to collect the splashed soil during the rainfall year (March to October of 1993), a normal rainfall year in the town. A total of 50 rainstorm events was studied. The least amount of rainfall that resulted in splash was 0.9 mm. The intensity of the rainstorms ranged between 3.6 and 149 m/hr. and the total energy load 21443.24 j/m.

The following are highlights of the result:

a) Splash occurred on all the surfaces studied.

b) Splash detachment was rather high, being far above the generally recognized figure of 1.3 $cg/m^2/yr$. It ranged between 49.25 kg/m^2 on grass to 99.39 kg/m^2 on bare surface.

c) The general progression was of the order: bare > teak plantation > cropped > forest > grass surface.

d) Application of Duncan's (1955) multiple range test produced only three distinct surfaces of bare, cropped/teak plantation and forest/grass surfaces.

e) The models developed show that splash in the area can be explained largely by clay content, percentage cover, A115, EI30, rainfall amount, built density and organic matter content of the soil, in that order.

f) Grass has shown up as the best to use for the protection of surfaces against splash, as has been shown for soil and nutrient loss (Daura, 1995) and runoff (Oyegun, 1980), in the same locality of humid tropical sub-urban geomorphological environment.

PATRICIA FANNING

Accelerated erosion and recent landscape evolution in arid Australia

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Accelerated erosion is a ubiquitous land degradation problem in arid Australia. Both wind and water erosion have been enhanced by changes which have taken place in land cover since the introduction of domestic and feral herbivores by Europeans in the nineteenth century, leading to widespread topsoil loss, surface scalding, rilling and gullying, and wind drift. This paper reports the results of research into rates of soil loss on a property in the Barrier Range north of Broken Hill in western NSW, and investigations into the effects on catchment and channel processes of changes in the hydrogeomorphic regime which have resulted from landcover change.

Average rates of soil loss on scald surfaces, measured over a ten year period on an erosion pin plot adjacent to Homestead Creek on Fowlers Gap Station, about 110 km north of Broken Hill, range from 30 to 209 t/ha/yr (Fanning, 1994). Somewhat lower rates would be expected over the rest of the catchment since the vegetation cover is more intact, but observations of mulga (*Acacia aneura*) root exposure and lichen growth levels on rocks scattered over the slopes suggest that topsoil thicknesses of up to 15 cm have been lost over the whole of this, and adjacent, catchments.

Homestead Creek is at present a rectangular channel (*arroyo*) entrenched into the valley floor. Monitoring of bedload transport and bank collapse indicate that the channel is widening and incising. However, the presence of remnants of narrower, more sinuous paleochannels on the valley floor surface which are transected by the modern channel indicate that there has also been a significant change in channel morphology. Charcoal from two aboriginal hearths located near the top of the sedimentary sequence along the floor of Sandy Creek, immediately to the north of Homestead Creek, has been radiocarbon dated at 350±50 years BP (Wk-4197) and 980±60 years BP (Wk-4102). A sequence through an aboriginal ceremonial site transected by Giles Creek in Mootwingee National Park, 130 km northeast of Broken Hill, has returned dates of 220±50 years (Wk-3147) and 420±110 years (Wk-3141) BP from hearths inset into the top unit of the original floodplain sediments. Incision of the stream channels at both of these sites has occurred after the sediments now exposed in the channel walls were deposited, as is the case in Homestead Creek at Fowlers Gap. Thus, stream incision has occurred in a number of upland catchments in the rangelands of western NSW within the last few hundred years and most likely since grazing of domestic animals began about 150 years ago.

Stream incision steepened hydraulic gradients and hence the erosive power of runoff channelled into them. As a result, the main and tributary channels have extended headwards by knickpoint retreat. Monitoring between 1990 and 1995 at Mootwingee recorded knickpoint retreat of up to 87 metres in a single runoff event. Channels enlarged by up to 2000% over the monitoring period, most commonly by undercutting and bank collapse, as is the case at Fowlers Gap. The sediment eroded by these processes is carried out onto the lowlands of the Bancannia Basin, where the combination of declining discharge, increased transmission losses and abundant sediment load results in channel choking and avulsion.

This latest phase of erosion is threatening an array of infrastructure at Fowlers Gap and Mootwingee: fences have been buried by wind-blown sediment, watering points have been undermined and the pipes damaged, roads are threatened by stream widening and bank collapse, and the camping area at Mootwingee is in the path of rapidly advancing gully heads. This is occurring in spite of conservative stocking rates at Fowlers Gap (around 1 dry sheep equivalent [Dse] to 6 ha), and complete removal of domestic stock from Mootwingee (though native and feral herbivores remain). The alteration to catchment hydrodynamics of which these examples are symptomatic is common in rangelands in arid Australia, and reflect the impacts of domestic grazing in altering the balance between surface runoff and infiltration when landcover change occurred. A conceptual model summarising these changes will be presented.

ENZO FARABEGOLI & CECILIA AGOSTINI

Definition and use of the term «calanco» (badland) in the Northern Apennines

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The term *calanco* (badland) is widely used in the topographic and geomorphological maps of the Northern Apennines. To strictly define the range of applicability of the term *calanco,* the quantitative geomorphological analysis of three areas located near Bologna and Faenza was performed. The considered lithologies consist of clayey and sandy-clayey bedrock as well as chaotic-structured clays («Argille Scagliose» *Auct.*,), typical of this area.

The shape analysis was carried out upon 67 hydrographic cells, whose data were digitized at 1:5,000 scale. For each catchment the hypsometric curve was evaluated. The local form of the topographic surface was eventually quantified by means of a new geometric parametre easily available from the contour elevation lines: LO/LF. This parametre is defined as the ratio of the original length of a contour elevation line (LO) and the length of the same line, after a preliminary smoothing (LF).

The cross-validation of the different performed analyses allowed to discriminate three classes of catchments with different geomorphological meaning. A special meaning could be attributed to the LO/LF parametre, which features high values within the badland areas, therefore allowing a consistent characterization.

DAVID FAVIS-MORTLOCK[1] & JOHN BOARDMAN[2]

The importance of large and infrequent rainfall events for long-term rates of soil erosion: a simulation study from the UK South Downs

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Following ten years of monitoring soil erosion on intensively farmed land in an area of the UK South Downs, Boardman (1996) noted that 71% of the total soil loss during the period 1981-92 occurred in just three years. However, no large and infrequent rainfall events, with a return period of the order of 100 or 1000 years, occurred during this time; thus we can only speculate regarding their impact. Yet events of this magnitude must have occurred during the 5000 years or so since the area was first farmed. While the evidence from valley-bottom sediments indicates that there was considerable soil loss during this period, our knowledge of the contribution of individual high magnitude, low frequency events to the totality of past erosion is largely based on a short and possibly atypical period of observation (Boardman & Bell, 1992).
Favis-Mortlock & *alii* (in press) showed that it is possible to employ a modelling approach to quantifying long-term rates of past soil erosion. The Epic model was used to simulate soil erosion during the last 7000 years on a South Downs hillslope. Simulations varied both climate and land use, and evaluated two scenarios for the thickness of the original loessial soil (fig. 1).

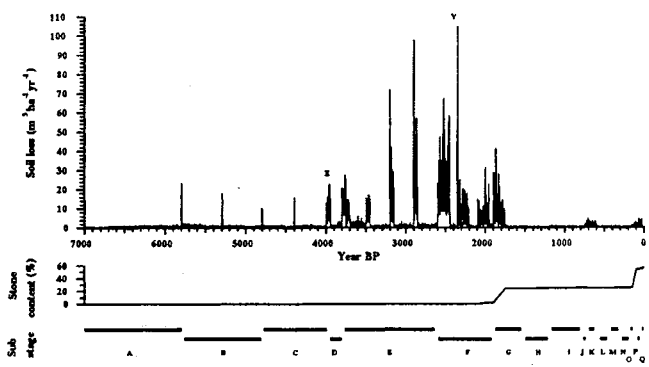

FIG. 1. Simulated annual erosion rates and surface layer stone content for the «thin» profile scenario (from Favis-Mortlock & *alii*, in press).

The current study extends this methodology. Several simulations are performed. Each retains the same land use history but uses a different (yet statistically identical) time series of synthesised daily climate data (Favis-Mortlock, 1995). From these, the contribution of a range of magnitudes of rainfall events to total soil loss during each land use stage is determined.

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Methods of calculation of the snow limit in a mid-latitude area, the Apennines

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The snow limit is a key concept for the interpretation of the glacial and climatic features of a region. It must be emphasized that in mountain glaciers of middle and low latitude mountains, where the superimposed ice produced by the refreezing of ablation water is of little importance, the permanent snow limit coincides with the Equilibrium Line Altitude (Ela). This corresponds to the contour line which divides the area of the glacier where accumulation prevails from that where ablation is predominant, in the zone where the balance of mass is equal.
There are various calculation methods proposed and used, but they have not always given converging results in the different mountain ranges of the world. In fact, it is important to point out that it is not always possible to use every method for every deglaciated valley or mountain because the appropriate conditions are not always present. However, all the methods, if applied specifically, give good approximations, taking into account that a margin of error always depends on imprecision in the correct application of the various techniques. It is evident that the various methods must however be applied according to the same principles in order to compare results. It is also important to distinguish between the orographic snow limit and the climatic and regional limit. This is the case of the Apennines. They consist of a mountain chain situated between about 45° and 38° latitude north and where there were glaciers throughout the range during the last glaciation before they became almost totally extinct (the only remaining one being the Calderone Glacier on the Gran Sasso d'Italia).
This study compares the methods used together with those which have never been used. They were applied, when possible, to the main mountain groups of the chain. The methods of Hugi (1842), Kurowski (1891), Reid (1896), Simony (1872), Partsch (1874), Hess (1904), Bruckner (1906), Höfer (1922), Louis (1927), Gortani (1930-31), Lichtenecker (1937), and Demangeot (1963) were all used and when it was possible they were compared among each other, whereas Porter's method could never be applied. Knowing the value of the results obtained on the present

glaciers with the surface method (Aar), we attempted an application of the various calculation methods of s.l.l. to the glaciers of the Apennines for which it was possible to reconstruct the presumed original surface. It was noted that some methods give more reliable results than others. For example, for the most extensive glacier of the Northern Apennines, the Val Parma, very well-known and mapped in great detail, the comparison between s.l.l. values obtained with the various methods and that of the surface method (Aar - Accumulation Area Ratio, with a value of 0.67), shows a very interesting correspondence between the values of the Ela obtained with the latter method and those obtained with Lichtenecker's method. This affirms that the highest altitude of the lateral moraines (Melm) corresponds to the altitude of the s.l.l. (as the heights of the lateral moraines register the height of the glaciers on the slopes). In the case considered, 1250-1260 m is the value of the s.l.l. for both methods. There is a minimal difference (a few metres higher) with the value obtained with Höfer's method, which specifies the altitude of the s.l.l. as the arithmetic mean of the mean height of the ridges of the mountainous barrier and the height of the glacier front. The methods based on the altitude of the cirques (mean height of cirque bottom, minimum height of bottom, ratio between the two), give interesting results and especially in the latest version, used by Demangeot (1963) for the mountains of Abruzzo, they can be reliably used. In conclusion, from this preliminary exam, the advisable methods are the method of Lichtenecker when there are complete series of morainic deposits, and Höfer's method, also because they need few data for their use. Höfer's method, in particular, in spite of Charlesworth's (1957) criticism is simple and applicable almost everywhere. However, in order to have reliable results the various calculation methods must not be applied purely mechanically. Being familiar with the mountains being studied, corrections should be carried out which take into account local factors, such as exposition, contribution of avalanches, winds, the topographic conformation of the basin and neotectonic influences.

SADAT FEIZNIA

The role of Iranian diapirs in degradation of natural resources (water , soil and vegetation) and desertification

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Different geological characteristics are important in desertification in Iran: Abundance of terrigeneous - evaporitic - marl Neogene formations, tectonics of Central Iranian plateau and abundance of diapirs. There are many diapirs (salt domes) in different parts of Iran which are located as point sources and degrade natural resources. The main areas of accumulation of salt domes are located in Bandar Abbass-Sarvestan , south Kazeron , north Kerman , north yazd-Ardakan , and south Semnan , north of Great Kavir.
Iranian diapirs are from Pre-Cambrian to Neogene in age. We can classify Iranian diapirs into active and inactive ones. Active Salt domes are usually younger in age and still incorporate salt into surrounding areas. Kamaraj salt dome located in Shahpour-Dalaki-Heleh drainage basin in Kazeron-Bushehr is an example of active salt dome. Inactive salt domes are usually older in age and they no more incorporate salt into surrounding environment. Most of their salt is been solved and there is only accumulation of accompanying rocks now.
Geological and geomorphological studies have been done in Hableh Rud drainage basin, Garmsar, Alborz Zone, Iran. The dispersion of salt domes has been studied in this region. Soil, water and vegetation samples were taken across the drainage basin and were analyzed. Finally the role of salt domes in degradation of quality of water resources, soil and vegetation were discussed. Some recommendations are given for prevention of degradation of natural resources in the vicinity of Iranian salt domes.

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Le «Pantanal da Nhecolândia»: cadre physique et dynamique hydrologique

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L'imense plaine du «Pantanal Matogrossense» (140.000 km^2), situé dans la partie centrale de l'Amérique du Sud (16° a 22°S et 55° a 58°W), correspond à un niveau de base continental encore actif. Cette plaine est récouverte par des sédiments quaternaires, deposés sous forme de nappes alluviales par les affluents du Paraguai, et est soumise à des inondations saisonnières en partie dues aux régimes hydrologiques des principales rivières. Le fleuve Taquari est le résponsable de la plus importante nappe alluviale (55.000 km^2), avec ses sédiments sablonneux sur un relief presque plat e sa végétation de savanes herbacées et arbustives et de forêts. Dans sa partie SSW, la région de la «Nhecolândia» est parcourue par les *corixos* (ruisseaux à écoulement permanent ou semipermanent) et par les *vazantes* qui relient les *baias*, zones deprimées à écoulement saisonier. *Vazantes* et *baias* sont entourées par les *cordilheiras*, petites élévations alongées à peine 2 a 3m plus hautes que leur voisinage et récouvertes par une végétation forestière. À l'interieur des *cordilheiras*, des dépressions fermées présentent en permanence de l'eau sâumatre et ne sont pas atteintes par les inondations.
L'interpretation des images Landsat - TM y a permis d'identifier 5 compartiments, par leur caractéristiques de

végétation, de fréquence et de distribuition des inondations, par la diversitée e distribuition des *corixos*, *baias*, *vazantes*, *cordilheiras* et *lagoas* et par les traces laissées par l'écoulement superficiel.
Les régions sous l'influence directe des crues du fleuve Taquari a W et du fleuve Negro au S, délimitent la Nhecolândia; elles présentent un système complèxe reliant des *corixos* aux *baias* et *vazantes* pendant les hautes eaux. La région «Vazante do Corixão» est une large bande récouverte par de la savane herbacée qui accompagne celle du Taquari; elle présente très peu de *lagoas* et est soumise à l'action de l'élévation du niveau de l'eau des *corixos* et de la nappe phréatique. La Nhecolândia plus humide a l'est, présente un écoulement anastomosé des *corixos* et des *vazantes*, souvent marqués par des forêts-galéries, et une absence presque totale de *cordilheiras* et *lagoas*; en haute saison elle reçoit l'influence de la montée des eaux des *corixos* et de la nappe phréatique. Le trait principal de la Nhecolândia centrale est le grand dévéloppement du système *baia-vazante-cordilheira-lagoa*, avec la très grande densité de celles-ci. Les crues sont dues sourtout à l'élévation de la nappe phréatique et en moindre partie, par les eaux des *corixos* et *vazantes* et l'aspect anastomosé de ceux-ci est peu prononcé. Il est possible de distinguer, vers le nord, une sous-région où le système *cordilheiras-lagoas* est plus restreint, traversé par des *vazantes* et *corixos* plus larges.

NELSON F. FERNANDES & CARLA B. SANTI

The convex hilltops of Southeastern Brazil and the question of dynamic equilibrium: insights from hillslope curvature and numerical modelling

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Convex hilltops are typical features of many soil-mantled landscapes around the world. These forms have been frequently interpreted as characteristic of well-developed landscapes, as the ones prevailing in most of the tropics nowadays. They have also been suggested as representing evidences supporting the classical idea of dynamic equilibrium, implicitly proposed by Gilbert and later well organized by Hack. Although the origin of these convex hillslopes has been attributed to the work of diffusive (slope-dependent) processes like creep, rainsplash and biogenic activity, a number of numerical models have shown that the hillslope curvature also depends on the baselevel conditions associated, in general, with the incision rate at the base of the profile. In addition, some of the models have shown that the relaxation time of these convex hillslopes, when evolving under diffusive processes and responding to typical climatic and tectonic oscillations that have occurred along the Quaternary, may be much longer than the frequency of these oscillations, prevailing these hillslope profiles to attain the dynamic equilibrium condition. This study focus on the geomorphological meaning of the smooth, well-rounded, convex hilltops observed in southeastern Brazil, based both on field evidence and numerical experiments.
Detailed hillslope profiles were surveyed in the field from convex hilltops in three different areas of southeastern Brazil, inside the state of Rio de Janeiro (Magé, Campos e Pira'). These areas were selected because they include a variety of bedrock conditions, incision rates, soil types, hillslope convexities, climatic conditions, vegetation and erosional processes. In addition, these factors are relatively homogeneous inside each area. Based on the curvature of the profiles we characterized the ratio between the incision rate and the diffusion coefficient for these areas. It is assumed here that where landscapes are close to dynamic equilibrium this ratio will be relatively constant along the hillslopes in that area. For the sites where the lowering rate is known, this procedure allowed us to estimate the diffusion coefficient of the landscape, a basic parameter of mathematical models of hillslope evolution. The values obtained in the field will be used to estimate the relaxation time of the hillslopes in these areas in response to climatic and tectonic changes.
The results show that hillslope curvature does not vary significantly inside each area studied. For example, the ratio between the incision rate and the diffusion coefficient for the hillslopes in the Magé site varies for a factor smaller than four. This range is extremely small since it is known from the literature that both the incision rate and the diffusion coefficient may vary, at least, three orders of magnitude. Although mathematical models tend to suggest the contrary, the results presented here do not allow us to reject the idea of dynamic equilibrium in the region.

DENISE B. FERREIRA

Assessment of erosional impact of land use change during the XXth Century in the inner Alentejo (Portugal)

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The main objective of the research presented here is the understanding of the various dynamic processes (natural and anthropogenic) responsible for the soil degradation in the inner Alentejo region. The guideline for the investigation is the assessment of the impact of land use and agricultural practices changes since the last decade of the XIXth Century on soil erosion at a regional scale, in relation to climate. Part of the results obtained in the councils of Moura e Barrancos (basin of the Guadiana River) are presented. These councils were chosen to be included in an information system on the *montado*'s transformations in

the XXth Century and its implications on soil degradation. Predominant in Alentejo, the *montado* is an extensive agroforestry system based on fodder production and grazing, cereal crops, evergreen oak trees (*Quercus suber* and/or *Quercus rotundifolia*) and olive trees exploitation, associated with latifundium. During the XXth Century, the system suffers pulses of injuries and transformation or substitution (intensification of the cereal production, overgrazing, cutoff of the trees, introduction of exotic species like *Eucalytus*).

The causes more frequently evoked to explain the spatial variation of soil degradation in Alentejo are the land use practices and the mismanagement of soil and vegetation. But, a particular attention needs also to be paid to the impact of the climate evolution, particularly of the variability in the precipitation seasonality, in the rainfall intensity and concentration, and in the frequency of drought spells. In Alentejo, historical changes in land use and climate involving soil erosion are reflected by geomorphological, runoff and soil capability changes. At diferentes scales, from the extrapolation of the results of experimental studies of the effect of crops and rotation on run-off and soil erosion, essentially at Mertola-Vale Formoso, from the analysis of sediments deposition in reservoirs, from the observed stream discharge, and from geomorphological evidences, we try to estimate the long term variations of soil erosional processes in Alentejo during the XXth Century. The overall objective is to show that the planning of the rural development in the inner Alentejo should not ignore the interactions of the history of land use and climate which have determined the actual soil suitability for agriculture and forestry. The effects of these interactions determine the future potentialities to be taken into account in a decision support system on rural land resources and land use management.

The poster shows the diferents aspects of the assessment of the erosional impact of land use change in Alentejo during the XXth Century (1886-1995), with an exemplification in the councils of Moura and Barrancos. The prime aim was to express the evolution of the spatial variations of the risk of erosion and to indicate sustainable land use. The results will be designed to provide an important input to the formulation of conservation schemes. It is organized in three parts which present the synthesis of:

– the diacronic analysis of the land use (evolution in an openfield for cereals crops; change in area and density of tree cover; importance of abandoned fields...; identification of critical fases for potential soil erosion);

– the evolution of climate in Alentejo during the XXth Century (total precipitation and variability, rythm, water stress and rainfall intensity) and its influence on vegetation and on the variations in the type, magnitude and frequency of water erosion processes.

– a comparative study of the assessment of land use capability and risk of soil erosion, using three particular moments in the XXth Century: at the beginning of the century, in the 1960's and at present.

ERIC J. FIELDING

Tectonic geomorphology of the Tibetan Plateau and Himalaya using high-resolution digital topography from interferometric analysis of Shuttle radar imagery

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The interior of Tibet is characterized by shallow slopes because the lack of long-wavelength relief and dry climate preclude fluvial and glacial dissection, and because late Cenozoic tectonics have not deformed the surface. In contrast, the active tectonics and wetter climates of the northern and southern margins of Tibet, the Kun Lun and the Himalaya, generate high relief and steep slopes. In the moderately dry Kun Lun, alluvial deposits are offset by displacement on the active Altyn Tagh fault. In the Himalaya, especially on the monsoon-washed southern slopes, rapid erosion can remove efficiently small geomorphic features such as fault scarps and glacial moraines.

New high-resolution digital topography has been produced for portions of a transect across the Tibetan Plateau and the Himalaya by interferometric processing of radar data. Analysis of this dataset provides new information on the geomorphic response to variations in denudation rates, relief, structure, and lithology. The present topography presumably represents a balance between the tectonic and erosion processes, and the latter have been affected by Quaternary climate changes. The north face of Everest has a fairly uniform hillslope angle of about 42° (with a ~80 m window size), which may be controlled by the shallow northward dip slope of the mylonitic schists, or may represent a maximum sustainable slope for those lithologies. Several other peaks and ridges north of Everest have more uniform, but shallower, slopes in the range of 30-35°, which may indicate either rocks of lower strength or less rapid denudation. Future geologic mapping in this area will help to constrain the lithologic contrasts and allow comparisons to the geomorphic characteristics.

Interferometric processing of suitable pairs of synthetic aperture radar (Sar) images can produce a high-resolution digital elevation model (Dem). Airborne systems can provide the highest resolution Dems, but spaceborne Sar provides greater data coverage, especially in remote regions such as the Himalaya. I have derived Dem's for the Kunlun, interior of Tibet and the Everest area of the Himalaya. I used a pair of images from the interferometry phase of the October 1994 Shuttle Imaging Radar (Sir-C) flight. The extreme relief in the Himalaya causes some problems for topographic measurements, even with radar. The Sir-C radar instrument can be steered to different incidence angles, and used a 51° incidence angle (measured from the vertical) for these data which works much better in high-relief areas than other radar systems, such as the Ers-1 Sar (21° incidence angle). The Dem extraction used the L-band (~24 cm wavelength) channel of the radar. The Himalaya Dem has a grid spacing of 20 x 20 m, and covers an

area that is roughly 25 km wide running NW SE from north of Everest down to the Arun river. Shadows and decorrelation in the radar image pair prevent the measurement of elevations in some areas, but most of the interferogram was converted to elevations. A future flight of the Shuttle around the year 2000 will use an improved interferometric radar to produce a topographic map of the earth's land surface between 60°N and 60°S.

Several quantitative geomorphic measurements have been derived from the Sir-C interferometric Dem, including hillslope angles, local relief, valley widths, and hypsometry. The hillslope angles and local relief were calculated with analysis windows of varying sizes from (~20 m to ~1 km across) to characterize their dependence on scale. The slope of a given window size is defined as the slope of the best-fitting plane or linear term of a higher order fit for that window, while the relief is defined as the difference between the maximum and minimum elevations within the window. Statistics such as slope histograms and hypsometry (elevation histograms) were determined for the studied regions.

Hillslope angles measured with ~80 m windows appear to reflect the dominance of landsliding in hillslope erosion, at least at the higher elevations. There is a significant difference between the slopes in the non-glaciated valleys at lower elevations where steep hillslopes reach the valley centers and the generally higher elevation glaciated areas where the slopes have a bimodal histogram with shallow slopes in the valley bottoms and steep slopes along the valley walls. Even in the glaciated zones, there are still only small areas with slopes greater than about 48°. This suggests that the rock-strength limitation on slope is perhaps 45-50° for the medium- to high-grade crystalline rocks and shallower (35-40°) for low-grade or sedimentary rocks. The relatively narrow range of slopes may reflect a state of self-organized criticality where the rocks on the hillslopes are everywhere close to slope failure as in sandbox experiments.

ALASTAIR FLEMING

River long profiles: implications for cyclical explanations of landscape evolution in South Africa

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Fluvial systems transmit base level alterations to the landscape system as a whole and thus they provide the fundamental connection between crustal deformation and landscape reaction. At the regional scale, longitudinal profiles of bedrock rivers preserve a unique record of the impact of both tectonic and eustatic adjustments and variations in the erosional susceptibility of the underlying lithology.

The landscape of eastern South Africa, dominated by the Drakensberg, an erosional escarpment, the near vertical face of which has a relief of up to 1000 m in Kwazulu-Natal Province, has been a major *foci* for evolutionary studies. The cyclical approach, first advocated by Lester King, and involving repeated denudational episodes in response to rejuvenation induced by regional scale uplift, although subject to criticism (particularly from recent tectonic models and denudation chronology studies) remains the dominant model for explaining the present landscape of southern Africa. A central tenet of this approach is regional scale Late Tertiary - Quaternary uplift, demonstrated by coastal fringing shallow marine deposits lying at elevations in excess of contemporary global sea level high stands. This event is questioned by those employing tectonic models which cannot easily account for surface uplift at this proposed time. Studies using apatite fission track analysis and offshore sediment volume data have identified variations in denudation rates during the Late Cretaceous and Early Tertiary only.

The proposed Late Cenozoic regional scale uplift, estimated to be of up to 500-900m, would be a significant event in the drainage history of the region. Provided that the rate of the proposed uplift exceeded the rate of fluvial incision, the likelihood of which is related to a river's size, the impact of such an event would be highlighted as a convexity in the river long profiles of the affected area, and hence a deviation from the characteristic concave upwards profile of a graded river. Long profiles for selected rivers in Kwazulu-Natal and Eastern Cape Provinces have been analysed using Hack's method (Hack 1973), which would produce a straight line semi-log plot for a graded river traversing a uniform lithology. Any deviations from this represent the impact of disequilibrium base level adjustments induced by eustatic or tectonic events, or equilibrium variations in lithological resistance to fluvial processes. These alternative causes of the observed anomalies in the profiles, including a possible Late Cenozoic uplift event, are discussed. The implications for the cyclical approaches to landscape evolution in southern Africa are also considered.

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A geomorphologic evaluation of the surface reduction and the equilibrium line altitude rise since the Little Ice Age in the Italian glaciers

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The Alpine glaciers are good indicators of climatic and environmental changes. In fact every variation in climatic

conditions affects the Equilibrium Line Altitude (Ela) and the mass balance, causing a dynamic response and a readjustment of the glacier size. The Little Ice Age (Lia) was a period of glacial advance that in the Italian Alps peaked between early 17th and middle 19th century. The majority of the Italian Glaciers reached the LIA maximum extent during the first half of the past century.

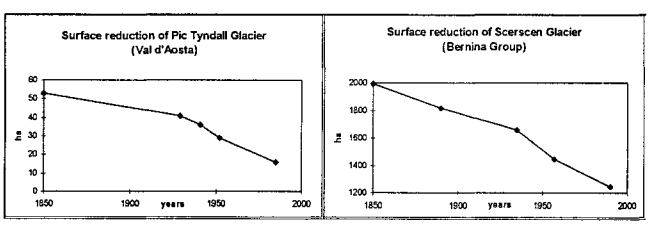
The geomorphologic survey of the end moraines abandoned since the maximum advance of the Lia allowed the reconstruction of the glacier surface area variations and of the Ela fluctuations in the last two centuries.

Present glaciers on the Italian Alps are more than 1400 and they cover a total area of about 607 km^2. They are mainly concentrated in the Western and Central Alps. Data regarding the area reduction and Ela rise, from the Lia maximum to the present, are summarised in this research for glaciers located in Valtellina (Central Alps) and in Valle d'Aosta (Western Alps). In Valtellina the studied glaciers are mainly situated in the Bernina-Disgrazia Group (43) and in the Ortles-Cevedale Group (39). In Val d'Aosta 143 glaciers were studied, mainly located in the Rutor, Monte Bianco, Cervino-Monte Rosa groups.

The Ela rise since the Lia maximum advance was 102 m in Ortles-Cevedale Group, 100 m in Bernina-Disgrazia Group and 129 m in Valle d'Aosta. In the Ortles-Cevedale Group the glacierized area was 65 km^2 in the Lia and decreased to 34 km^2 at present, with an ice surface reduction of 48%. The glaciers located in the Bernina-Disgrazia Group shrank from 61 km^2 in the Lia to 36 km^2 at present, with an area reduction of 42%. The total area of the glaciers studied in Valle d'Aosta was 271 km^2 in the Lia and now is 158 km^2, with a surface reduction of 42%. For a few glaciers in Val d'Aosta and in the Bernina Group it has been possible to reconstruct the surface reduction in different time intervals, showing an increased rate of retreat in 1930-1960 and in the last decade.

The studied glaciers confirm the general trend observed in all the tempered glaciers and particularly the sensitivity of Alpine glaciers to the atmospheric warming, that has been evaluated in 0.5/0.7°C from mid 19th century to present.

Glaciers	Δ ELA (m)	LIA area (km^2)	Present area (km^2)	Δ area (km^2)	Δ area %
Ortles-Cevedale G.	+102	65	34	–31	–48
Bernina-Disgrazia G.	+100	61	36	–25	–42
Valle d'Aosta	+129	271	158	–113	–42



NAHSANG F. FOMBUTU[1] & EFFIOM E. ANTIA[2]

Characteristics and implications of low frequency oscillations on mesotidal dissipative beaches, SE Nigeria

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The role, characteristics and morphologic expressions of low-frequency oscillations (Lfo) in the beach-surf zone are well documented in the literature, but so far with little cognizance of the effect of tidal range on the characteristics of the Lfo. Most of the Lfo observations to date were conducted in microtidal, high-energy beach settings. By contrast, this study has been undertaken in a mesotidal coastal setting of SE Nigeria, the main aim being to evaluate the effect of daily tidal amplitude (2.5-3.0 m) on the characteristics of Lfo on the moderate to high energy dissipative beaches. Using several tidal cycle, time-series data of wave run-up relative to fixed cross-shore reference positions, it was found that (1) the run-up period in 90% of the cases greatly exceeded the incident wave period (typically 5-8 secs), (2) run-up period distribution statistics were rarely unimodal, (3) run-up periods in the 15-30 and 45-60 sec range were relatively frequent (20-40%), and (4) modal run-up period and run-up statistical distribution could change dramatically over interval of 24 hours. The above results were not markedly influenced by fortnightly tidal amplitude variation as well as variations in incident wave-breaker height (50-200 cm), breaker patterns (dominantly spilling), beach sediment size (fine sand to mud), beach slope (<1-5°), surf zone width (50-250 m), and surf zone morphology (single to multiple sand bars).

Consequently, no conclusive model for the origin of the Lfo can be proferred for the study area. However, the presence of beach cusps and alongshore rhythmic beach volume and textural change patterns are morphodynamic expressions of the significance of Lfo in the nearshore region.

DEREK C. FORD

Principal features of evaporite karst in Canada

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Outcrops of sulfate and mixed sulfate-carbonate rocks are common everywhere in Canada outside of the Shield geo-

logical province. Gypsum bedrock outcrops total at least 80,000 km^2, although most are mantled by glacial deposits. Interstratal salt deposits are abundant in the interior lowlands at depths greater than 100 m and there are outcrops in the high arctic islands. Types of karst that occur are determined chiefly by relations between (i) formation thickness and purity, (ii) regional topography and hydraulic gradient, (iii) effects of receding Wisconsinan and earlier glaciers, and (iv) extent of modern permafrost.

Exposures of bare karst on thick, pure sulfate formations are comparatively rare. Two principal landform types found on them are (1) high density polygonal karst (microdoline densities up to 40,000 km^{-2}) where hydraulic gradients are high and tills are thin; morphometric analysis has determined that doline distribution approaches uniformity, with Nearest Neighbour values generally greater than 1.40; (2) hills and ridges of blocks uplifted and fractured by hydration (anhydrite) tectonics at paleo-icefront positions where hydraulic gradients are low. Bare salt karst is largely limited to seasonally active (thaw) zone features in the extreme northern permafrost. Covered karst is abundant on sulfates conformably overlain by carbonate strata; collapse dolines are the principal landform. Very large breccia pipes (up to 25 x 15 km) are associated with deep subrosion of salt during glacier recessions in Saskatchewan and Alberta. Polycyclic breccia karst is a third, distinct category created in some formations of thin, interbedded dolostones and sulphates in the Northwest Territories. Where these are exposed to high groundwater hydraulic gradients, deep calcite-cemented breccias form by incongruent dissolution and common ion effects in a first cycle, upon which doline and pinnacle karsts and remarkable dissolution draped topographies develop rapidly in subsequent cycles.

MONIQUE FORT

Large scale geomorphic events in the Nepal Himalaya and their role in the evolution of the landscape

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The Himalaya, a still growing mountain created by the collision between Indian and Asian plates, is eroding down at a very fast rate, as attested by the volume of sediments annually trapped in the large sedimentary reservoirs of the Indus and Ganga-Brahmaputra fluvial, deltaic and submarine systems. In fact, the overall characteristics of the mountain are such that all favorable factors for intense denudation, acting at all scales and frequencies, are represented: bedrock uplift, tecto-seismic activity, steep and long slopes, monsoon climate and/or glacially dominated slopes.

This contribution is aimed at documenting and assessing the significance of large scale, low-frequency events recorded in the Nepal Himalaya, which is very representative of the entire Himalayan Range. These events are related to three types of major processes: tectonic/unloading collapse, slope weathering and landsliding, and river downcutting and flooding. Large magnitude events typically associate at least two, if not the three types of processes, as illustrated by selected study cases.

1. Gigantic landslides, mostly found in the Greater Himalaya (cf. in Mustang, Manang, Langtang, Khumbu), typically affect entire valley slopes. Their morphology and associated displaced materials ($10^{9\text{-}10}m^3$) are generally complex, and currently induce specific low-magnitude, high frequency mass wasting processes which would otherwise be probably absent. Their frequency is very low (> $10^{4\text{-}5}$ years recurrence interval) and they durably impact the overall morphology of the valleys.
2. Catastrophic debris-flow equally characterize the upper and middle himalayan valleys, as attested by very thick, very coarse, mud-supported deposits (>$10^{8\text{-}9}m^3$ sediments accumulated for one event) (cf. Pokhara and Marsyangdi valleys). Their development is related to an exceptional combination of favorable conditions (steep topographic gradient, glaciated areas, deep fluvial incision, adequate lithologies, high seismicity). The recurrence interval ($10^{2\text{-}4}$ years) is not well constrained, because of later reworking of the catastrophically carried material by smaller, more frequent events.
3. Exceptionnal floods affect both the Greater and Lower Himalaya. Whereas in the upper valleys these are mostly glacial lake outburst floods (Khumbu, Mustang), in the lower valleys, they are basically climatically induced floods (rainfalls of exceptionnal intensities and/or duration). The volume of sediments transported is considerable ($10^{4\text{-}5}$ m^3/km^2/flood; Bagmati 1993 event). Their large extent may affect on a large scale the himalayan foothills, the most threatened and densely populated areas.

The origin of these events is undoubtedly natural, compared to small-to-medium scale events, induced both by natural and/or human factors. It is shown that these high magnitude events play a major role in the shaping and denudation history of the entire range. The more high magnitude-low frequency, the longer rate of landscape recovery. In turn, the time of recovery may be indirectly used for estimating the magnitude of a given event.

High magnitude events not only contribute to a large transfer of materials across and out of the mountain; their geomorphic and sedimentary remains also indirectly control the present zoning of geomorphic instabilities and the nature and intensity of current processes, thus eventually the distribution of potential hazards. Further studies are however necessary to better predict sediments yields and geomorphic remodelling of the landscape by these extreme

events, so that their impact can be accurately considered in landuse management and projects implementation, in order to avoiding further damages and heavy losses among local populations.

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The relationships between man and his environment around Lake Maliq (Albania) in the Holocene period

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Lake Maliq is situated in the greco-macedonian border of South- East Albania, north west of the graben of Korçë, at an altitude of 800 m. A thick layer of turf formed itself in the Holocene period and until the 1970's, when a series of drainage works dried out the lake for good.
On the western side of this former lake lies the archaeological site of Sovjan. This tell dating back to the Iron and Bronze Age has been excavated by the French-Albanian archeological mission of the Korçë basin (Cnrs Ura 1473, University Paris I, French School of Archeology in Athens, Archeological Institute of Tirana).
The joint analysis of the results of the archaelogical excavations, of the regional neo-tectonic and geomorphological context, of ^{14}C datings, of drills and particularly the pollen study of 9,30 m of turf taken in one continuous part from the middle of the former lake, leads us to propose a new comprehensive paleo-environmental study on Southern Albania. We try to make out the respective influence of climatic and anthropic factors in the Holocene period on the variations in the level of the waters of former Lake Maliq as well as on the evolution of the vegetation.

ERIC FOUACHE [1], GJIOVALIN GRUDA [2], SKENDER MUCAJ [3] & PAL NIKOLLI [2]

The recent geomorphological evolution of the Rivers Vjosë and Seman (Albania)

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Coming out of the Neogene molasse hills of the Mallakast'r, the rivers Seman and Vjos' have built up two large joint deltas on the Albanian adriatic shore which is characterized by a low lido-coast. The changes in the river courses and the migrations of the heads of the deltas were quick and numerous from the Holocene period down to the drainage works started in the 1950s.
The use of a Spot image dated May 25 1995 (Hrv 3 081-268) enables us to visualize the coastal and fluvial dynamics, the role of neotectonics as well as the predominance of the flume of turbidity of the Seman River.
The fact that we took part in the French-Albanian archaeological mission in Apollonia since 1994 allowed us to confront geomorphological, archaeological and historical data, in particular ottoman and medieval archives and a detailed inventory of the maps available. So our research opens on to a geomorphological map and an accurate dating of the changes in the courses that occurred since antiquity. It appears that the 20th century has known by far the largest progression of the deltas in historical times.

WOLFGANG FRISCH, JOACHIM KUHLEMANN & ISTVÁN DUNKL

Geomorphological evolution of the Eastern Alps as a response to Neogene postcollisional tectonics

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The topographic pattern of the Eastern Alps is mainly determined by Neogene lateral tectonic extrusion, which is a combination of gravitational collapse of the thermally equilibrating thickened crust and tectonic escape of rigid blocks of the upper plate orogenic lid. During extrusion, tectonic blocks migrated towards the east, which was enabled by subducting oceanic lithosphere in the Pannonian region creating free space to escape. This process was accompanied by considerable crustal and lithospheric thinning.
As a consequence of lateral tectonic extrusion, there is a general decrease from west to east in mean and maximum elevations of each tectonic mega-unit (Subalpine Molasse, Rhenodanubian Flysch, Northern Calcareous Alps, Austroalpine basement zone, Penninic Tauern window). This picture becomes more differentiated if lithological parameters and exhumation data from apatite fission track analy-

sis are considered. In the northern Calcareous Alps, topographic elevations and morphology are strongly influenced by the thick Upper Triassic carbonates (Hauptdolomit vs. Dachsteinkalk). In the central zone of the mountain range, relief and elevations are mainly determined by differental uplift of tectonic blocks in Neogene times. Paleogene apatite fission track ages >30 Ma are characteristic of Austroalpine basement areas east of the Tauern window, where relatively smooth morphology in the peak regions represent modified Oligocene-Miocene land surfaces. In contrast, the Niedere Tauern have a rugged relief and higher elevations and reveal Miocene apatite fission track ages. They are part of a wide zone including also the areas west and south of the Tauern window and the Tauern window itself, where Miocene apatite fission track ages correspond with high relief and topography.

The geomorphologic evolution since the start of extrusion tectonics around the Oligocene/Miocene boundary is reconstructed from information attained (1) by apatite fission track data in the mountain body as well as in conglomerates and sandstones of the Neogene basin deposits, (2) by provenance and grain size studies of clastic material in these basins, (3) by sediment mass balances, and (4) by the evaluation of the main tectonic lines active in Neogene times and acting as guidelines for the drainage system. The result is a reconstruction of the paleogeology and paleotopography for time slices in the Late Oligocene and Miocene, shown in maps on the basis of a palinspastic restoration of the tectonic evolution. This restoration shows that the Penninic Tauern window was essentially exhumed by tectonic denudation and only to a minor extent (in the order of 10-20%) by erosion. The tectonic blocks presently positioned to the west and east of the window were originally coherent and were pulled apart for 160 km in the course of extrusion tectonics, which means stretching of the entire Eastern Alps in the order of 155% since the Oligocene. The Northern Calcareous Alps (Nca), the Rhenodanubian Flysch and the Subalpine Molasse experienced the same amount of stretching. This means that the Eastern Alps attained their elongated shape in E-W direction during Neogene postcollisional tectonics. Our paleotopographic reconstruction has been performed for three time slices:

1. Late Oligocene (ca. 29-23 Ma): In the area west of the later Tauern window a mountainous relief already existed, which is probably related to Oligocene uplift processes in the Swiss Alps. The western Nca formed a mountain range that dewatered into the molasse basin due north. The crystalline area to its south delivered material in the molasse basin in the Chiemsee area further east, because the drainage was deviated by the paleo-Inn valley which followed a prominent fault zone. The main water divide was situated as far south as the Periadriatic magmatic belt, today positioned south of the main divide. The area east of the later Tauern window was a hilly landscape formed by Paleozoic rock sequences, which delivered eroded material due north. This conglomeratic and sandy material was deposited by braided rivers as a sediment sheet several hundred metres thick on top of the central and eastern Nca, which formed lowlands not much above sea level.
2. Early/Middle Miocene (ca. 18-15 Ma): In the western part of the Eastern Alps the situation did not experience much change. The area of the later Tauern window became increasingly mountainous. Enhanced tectonic movements caused fundamental changes in morphology and drainage pattern east of the later Tauern window. Rivers created a higher relief in the uplifting area and followed the main tectonic lines. They became oriented towards the east and deposited their load in the Styrian basin. A number of short-lived intramontane basins formed as pullapart structures along the main tectonic lines. The clastic deposits on top of the Nca started to be eroded and redeposited in the molasse basin further north.
3. Middle/Late Miocene (ca. 13-8 Ma): The Penninic contents of the Tauern window was exhumed by that time. Surface uplift governed the entire Eastern Alps. The paleo-Inn river built a large fan system in the molasse basin NE of the town of Salzburg. The central and eastern Nca started their uplift history in pulses separated by periods of relative quiescence. Around that time, the Eastern Alps start to become a climatic divide.

AMOS FRUMKIN

Radiocarbon dating of a karst terrain exposure

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Mount Sedom salt diapir, Israel, appears to be unique in its short time scale of landscape evolution, for it was exposed above base level only during the Holocene. An extensive salt karst system has developed during this short period. Multi-level vadose caves were ^{14}C dated using wood fragments embedded in alluvial deposits. The oldest date of each cave is used to constrain the age of the salt exposure. The area exposed above base level has grown from a small hill at 7000 yr B.P. to two ridges by 4000 yr B.P., which combined recently to form the present elongated mountain. The upper portion of the southeastern escarpment was the first to rise above base level ~7100 yr B.P. Caves in the surrounding area indicate gradual landscape exposure around this initial karstified area between 7000 and 4000 yr B.P. The northern part of the mountain experienced a similar exposure history, lagging some 3000 yr after the southern part. This lag may be attributed to the narrow width of the diapir in the north, which increases viscous drag at the borders of the rising diapir.

The method used is different from other techniques of surface exposure dating, such as *in situ* produced cosmogenic isotopes and may be applicable to other karst landscapes.

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& ANA BLÁZQUEZ

Geomorphological evolution of the Valencian coastline during Upper Quaternary (Spain, Western Mediterranean)

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The study of Pleistocene sedimentary series (dunes, beaches and colluvial deposits) at the Southern coast of Valencia (Spain) lets us know about geomorphological changes of that littoral area during Upper Quaternary.
As for its structure, the area corresponds to the outer units of the Betic System, and shows Mesocenozoic calcareous lythologies. This range forms a line of low and middle cliffs interrupted by low coast segments as it reaches the littoral area. Methodology employed involves geomorphological study of the area, analysis of sedimentary bodies (bio and lythofacies) and obtention of numerical chronologies of the most important units.
A number of stratigraphical records have been located according to these data on the following typical sectors: 1. Dénia sector (Les Rotes and Cova Tallada); 2. Xàbia sector (Muntanyars); 3. Ifac sector (Moraira, Fustera, Bassetes, Banys de la Reina); 4. Altea sector (Olla and Penyes de l'Arabí).
On this study we have been able to determine the chronostratigraphical and paleogeographical sequence of the area and draw some conclusions, such as: 1. The determination of the eustatical oscillations of Western Mediterranean during recent Quaternary, and their geomorphological influence on the Valencian coast.; 2. Climatic changes and associate morphogenetic processes; 3. The role of Neotectonics in landscape configuration.
The main sequence consists of two big colluvial series (associated respectively to Upper and Middle Paleolythic) with thick dunar bodies intercalated. Several fossil beaches found at the surface approximately between 0 and 4 m above sea level point out previous transgressive periods. These deposits form nowadays a detritic cliff modelled by the Holocene sea.

GIOVANNI GABBIANELLI[1] & PAOLO COLANTONI[2]

Palinuro Seamount: a large open-sea volcano in the Tyrrhenian Sea partially modelled by Late Quaternary glacio-eustatic sea level changes

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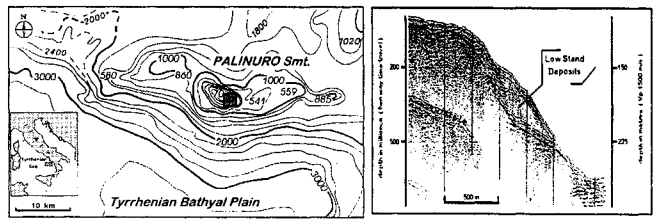
The Palinuro Seamount, located in the southeast Tyrrhenian sea (Central Mediterranean) about 80 km offshore the coasts of Campania Region, is a wide volcanic complex due to Plio-Quaternary faults connected to the extension of the Tyrrhenian basin (Barberi & *alii*, 1974; Beccaluva & *alii*, 1984; Serri 1990). Detailed informartions on the volcanic morphology and on discovered ore deposits (mainly Mn and some metallic sulphides) were obtained by means of direct inspections carried out by manned and un- manned submersibles, narrow beam echosounding, side scan sonar surveys, high resolution seismic profiling and bottom sampling (Selli & Gabbianelli, 1979; Rossi & *alii*, 1980; Minniti & Bonavia 1984). Its sampled lavas are mainly tholeitic. Some calc- alkaline samples collected on its summital area showed an age of about 350 ky B.P. (Colantoni & *alii*, 1981).

The seamount is marked by an E-W prevailing extension (about 55 km of length Vs. about 30 km of width) and rises from the over 3200 m deep tyrrhenian Bathyal Plain up to 80 metres. In addition to the main and shallowest summit, other eight E-W ranging peaks with a clear conical morphology and all corresponding to single eruptive centers, are encountered at depth between about 1300 and 500 m. The main summit itself is composed at least of two different eruptive features separated by a little sill lying at a maximum depth of 180 m. The minor and western one is clearly cone- shaped and shows, at its narrow top about 136 m deep, radial little ridges and a well recognizable crateric morphology, while the major and eastern feature is characterized by a general more complex and rough morphology.

It presents a wide plateau (about 3 km of radius) whose depth ranges from less than 80 m at the center to 100-120 m at the external edges. A number of small reliefs raise above the plateau and represent relics of wave erosion; to one of these corresponds the shalloweat depth of 70 m (Colantoni & *alii*, 1981). At major depths the slopes deep rapidly at a rate of 1 to 2.

The summit of the volcano has been visited by divers that observed a clear erosional surface, covered by organogeneous sands, with rough outcrops of hard lavas surrounded by large cobbles up to 30 cm in diameter, indicative of an old and strong wave action. The debris pulled away from the eroded surface fed a depositional wedge on the western edge of the platform, similar to the low-stand deposits described in the classic model of the sequence stratigraphy. The wedge, whose thickness is up to 40 m, shows clear downlap terminations and internal foresets lying on a slant surface of unconformity which stretch forth the erosional surface.

The Palinuro Seamount is therefore the first documented example in the Mediterranean of an open-sea seamount, where the morphology of the top has been largely controlled by the late Pleistocene glacio-eustatic variations that about 18 ky B.P. brought the sea level down to 110-130 m below the present level, triggering widespread erosions.



GIOVANNI GABBIANELLI & CARLO ELMI

Submerged evidences of the Roman delta of the Po River near the Reno River mouth (North Adriatic italian coast)

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The Reno River is a minor Apennine river that debouches into the Adriatic sea, North of Ravenna. The area of its modern mouth represented in historical times the place of two wide cuspidate deltas of another river, the Po River, that followed each other in the complex evolution of its dispersing system. In the last 2500 years and before the formation of the modern Po bird-foot delta (17th century to present), at least ten distinct major cuspidate subdeltas developed, following the repeated shifting of the distributary channels and the increasing man's control on the Padan hydrographic system (Ciabatti, 1966; Roncuzzi & *alii,* 1970; Fabbri 1985, Bondesan 1989). These delta bodies, largely reconstructed on the basis of inland geomorphologic elements (buried barriers island, lagoon remains etc.) and of historical-archaeological information, generally did not prograde far out from the shorelines for two main causes:

– the rivers flow was distributed along a wide frontal area and through small outlets, delta interlagoonal areas, interdistributary bay etc. (Nelson, 1970);

– the sediment supply was lower than the present one, due to the low man's impact on the natural system.

Their largest extension generally never reached nor passed the present coast line, with the exceptions of: i) the late

Roman delta; ii) the Renaissance delta, both exactly corresponding to the modern Reno River mouths.
The first and the largest of these triangular deltas, built up by the ancient *Padus* or *Eridanus* (Pliny the Elder) or *Padoa* (Polybius) begins 7 km inland far from the present coast, with a basal width of more than 44 km and an «height» of about 11 km (Ciabatti, 1966). So the delta cusp was at about 4 km far from the present day shoreline. Already in the Middle Age, around the 8th century, the Eridanus branch has been abandoned, substituted by a new northern branch, the Po di Volano (Gandolfi & *alii*; 1981, Castiglioni & *alii,* 1990) and its delta system must have been completely eroded.
The second and more reduced delta system is built up by the so called Po di Primaro, (name whose earliest mentions go back only to the 9th - 10th century - Fabbri, 1985), one of the most active and predominant during the Renaissance even because several Apennine rivers were artificially made to debouch into it. The delta can also be reconstructed on the basis of numerous and reliable «pre-geodetic» maps and of historical-archaeological data as well (Fabbri, 1994, Gabbianelli & *alii,* 1994). Its large cusp showed a basal width of 10-15 km while its cusp grew 1 to 2 km offshore the present shoreline. This extension, however, has been reconstructed with good precision by the automatic reshaping of some «pre-geodetic» maps and mainly on the basis of the discovery about 1300 m far from the present shoreline at 8 m deep of an ancient guard tower (Torre Gregoriana) built in the 1598 near its mouth. Following the deactivation, around the middle of the 17th century, of the Po di Primaro and its separation from the Po River main system, the tower after only a century was partly submerged because of the wave and current erosion (Baldini, 1985). The abandoned river assumed, after a little span of time, the name of its only left tributary, the Reno River (Fabbri, 1994, Elmi & *alii,* 1995).
A very-high resolution seismic survey, carried out for the researches on the submerged guard tower, shows the presence of the remains of a complex buried channel system, with a sinuous pattern roughly perpendicular to the shoreline, covered by recent marine, mainly clay, unconsolidated sediments, 2-4 m thick. The channels, filled by 1-4 m of coarser sediments, range in width from 250 to 500 m and can be followed for long distances, at depth varying between -5 and -15 m. Their position, shape and size seem to indicate a system of branching distributaries, of the same dimension of the present Po R. distributaries. We cannot exclude, at the present state of the studies, that the channels are of tidal origin, i.e. tidal inlets cutting a barrier island or a spit, as clearly sketched in the 16th and 17th maps (Mangini, 1598).
Shape, dimension and orientation of the detected channels, as well as their distance from the present shoreline, are well consistent with the reconstructed delta system of Late Roman - Early Middle Age Eridanus River.

JEAN-MICHEL GARDAZ, RALPH LUGON
& REYNALD DELALOYE

Mesures Bts et sondages géoélectriques pour la prospection du pergélisol de montagne dans les Alpes penniques valaisannes (Alpes suisses)

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Le poster présente une synthèse des mesures Bts et des sondages géolectriques réalisés ces 4 dernières années dans les Alpes penniques valaisannes par les chercheurs de l'Institut de Géographie de l'Université de Fribourg. Au total plus de 500 mesures Bts et environ 40 sondages géoélectriques ont été réalisées dans divers sites d'études et pour des problématiques variées: étude de la distribution spatiale du pergélisol, prospection du pergélisol sur des versants instables (glacier rocheux, moraines), étude hydrologique des glaciers rocheux. Les résultats des mesures Bts et des sondages géoélectriques ont permis également de situer la limite inférieure du pergélisol dans les différents sites étudiés. Cette limite varie en effet m me à l'intérieur du cadre régional des Alpes penniques valaisannes. Un inventaire des difficultés techniques rencontrées et des limites des deux méthodes utilisées est également présenté.

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Effect of subducting seafloor roughness on drainage basin, evolution and morphology in the forearc of Costa Rica

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Along the Pacific Coast of Costa Rica, forearc deformation in the Panama block is controlled to a large degree by roughness elements on the subducting Cocos plate. The dominant bathymetric feature on the subducting plate is the northeast-trending aseismic Cocos Ridge offshore of southern Costa Rica. Regional distribution of both modeled and observed Quaternary uplift rates in the forearc generally correspond to the average long wavelength (several hundred kilometers) bathymetry (up to 2000 m of relief) of the indenting aseismic Cocos Ridge. Fastest uplift rates (up to 8m/1000yr) are over the Cocos Ridge crest on the Peninsula de Osa and decrease along the coast northward toward the Peninsula de Nicoya (~1m/1000yr) and southward toward the Peninsula de Burica (4m/1000yr).

Northwest of the Cocos Ridge along the Pacific coast, seafloor bathymetry of the Cocos plate reveals short wavelength roughness elements related to northeast-trending seamount chains. Most of these seamounts are aligned parallel to the Cocos Ridge and produce embayments in the accrectionary prism as they pass beneath the overriding plate. Because the linear seamount chains are nearly parallel to the relative velocity vector between the Cocos plate and the Panama block, the position of seamount subduction does not change significantly through time. Thus, forearc deformation associated with subducting roughness elements is spatially stationary and cumulative through time. Locally observed deformation that is not consistent with the long wavelength bathymetry of the Cocos Ridge occurs inboard of these linear seamount chains, with the highest «above background» uplift rates onshore of the linear seamount chains.

Onland, the Costa Rican forearc is cut by normal, strike-slip and oblique faults that trend nearly orthogonal to the coast. These faults cut Mesozoic basement (Nicoya Complex), Tertiary sediments and volcanics, and Quaternary marine and fluvial terraces. The Costa Rican forearc is effectively segmented into discrete tectonic blocks with different uplift rates. Differences in the distribution and rates of Quaternary deformation along a ~500 km stretch of this segmented forearc are constrained by offset volcanic rocks and regional correlation of fluvial and marine terraces. Terrace chronosequences based on radiometric ages, soil development, and weathering rind thickness establish absolute and relative timelines that are correlated across active faults. Terrace elevations vary significantly along the coast, with sharp changes across major faults. Higher elevations typically occur within fault blocks that expose Mesozoic basement.

This generally well constrained deformation along the coast allows us to investigate the relationship between uplift and drainage basin evolution and morphology for fluvial systems draining the Costa Rican forearc. Along the coast the first order effect is a broad, regional tilting about an axis of rotation that is centered on and parallel to the Cocos Ridge. Inboard of the Cocos Ridge crest the regional tilting is down-to-the-northeast, away from the coast. This regional tilting is evident in pronounced drainage basin asymmetries, where the asymmetry factor (AF) is

$$AF = 100\ (Ar/At)$$

and Ar is drainage area on the downstream right of the trunk stream and At is total drainage area. Regional tilting is further augmented across segmented tectonic blocks in the forearc where AF values are maximized and show consistent tilting directions. Additionally, stream length-gradient index (SL) where

$$SL = (\Delta H/\Delta L)L$$

and ΔH is change in elevation of a reach, ΔL is reach length and L is total channel length from the reach of interest to the drainage divide have values consistent with tilting directions and asymmetry factors.

These rapidly uplifting blocks generate scarps that deflect major trunk rivers from coast-parallel, longitudinal valleys within the active fold and thrust belt into coast-perpendicular, fault controlled valleys with direct access to the ocean. These trunk systems tend to migrate down the regional slope, off the Cocos Ridge crest, further accentuating basin asymmetries.

ALEXANDR A. GAVRILOV

The largest-scale ring structures of the Earth (on date of tectonic geomorphology)

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The mid ocean ridges have its orographic continuation on continent, formed together with mountain chains of land united closed orogenic systems (Gavrilov, 1989, 1994). One can distinguish Indo-Pacific (In-P) and Indo-Atlantic (In-At) global ring structures. Their forms in Mercator projection are similar to ellipses. The length of big half-axis of In-P structure at equator is 10 th. km., the small is 8 th. km. In-At structure has the big half-axis 9,5 th. km., the small half-axis at 20° W meridian is 7,5 th. km. The geological and geodynamic asymmetry about equator is characterized for these structures. There are zones of tectonic collision and granite magmatism in north within the limit of continents and, on the contrary, there are rifting processes and massed basalt eruption in south at ocean districts. In-P structure can have cosmogenic or endogenic origin, In-At - only endogenic one. These are the main elements of global system of ring structures (fig. 1). The anomal high concentrations of magmatic and metamorphic rocks areas, epicentres of earthquake and zones of tectonic collisions indicate that the ring structures are the main reflection forms of global and regional heat flows.

FIG. 1 - Global System of ring structures

1. boundaries of the land; 2. ocean rifting system; 3. fracture zones; 4. mountain chains of land; 5. large-scale relief ledge of abyssal trenches and depressions; 6. geology-geomorphological boundaries of ring structures, correlated with projection of deep endogenic centre; 7. volcanic uplifts of ocean bed; 8. abyssal depressions.

PIOTR GĘBICA

Lithology and stratigraphy of the Plenivistulian terraces in the Vistula valley (Sandomierz Basin, South Poland)

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In the Vistula river valley there occur two terraces of the Plenivistulian age: loess-covered terrace (13-17 m above the channel level) and sandy terrace (4-8 m above the channel level). On the basis of the field studies and lithological analyses different types of fluvial and aeolian sediments thickness of 12-16 m have been determined. The ages of deposits have been determined by thermoluminescence and radiocarbon datings.
In the base of the loess terrace coarse and medium sands channel facies were dated TL at 69±9 ka BP. The Middle Plenivistulian deposits are most differentiated. There are channel deposits (sands with gravel) and overbank deposits (channel fill deposits, floodplain deposits backswamps and organogenic deposits). These are steel-gray silts, silty clay and clay, in some strata with organic matter. Stratification of the deposits is less well developed and often disturbed by involutions. Mean diameter (Mz) ranges from 4-8 phi. The age of the sediments determined by TL datings ranges from 42 to 37 ka BP. Radiocarbon datings of the organic silts in the base of the paleochannel infilling and peat layer on the alluvial plain indicate Denekamp interstadial. Above the interstadial peat there are overbank sediments with fossil soil in the top dating from the Upper Plenivistulian.
Alluvial deposits are overlain by yellowish massiv silts with following grain size composition: fraction above 0.06 mm - 4-10%, 0,06-0,02 mm - 45-56%, below 0,004 mm - 13-20%. Sorting is very poor. Granulometric composition of silts is very similar to grain size content of loess of aeolian facies. Loess was dated TL at 23±3 ka BP. Content of calcium carbonate increased upward from 2% to 8% CaCO3 pointing aridization of climate. Mean grain diameter become gradually increased upward from 6,2 to 5,8 phi indicating aeolian (wind) transport with increasing dynamics during the maximum extent of theVistulian ice-sheet (about 20 ka BP).
On the right bank of Vistula river occur typical sandy braided river deposits. In the lower face of terrace these are medium and coarse sands with gravel fining upward. Mean grain diameter varies from –0,35 to 1,7 phi, sorting from very poor to moderate. In the upper face these are medium and fine sands, silty sands including strata of clayey silts. Mean grain diameter become reduced upward from 1,4 to 6,3 phi. Properties of the deposits indicate channel environment with decreasing dynamics and overbank sedimentation. In the uppermost face of the terrace these are well sorted, medium and fine cover sands indicate that river activity weakened and was replaced by aeolian processes pointing drier conditions during the late of Upper Plenivistulian.

RÓBERT GÉCZI, EMIL KUCSERA & JÁNOS RAKONCZAI

Geoecological impacts of aridification and human activity in the Maros River talus (Hungary)

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In the last decades the territory of 3.000 km^2 surface which is situated in the South East part of Hungary has undergone importand precesses of ecological change. In spite of the single water-course of investigated territory is under regulation it was dried up, so that got under way the transformation of vegetation. At the same time the buildings of this area have been demaged because the ground water's level decreased.
In this paper the authors try to explore the relation between above mentioned transformation and aridification respectively how greater effect has produced by the human activity in the ecological change. The authors try to predict the future scenario and to find which steps must be taken to keep back the evolution of this process.

GIUSEPPE GENTILI, ENNIO GIUSTI & GIUSEPPE PIZZAFERRI

Photogrammetric and remote sensing techniques for the investigation of the Corniglio landslide, N. Apennine

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The paper deals with the application of aereophotogrammetric and remote sensing methods and techniques to the study of landslides' movements.
The magnitudes of the vertical and horizontal components of the displacements are defined by comparing analytically rectified aerial photos taken at various times over the active landslide and measuring displacements of recognized natural and man-made objects.
The orthorectification of the air photos has also provided a cartographic base for comparing their man-made structures with the old cadastral maps of the area. From the analysis of the altitudes of the digital terrain model grid, obtained by interpolation from the photogrammetric measurements, we have constructed a tridimensional documentation of the geometry of the landslide and of its displacements.
Data from the Mivis hyperspectral sensor, integrated with the aereophotogrammetric data, provide another dimensional data base to aid in the interpretation of the hydrogeology of the slide.
The 2 complete high altitude aerial surveys of Italy from the Volo Alto 1988-89 and 1994 constitute an important

aerial photography data base with a resolution of less than one meter which can be used to compare, photogrammetrically, new aerial surveys to evaluate possible terrain displacements anywhere in the country.

NATALIA P. GERASIMENKO

Indication of the Pleistocene river terraces in the Northern Ukraine

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Alluvia of the 7 Pleistocene terraces exposed in outcrops and boreholes in the Dnieper and its tributaries basin around Kiev have been investigated as well as morphometric parameters of the terraces. To recognize the characteristic features of each terrace alluvia are very important for the determination of possible subsequent distortion of terrace surfaces.

Substantial differences between alluvia of the cold and temperate Pleistocene intervals firstly described by Goretsky (1970) have been also observed in the investigated region. Alluvia formed in the temperate intervals show more specific features characteristic of each individual terrace unit.

The Early Pleistocene temperate alluvia form lower parts of the VIIth, VIth and Vth terraces and are up to 35 m thick. In the VIIth terrace with the base 10-15 m above modern alluvia floor the coarse basal facies are poorly represented and the oxbow sediments form up to 60% of the alluvia. Temperate alluvia of VIth terrace, 20-25 m above the base of recent alluvia, frequently overlie the older terrace. Overbank floodloams build up to 50% of the alluvia body. Base of the Vth terrace alluvia are close to that of the recent ones. The floodloam facies are infrequent while the coarse basal facies and channel crossbedded sands are well developed. Oxbow facies are also presented.

Alluvia of the Mid-Pleistocene temperate stages in the lower parts of the IVth and IIIrd terraces are about 15 m thick and lie some 15-20 m above the floor of recent alluvia. About 45% of temperate alluvia thickness of IVth terrace are of the coarse erosional facies. The rest is presented by channel crossbedded sands while floodloams and oxbow facies are absent. The temperate alluvia of IIIrd terrace, on the contrary, has only about 25% in the coarse basal facies and up to 50% in the overbank floodloam facies.

The Late Pleistocene temperate alluvia of the IInd and Ist terraces are up to 10 m thick. Base of the former is some 5-10 m above and the latter at about the same level as the recent alluvia floor. All facies are well developed while the overbank facies form about 75% of the latter. Coarse basal facies are less developed in the Ist terrace alluvia.

Alluvia of the cold stages form the upper parts of the terrace bodies frequently overlying the alluvia of the warm stages. Cold alluvia units are very much alike and presented by the poorly sorted thick sands and loams of so called periglacial facies. Those of the Vth and VIth terraces are of the fluvioglacial type.

DAVID P. GILES & MALCOLM C.Z. WHITWORTH

Periglacial geohazard prediction utilising remotely sensed imagery, geomorphology and piezometry

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With the advent of Geographical Information Systems (Gis) the applied geologist is provided with a powerful interpretive and visualisation tool. These systems allow the integration and manipulation of multiple data sets that are referenced in the spatial domain. This paper will present work that is being undertaken in integrating remotely sensed imagery, geomorphological maps and substantial piezometric data available from a borehole ground investigation programme to detect, delineate and interpret active and relict periglacial solifluction and landslide features.

Much of southern Britain has been affected by intense periglacial activity as a result of several major ice advances during Quaternary glacial stages. The project area for this research is located north of the village of Broadway in the Cotswold Hills, an area which was adjacent to the maximum extent of these ice advances. As a result the area experienced severe periglacial conditions resulting in frost shattered bedrock, considerable solifluction and major landsliding. The geotechnical and geomorphological aspects of these features and their associated deposits give rise to significant engineering geological problems. These periglacial landforms and landslides are deemed metastable under normal conditions due to the presence of extensive shear planes which can be reactivated, potentially initiating subsequent failure of the slopes. This area is of particular interest as a road by-pass scheme is being proposed for the village of Broadway with the route running directly across many these features.

Geologically the study area is located within the northern Cotswolds and is underlain by Lower Jurassic strata of Lias age. The area comprises of Lower, Middle and Upper Lias overlain by Middle Jurassic Inferior Oolite which outcrops beyond the initial study area. The regional dip is approximately horizonal and the area is faulted. The geological sequence consists of interbedded siltstones, sandstones and limestones all of which are prone to mass movement. The Lower Lias strata generally has a high moisture content and it's boundary is delineated by a marked spring line with the contact between the permeable Middle and relatively impermeable Lower Lias. The area displays both solifluction movements as well as rotational and shallow translational type landslides.

Traditionally to identify periglacial hazards in the field detailed geomorphological mapping would be undertaken. However, walk-over surveys may not always identify all such features since natural degradation such as hill wash and intense agriculture and ploughing may have removed surface traces which will impede their identification. Additional data sources such as aerial photographs can be used together with borehole surveys but a more robust and comprehensive interpretation and investigation is needed to reduce the risk of encountering these features.
Moisture sensitive wavelengths of remotely sensed imagery are being used to explore the fundamental relationship between the surface vegetation, underlying bedrock geology and ground that has been disturbed or undergone some form of mass movement in order to delineate potentially hazardous ground. The piezometric data from the borehole ground investigation provides a detailed indication of the groundwater conditions at the time of capture of the remotely sensed imagery. This project is utilising Geographical Information Systems to integrate, manipulate, analyse and display these major data sets in order to identify these geohazardous features. Primarily moisture sensitive bands of remotely sensed imagery including Landsat Tm, Spot Xs and Airborne Thematic Mapper data are being integrated with 'ground-truth' geomorphological mapping and ground moisture sensitivity surveys to delineate and interpret areas of potential hazard. Known periglacial features and landslide areas are being spectrally defined in order to provide a predictive tool for other areas of similar geology and slope conditions.
This project will provide a geohazard delineation methodology which can be utilised for the investigation of periglacial features which are critical in engineering geological and geomorphological investigations. The research is developing methods for the use of remotely sensed imagery and Geographical Information Systems as part of an integrated hazard assessment of periglacial solifluction and landslide hazards.

SERGIO GINESU

The periglacial deposit of the Middle Pleistocene in Sardinia

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The main geomorphological characteristics of Mt. Tuttavista near Orosei, long the coast of eastern Sardinia, have bein investigated on the basin of new paleontological dating in a lot of fossiliferous karsts.
This region is partially occupied by pliocenic lava flows consolidated from 3.9 M.Y.B.P. to 2.1 M.Y.B.P., the periodical volcanic activities offer more possibilities to recostruction the landscape evolution during Pliocene.
The most important observations are connected to the comparision by periglacial deposits and landforms with each fossiliferous karst; the ages of the karst are different (from Middle-Lower Pleistocene to Upper Pleistocene-Holocene) thanks to the determination of new faunistic species still under observation.
For the first time in Sardinia it is possible to attribute an age to the periglacial deposits as *eboulis ordonnés* or stratified slope deposits in two different episodes: the first located before the ancient fossiliferous karst known in the M. Tuttavista (before 0.7 M.Y.B.P.), a second during the climatic change that produced the probably exitinction of some species in the island.
The landscape recostruction and evolution until the Pliocene let us to identifie the possible climatic change and the different quantity of material produced during the cold stages.

SERGIO GINESU[1], ANDRÈ OZER[2], VALERIA PANIZZA[3], MARIA ANTONIA PULINA[4] & STEFANIA SIAS[1]

Recent evolution of the Coghinas coastal plain (Anglona, North Sardinia, Italy)

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The coastal plain of the Coghinas river represents one of the best examples of alluvional evolution of a fluvial valley influenced by tectonics. Previous studies have given a solid base for the realization of a geomorphological map representing the evolutional processes and forms that influenced the formation of the valley during the Quaternary.
The territory of the Coghinas low plain preserves all forms that determined the evolutional processes of the west-central Sardinia, with particular reference to the following morphologies and processes: big landslide movements, morphostructures, paleosurfaces, fluvial terraces, coastline variations and fluvial course variations.
The origin of the valley may be brought back to a big tectonic structure of regional importance, which caused the abandonment of the ancient course at the end of the Tertiary. The new course, thus set up, allowed the opening of the actual plain with an evolutional pattern mainly linked

to the fluvial dinamics. This process is little represented in the island where the fluvial processes are rare and highly conditioned by the prevaling erosion.
The considerable morphological differences of the area also allowed the localization of three distinct morphogenetic bands. The first, localized in the western sector, is influenced more by the structures. The second one, in the centre, preserves forms and fluvial deposits that define also the ancient surfaces of the plain. The third band, localized in the eastern sector, is almost exclusively represented by eolic processes.
The most recent and historically documented data are also reported, as well as the data about the climate and the recent variations of the River, so to add elements for the analysis of the relationship between climate and runoff regime.

SERGIO GINESU & STEFANIA SIAS

Morphocronological correlations between paleosurfaces and plio-quaternary volcanic events in the Northen Sardinia (Italy)

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The presence of flat isolated surfaces long the valley slopes have been interpreted as erosional terracces, generally placed in calcareous rocks. These surfaces present a restricted area, a width till 0.5 to 1 km^2. Moreovever, it was been possible to identified some areas included from 20 to 30 km^2 as relicted surfaces. These are characterized by a weak relief energy and isolated in the landscape. A third surface is present at altitude between 650-700 m in all the territory.
During the Plio - Pleistocene the island was interested by a periodical volcanic activity from 5 to 0.14 m.y.B.P., many morphologies and deposits have been fossilized by the basaltic lava flows. The pliocenic volcanic activities have fossilized flat surfaces and small plains mostly at an altitude over 600 m. During the Middle Pleistocene the basaltic lava flows have preserved the fluvial network at 400 - 300 m altitude. The recentest volcanic events (Upper Pleistocene) have procteted some lacustrine deposits and some (2) buried soils formed by the volcanic dam in a subordinate creek.
The correlation between all the different surfaces and the dating of each volcanic episodes has permitted to have the age of these landforms and dating the evolution processes that have formed the differnt landscape during the last 2 million of years B.P.
It was possible to identifie the climatic changes thanks to the presence of the deposits under the lava flows, the buried soils and the periglacial sediments.

GABRIELE GIORGI

Morphological evolution of the Bolognese plain (Italy)

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The aim of this study is to point out the morphological transformations in a portion of the Po River plain. To this end several methods were used, such as digital elevation model-building, archaeological, historical and cartographic data collecting and soil studies.
In Po Plain rivers tend to flow elevated respect the surrounding areas, this is due to the continuous sedimentation in the river bed. When rivers overflow and flood, they abandon the previous course, creating a new one. The abandoned relief marks the old river bed.
The invesigated area has been inhabited since the Bronza Age (about 1000 BC). During the Roman Age, the colonists developed the architectural grid (*Centuriazione*) still visible today. The traces of the ancient settlements are sometimes visible on the surface, but often are buried under many meters of sediments.
The ground where the Roman Age finds were made on the surface, corresponds to those portions of the terrain where the most developed soils are, where the morphology is quite regular and the terrain was not subject to flooding over the last 3.000 years. Where the recent soils lie, the ancient sites are buried under several meters of sediments, to the extent that in some cases no finds at all were possible, and morphology is irregular.

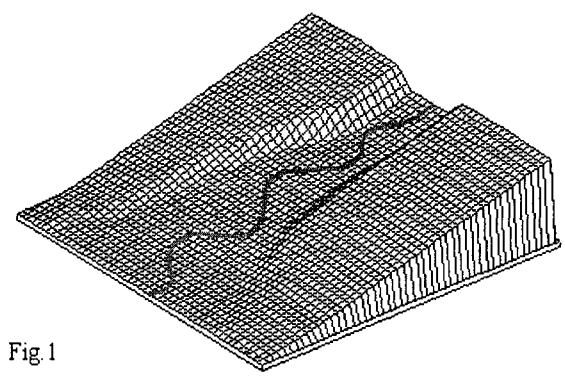

Fig. 1

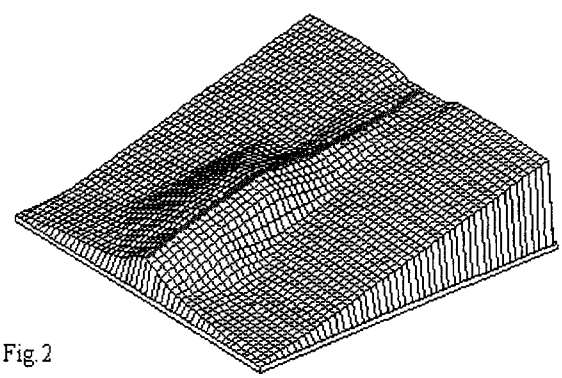

Fig. 2

Such a lack of finds can only be explained by changes in the ancient morphology; rivers flowed in a several meters deep engraved floodplain (fig. 1) the alluvial sediments filled up the engraved valleys as a consequence of subsidence and change in climate during the High Middle Age (fourth to eighth centuries AD) (fig. 2).

ALESSANDRA GIOVANNINI[1], NASSER ABU-ZEID[2] & GIANDREA ALLEGRI[3]

Application of an integrated methodology in the characterisation and analysis of the fluvial morphology of paleo-riverbeds in the eastern lowlands of Ferrara (Northeast of Italy)

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This work deals with the application of an investigation methodology to characterise the mechanism by which two old tributaries (paleo-riverbeds) of the Po River were formed. These are located to the SE of Ferrara, along the Voghenza-S.Vito-Ostellato-Spina and Finale di Rero-Migliarino-Migliaro-Massa Fiscaglia alignment and are known as Padoa-Eridano (VII-VIII A. C.) and Volano (Roman epoch-Upper medieval period).
The applied methodology aims at integrating the geomorphologic studies with recent geoelectrical measurements that included the execution of several Vertical Electrical Soundings (Ves), a number of profiles (Dipole-Dipole) and many auger holes drilled to a maximum depth of 10 m over the two sites.
Analysis of these data led to the identification of the old riverbeds main characteristics in terms of principal channel pattern, delimitation of their levees, individuation of the flooded planes, determination of paleo-channel thickness and localisation of the interdigitating zones.
The resulting geomorphological conceptual model for the studied areas proved to be complex. Although many pieces of information have been obtained, a complete view of the relative evolution of the dynamic processes that led to the formation of these areas were not totally resolved. For this reason a resort to statistics have been made through the employment of the geostatistical techniques (Kriging). The advent of such technique is to assist in the construction of more detailed conceptual models taking into consideration not only the probability with which a certain parameter would exist, but also the error committed in its extrapolation. To do this, all data were analysed by constructing several experimental variograms describing the spatial distribution of paleo-riverbeds characteristics (e.g. subsurface heterogeneity distribution). The obtained models were further compared to known theoretical models, then the variogram parameters (i.e. sill and range of influence) of the model that resulted in the best fit to the experimental data was used as input for the construction of bidimensional maps (detailed geomorphological map). In this way, the spatial variation of each parameter was investigated, hence ambiguities regarding the lateral extension of these parameters where minimised, if not completely resolved. This was made possible through the construction of maps demonstrating the standard deviation of the analysed parameter (thickness and resistivity), thus reflecting the amount of estimated error.
Finally, all the obtained results where used to construct a detailed geomorphological map of the two sites. Such a map show the probable limits of the paleo-riverbeds as well their mutual relationships which were of help in the reconstruction of their geomorphological development.
Last but not least, the research demonstrated that the application of such an integration methodology, characterised by a good cost/benefit ratio, could be of extreme utility for the investigation of areas where their is an urgent need to define and delimit the probable extension of buried structures such as paleo-riverbeds (e.g. protection of groundwater from contamination). Moreover, these studies are believed to be of paramount importance to land planing organisations, especially for those engaged to the planning of lowland areas (e.g. the Padana Plain).

CHRISTIAN GIUSTI

Aplanissements étagés dans le sud du Massif Central (France)

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Dans le sud du Massif central fran ais (Aveyron, Hérault, Tarn), à la charnière des mondes hercynien et alpin, les contrées s'étendant des confins du Sidobre à l'Escandorgue et du sillon Jaur - Thoré aux vallées du Dourdou, du Rance et du Dadou constituent une seule et m me unité géomorphologique: la Montagne.
Du Somail aux Monts d'Orb et du Lacaunais aux Monts du Haut-Dourdou, le plan d'organisation des formes majeures du relief est en effet remarquable de cohérence puisque, en dépit d'innombrables nuances liées à la complexité du canevas structural, partout s'observent les vestiges de deux surfaces d'aplanissement étagées et déformées: la haute surface S_1 et la basse surface S_2. Parce que les traces respectives des deux aplanissements se suivent sur des kilomètres indépendamment de la nature du substrat dans lequel elles s'inscrivent, l'essentiel est bien moins d'opposer les formes para-appalachiennes de la Zone axiale aux formes ortho-appalachiennes de son flanc septentrional, que de distinguer les contrées où l'aplanissement S_2 règne

sans partage d'une aire où les vestiges de la basse surface S_2 se tiennent en contrebas des témoins d'un aplanissement plus ancien, S_1.
L'analyse du dispositif étagé culminant S_1 - S_2 dans les Monts du Haut-Dourdou (série sédimentaire plissée et faillée cambro-silurienne) corrobore en outre un enseignement fondamental tiré de l'examen des faits d'étagement des deux surfaces d'aplanissements dans les Monts de Lacaune (granites et gneiss de *metamorphic core complex*): à savoir que la haute et la basse surface sont non pas des niveaux d'altitude qui tireraient leur justification de pures concordances altimétriques, mais des aplanissements cycliquement étagés, autrement dit d'anciennes formes fonctionnelles. Ces deux surfaces ont ainsi enregistré, au cours de leur très longue histoire, les effets de diverses déformations tectoniques. Si les unes (anté-S_2) n'ont intéressé que la surface S_1, les autres (post-S_2) ont par contre affecté en bloc S_1 et S_2. D'où la circonspection avec laquelle il convient d'utiliser ici le témoignage des modèles numériques de terrain, les deux aplanissements étagés étant des surfaces gauches et non plus des surfaces subhorizontales.

THOMAS GLADE

Spatial and temporal occurrence of rainfall-triggered landslides in New Zealand

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Rainfall-triggered landslide events are a common problem in New Zealand and some have caused extensive damage. Many of these events have been investigated on a regional or site level by various institutions, such as: universities, territorial and regional authorities, Crown Research Institutes, private consultancies, and transport authorities. The output from these investigations is strongly dependent on their specific aims. These studies use different methodologies and techniques related to the nature of the individual problem being investigated, which makes comparative analysis difficult. However, these investigations demonstrate the widespread influence of landslides on all aspects of life and environment and illustrate the need for further detailed investigation.
On the regional scale, studies relating landslide occurrence to rainfall distribution in space and time are rare, which is surprising because of the high yearly total damage caused by rainfall-triggered landslides in New Zealand. The knowledge of rainfall/landslide relationship has potential value to farmers, land managers, politicians, engineers, territorial and regional officials, transport authorities, and insurance companies. Historical records indicate that most parts of the country can expect to suffer damage from this phenomenon. Other overseas agencies have already responded to this need. For example, the U.S. Geological Survey established a real time landslide warning system during heavy rainfalls in the San Francisco Bay Region, California, USA, which operated successfully during a rainstorm in February 1986.
For this investigation, three different regions within the North Island of New Zealand have been chosen to compare magnitude and frequency relationship between landslides and rainfall in both time and space. The regions are Northern Hawke's Bay, Wairarapa, and Wellington. They were selected because of the availability of the necessary temporal and spatial rainfall data, a good landslide record, differences in their physical environment and a complete aerial photo coverage for these areas, especially after highly damaging landslide events.
The study aims are:
1. establishing regional rainfall thresholds, their probabilities of occurrence as well as the probabilities that rainfall of a given magnitude and frequency trigger landslides, by comparing historical records of landslide occurrence with time series rainfall data,
2. relating these thresholds to antecedent soil water conditions,
3. analysing for one episode per region the spatial extent of landslide occurrence and its relationship to the distribution of the triggering rainstorm,
4. summarising and characterising the similarities and/or differences between these regions,
5. establishing a landslide hazard assessment for each region on the basis on historical records.
The overall intention is to establish regional thresholds and to develop some ideas of how rainfall cells trigger landslides and which factors prepare and control the pattern and nature of occurrence. Furthermore, these scientific results are applied to the specific region by a landslide hazard assessment.

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Fission track thermochronology, denudation and tectonics

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Thermochronology, the quantitative study of the thermal histories of rocks through the use of temperature-sensitive radiometric dating methods, provides a powerful new approach to the quantitative reconstruction of long-term patterns of denudation. Methods of quantitative thermal history analysis are now largely based on the $^{40}Ar/^{39}Ar$ and fission track dating methods. Most of these mineral dating systems are affected by temperatures that are typically found at middle crustal depths, but one of them, the apatite fission track system, is particularly useful for studies of the low-temperature environments that prevail in the upper several kilometres in the continental crust. Apatite is a

common accessory mineral in many rocks types so that fission track thermochronology is almost universally applicable to large areas of the earth's crust. The link to denudation arises in that cooling of rocks through the thermal gradient that prevails in this upper crustal domain is mostly dominated by denudation at the surface. In effect, the quantitative thermal history for each rock sample gives a measure of its movement towards the landsurface as material is gradually removed from that surface.

The fission track dating method relies on the accumulation of microscopic lines of radiation damage in natural uranium-bearing minerals, such as apatite, from the spontaneous nuclear fission of ^{238}U. In general, the older the sample the greater the number of tracks that can be observed. However, over geological time-scales, fission tracks are stable only at temperatures relatively low temperatures. As temperature increases the fission tracks are gradually repaired and, eventually disappear, in a processes known as annealing. During annealing the tracks gradually shrink from their ends so that the degree of annealing is indicated by the lengths of individual tracks. The apparent fission track age of the sample and the distribution of track lengths are analysed together to reconstruct the thermal history up to the temperature at which the tracks are lost completely. For apatite, fission track annealing takes place from ambient surface temperatures up to a maximum of about 110°-120°C. Such temperatures are typical of the upper 3-4 km of the crust.

Understanding of the long-term stability of fission tracks is largely based on laboratory annealing studies, which can reproduce the natural geological annealing process on shorter time scales, but at higher temperatures. These studies have led to numerical modelling procedures which can quantitatively reconstruct the thermal history experienced by any particular apatite sample. Fission track modelling procedures are now routinely used to quantify the thermal histories (i.e. the variation of temperature through time) for the host rock masses containing the apatites. Such reconstructions of thermal history make realistic predictions which can be tested in deep drill holes which access temperatures across the geological annealing zone for apatite. Other environments such as sedimentary basins also enable the fission track thermal histories to be tested against other kinds of geological information and palaeotemperature indicators. These studies indicate that the fission track annealing models are well established and provide realistic estimates of past temperature variations.

Different styles of thermal histories give rise to distinctive fission track length distributions which show that only rarely can a fission track age be taken as indicating the timing of some particular event. Most fission track ages are cooling ages or mixtures of two different age components which can be misleading if interpreted at face-value. Where sampling is available over a significant vertical interval, such as from a drill hole or in areas of high surface relief, then distinctive profiles of fission track age with sample elevation are found which are also indicators of the style of thermal history experienced. Because the samples in such a profile have a fixed geometric relationship to each other, reconstruction of the thermal histories also enables the palaeo-thermal gradients to be estimated directly. Knowledge of the thermal gradient is important in calculating denudation rates from the observed cooling rates. Even without such vertical sampling information, however, it is still possible to estimate denudation rates because the range of variation of thermal gradients is reasonably well known in a range of geological settings.

Using these fission track techniques, thermal histories of upper crustal rocks can now be reconstructed in great detail and have proved effective in the study of patterns of denudation in various tectonic settings over time-scales of millions, to hundreds of millions of years. These patterns can also be studied on various spatial scales from regional up to continental with a relatively high spatial resolution. The wide applicability of fission track methods means that this information can be collected relatively easily from large areas of the crust. This type of information, together with associated studies of the natural controls on denudation, provides an extremely powerful methodology for investigating the relationship between tectonics and the evolution of topography. A large fission track data set covering much of southeastern and eastern Australia illustrates the usefulness this approach in reconstructing past variations in palaeotemperature, denudation and landscape evolution in an evolving rifted continental margin setting.

VALENTIN N. GOLOSOV

Redeposition Chernobyl Cs-137 in small basins of Central Russia

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Chernobyl accident caused serious radionuclide pollution of the vast areas of the Russian Plain. According to the latest maps of radionuclide pollution the highest level of pollution (more than 1 ku per sq. m.) are to be found in the Tula, Kaluga, Orel and Bryansk regions of Russia. Detailed large-scale maps of radionuclide inventories are available for all areas with high level of pollution.

The dominant pathway for radionuclide redistribution is associated with soil erosion and sediment delivery, since the radionuclides are strongly sorbed by soil particles. Recent field investigation undertaken by Laboratory of Soil Erosion and Fluvial Processes has shown that significant redistributional transport of radionuclides has occurred within balka or dry creek systems, where substantial levels of accumulation have been dominated. Preliminary estimates of future redistribution and accumulation indicate that 40 years after Chernobyl accident radionuclide inventories in the balka bottoms will be in 7 times higher than at present. The balka bottoms thus represent important sinks for radionuclides and other chemical pollutants, which could

be readily remobilised and transported to the river systems if gully development and incision occur. Because the balka bottoms are commonly < 100 m in width, the existing maps of radionuclide pollution are unable to identify these sinks. Furthermore, redistribution of radionuclide is a continuing process, such that the inventories existing in areas of sediment accumulation will change after each rain storm or snowmelt period when significant transport occurs. Investigations of the contemporary redistribution of Chernobyl radionuclides fallout in Chasovenkov Verh drainage basins (Tula region) provide valuable information on the erosional development and associated sediment budgets of the study areas. Such information is difficult. if not impossible, to obtain using more traditional approaches. Sediment budget calculation for Chasovenkov Verh basin shows that about 93% of sediment from the slope redeposit into basin. Most of them accumulated in the bottoms of main channel and tributaries. The areas of erosion and sedimentation zones relate as 100:1, so Cs-137 concentration in the bottom's sediments increased in 2,5 times (relatively May 1986) during nine years after Chernobyl accident and will be increase in future. These results agree with theoretical suggestions.

Redeposition of sediments in small basins of areas with high level of Chernobyl pollution promotes to increasing concentration of Cs-137 in basin's bottoms. If repeated incision will happen in bottoms due to climate or land use changes, huge quantity of radionuclide's pollutants can be entered the river channels during short period of time. It is necessary to take in consideration during elaboration of water and soil conservation works for areas with Chernobyl pollution.

VALENTIN N. GOLOSOV & GENNADY A. LARIONOV

Recent badland processes in Russia: genesis and geography

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There are few points on the Russian territory, where new badlands are forming now. First, it is North Caucasus region. Overgrazing is the main reason of badland processes here. The geneses of badland are different in steppe and alpine belts. The developments of rill erosion on the mountain slopes, which surround the villages, promote to badland formation in steppe belt. According of our field observation the rates of rill erosion change from 6-7 mm per years if surfaces cover less 5% till 5-6 mm per year, if surface cover 5-10%. Badlands form here on the salt rocks. This is the main reason, why vegetation can not occupy these slopes.

Path erosion gives the development of soil erosion in the alpine zone. This process begins after destruction of turf. Then cliff retreats up to slope due to influence of denudation processes. Rates of cliff displacement vary from 8 till 31 sq.m. per year. Wide areas without any soil occupy slope. Then erosion processes as well as scree processes develop here. Now about 60-70% of pastures are destroyed by processes of path erosion in some basin of alpine zone of Dagestan Republic. The same processes are observed in some other mountain region of Russia (Altai, Sayany and other).

South Zabaikalie is the other area, which located in the steppe zone in the Onon river basin (one the main tributary of the Amur river). Relief of territory is small hills with steepness of slope 5-20 degree on the relatively flat surface. Cultivated areas occupy about 10% of territory. Climate of territory is typical monsoon with intensity rainfalls in July and August, about 80% of summer precipitation fall. This change of climate happens in the beginning of 1980, when monsoon climate became to move inside continent till the Zabaikalie. As a result, summer heavy floods happen in Zabaikalie almost each year. Early the climate of territory was more dry. Intensity of rill and gully erosion formation is about 50-100 m per year. Usually rill and gully form by the three ways. First, they form in the natural hollow and retreat up to the cultivated slope. Second, rills and then gullies wash out the furrows, which usually appear after cultivation along slope length. At least, gully form in the bottom of aggradated creek, which are used as the tillage. Gullies resolve not so far from each other along the slope bottom and grow in length, depth and wide. In the result they dissected all slope. Only for last 5 years about 40% of tillage transform in badlands in Aksha region of Zabaikalie, for example. Cultivated field may be completely destroyed and became badland after one summer season.

At least, mining regions of Russia (Belgorod, Ural, Kuzbass and other) are the last points with active badland's processes, which are observed on the dumps and terrace slopes. So it is completely artificial process, but it extremely strong influence on the local environment. As a rule, the materials from dumps are entered to the small rivers and promote to their aggradation. The detail study in Tula mining region shows us that during each year about 500 meters of small river completely aggradate.

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Downstream changes in bed material size, Waipaoa River, New Zealand

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The 104 km long Waipaoa River is located in the East Cape region of New Zealand's North Island; the river rises on the eastern slopes of the Raukumara Ranges and drains in-

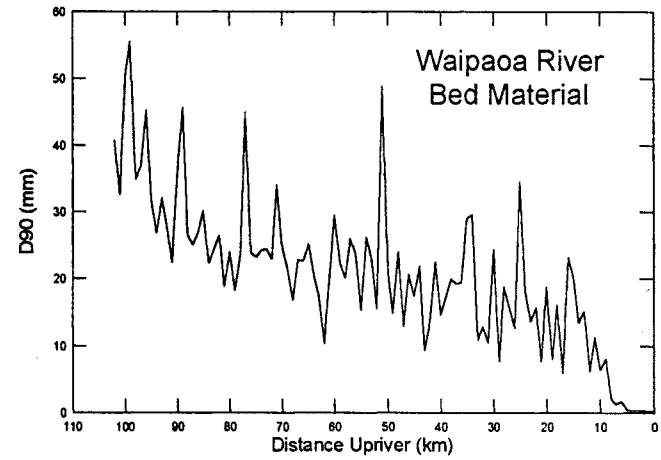
to Poverty Bay. Erosion rates in the headwaters of the 2150 km^2 catchment, where the underlying rocks predominately are poorly indurated sandstones, siltstones and mudstones of Cretaceous to Tertiary age, were enhanced following a phase of forest clearance in the period 1880 to 1920. Channels throughout the basin subsequently were overloaded by sediment supplied to them by mass movements and gullies. The upper reaches of the mainstem (>92 km from the coast) are braided and have aggraded by >5 m in past 48 years. Throughout the lower reaches (<77 km from the coast) the river maintains a single thread, meandering channel and, in the period 1948-1996, the amount of aggradation was ~1 m. A narrow, 15 km long, gorge separates the braided upper and meandering lower reaches.

Bed material samples were collected at 1 km intervals along the entire length of the channel, and at locations immediately upstream from the confluence along major tributaries. The sample sites were located as near as possible to the channel centre-line. Bulk (50 kg) samples of the subsurface bed material were obtained at all sites <102 km from the coast. At the remaining sites the calibre of the bed material made it impractical to accomplish a bulk sieve analysis, and areal samples were collected using the Wolman method. The shape and lithology of all particles >16 mm in diameter was resolved for every fifth sample. A less comprehensive survey of the subsurface bed material also was undertaken at 1.6 km (1 mile) intervals along the channel in 1960.

The gravel-sand transition in the Waipaoa River occurs between 7 and 8 km from the coast. The rate of downstream fining is highest for the coarsest particle size fractions, decreasing for finer size fractions. Within the 96 km long reach upriver from the gravel-sand transition the subsurface bed material rarely contains <25 % sand; the D_{90} of the subsurface bed material declines from ~41 mm in the headwaters to ~4 mm, and the D_{50} from ~5 mm to ~1 mm. The high proportion of sand present in the subsurface bed material throughout the river system reflects the dominance of fine over coarse inputs to the channel from both tributaries and the surrounding hillslopes.

Comparison with the bed material samples collected in 1960 revealed a tendency towards coarsening in the braided reaches and fining in the meandering reaches over time. The diminution coefficient (for the D_{90}) is highest in the 14 km long braided reach (0.052 km^{-1}); within the single thread channel downstream from the gorge it is 0.012 km^{-1}. There is no variation in the diminution coefficient with particle lithology. Coarse and fine inputs from actively eroding bluffs, hillslopes and other riparian sources dominate over sediment inputs from tributaries throughout the lower reaches, but have an extremely localised effect on both the bed material size distribution and the downriver decrease in particle size. Coarse (>16 mm) particles of all lithologies show insignificant changes in particle form in the downstream direction.

We conclude that, in the Waipaoa River, abrasion has a negligible effect on the observed downstream decrease in particle size at the catchment scale, although it may be important at the reach scale. Selective transport is the dominant process contributing to downstream fining in this actively aggrading, gravel bed river.



DULAL C. GOSWAMI

Pattern of bank erosion and channel migration in the Brahmaputra River, Assam (India)

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The Brahmaputra is a major alluvial river of the world characterised by extremely high rates of sediment transport, channel aggradation and bankline migration. The river carries an average annual suspended load of 402 million metric tons at Pandu (India) where the mean daily sediment yield during the monsoon season, May through October, is of the order of 2 million metric tons. The bankline of the Brahmaputra, for the most part, is extremely unstable. Bank failures are rampant here and these seem to be a function of hydraulic character of flow and engineering properties of bank materials that are composed of varying proportions of fine sand and silt with occasional presence of minor amounts of clay. Shear failures in the upper bank materials seem to be by far the most widespread mode of bank failure. It is caused either by undercutting of upper bank materials by currents during high flows producing and overhanging cantilevered block which eventually fails, or by oversteepening of the bank materials due to migration of the thalweg closer to the bank during the falling stages. Textural and mineralogical characteristics of bank materials, hydrodynamic conditions of flow and sediment in the channel, provenance of source rocks from heavy mineral analysis and X-ray diffraction of the clay fraction are some of the aspects investigated in the study. The profiles of bank malerials indicate two distinct parts-a relatively fine-grained topstratum and a coarser substratum. Large

scale slumping of banks observed during the falling stages of the river may be associated with return flows in the permeable alluvium. High moisture content, low proportion of clay and good sorting of bank materials are some of the major factors responsible for high susceptibility of banks to erosion by the river.
The channel configuratfion of the Brahmaputra undergoes drastic changes in response to variation in the flow regime and patterns of sediment transport in the river corresponding to the rhythm of the monsoon and freeze-thaw cycle of Himalayan snow. With the onset of the flood season, the thalweg keeps shifting from one location to another within the banklines of the river. The movement is high during the rising stages (May-June), less during the peak of the flood (July-August), most erratic during the falling stages (September-October) and very little during the low flow stage (November-March). The spatio-temporal movements of the thalweg in the river are studied based on sequential cross-sections. The mechanism of braiding of the river channel and its impact on the stability of the banks is also discussed. An enquiry into the nature and intensity of bankline migration of the Brahmaputra at selected vulnerable reaches like Dibrugarh, Majuli and Palasbari is made with the help of satellite remote sensing data. Through integration of remotely sensed digital data and ground based field as well as laboratory measurements using GIS, an attempt is made to identify the various geomorphic as well as hydraulic factors responsible for the high rales of bank erosion and channel instabilily in the vulnerable sections.

S.C. Goswami

Multi-component minerals in some saline-alkali soils

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Mica weathers to give rise to a variety of secondary minerals under different climatic conditions. X-ray diffraction studies of some soil profiles from the state of Uttar Pradesh, India, revealed the presence of such weathered products of mica as suggested a mixed-layering of mica with one or two layers of 1.4 nm minerals.
The horizon-wise semi-quantitative estimates of the layer silicate minerals, which were obtained by measuring the peak areas under the X-ray reflections, indicated that vermiculites (4-10%), smectites or chloritized-smectites (18-28%), and interstratified minerals (27-32%), were formed as a result of the weathering of the micas because the amount of chlorites (12-14%) remained practically constant throughout the profile. The 001/002 intensity ratio of the micaceous minerals suggested that both the dioctahedral and trioctahedral varieties of mica were present in the soil. Further, the predominantly trioctahedral character of the secondary minerals pointed towards a preferential weathering of the trioctahedral mica, that is biotite.
The prevailing semi-arid climate, highly alkaline soil (pH 10 or more) coupled with excess sodium seem to be the factors favouring the formation of mica-vermiculite-smectite or mica-chlorite-smectite type of interstratification.
Nucleation of hydroxy-Al/Fe/Mg ions in the interlayer region of the smectitic component of the mica-smectite mixed-layer mineral could result in the formation of an octahedral sheet. Silica which occurs as non-ionised silicic acid in natural soil environment might combine with the hydroxyl groups on both sides of the newly formed octahedral sheet resulting in the formation of a complete 1.4 nm packet in the interlayer space of the two-component mineral. This is one possible mode of formation of the observed multi-component minerals.

Allen S. Gottesfeld

Bed-load transport during salmon spawning and floods, Stuart-Takla experimental watersheds, British Columbia, Canada

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Movement of over 1400 bed-load clasts were recorded from 1992 to 1995 in Forfar and O'Ne-ell (Kynoch) Creeks, important salmon spawning streams of the upper Fraser River. These streams are bed-load dominated, have pool-riffle morphologies, gradients of about 0.01, widths of 8 to 15 m and annual peak discharges from snow-melt of 13 to 20m^3/sec.
Clasts were painted and marked with neodymium magnets for relocation visually or with magnetometers. Clast movement was monitored 3 or 4 times per year: in April, following fall and winter storm transport; in July, after nival flood transport; and in September, after salmon spawning. Over 8000 recoveries were made during the relocation surveys. Although transport distances were as great as 340 m and clasts were recovered after burial by as much as 80 cm, most clasts were recovered within 20 m of their original position following burial of less than 15 cm. The average annual transport distances at all sites for the three years monitored was 18.81 m. Overall, at the five stations monitored, sockeye salmon spawning activities resulted in 11% of the annual bedload transport. Sockeye salmon bioturbation accounts for 4% of the bedload transport on the higher gradient upstream stations, and 48% on the lower gradient downstream stations. Nearly all of the remainder of the bedload transport was by nival flood transport.
Forfar and O'Ne-ell Creeks have average adult salmon returns of approximately 11,100 and 12,900 fish. Sockeye salmon spawn in August, during low to moderate flow conditions. In normal spawning years redd excavation reworks most of the stream bed in the lower 3 to 4 km of the spawning streams. Nival flood transport is more selec-

tive, with a smaller portion of the bed mobilized, but with longer transport distances. Travel distance of individual clasts show a gamma distribution with both processes. The average depth of burial of clasts after nival flood transport and after sockeye spawning transport are nearly identical (7 cm), although the depth of burial varies with each transport event.

During the course of spawning, individual redds of approximately 0.3 m^3 are excavated. As spawning density increases, redds become aligned forming a series of gravel dunes. Finally, as the gravels are further excavated, a uniform gravel sheet is produced. Sockeye salmon spawning results in the filling in of pools and the channel thalweg, and the widening of the effective channel. The intense bioturbation by sockeye salmon results in selective winnowing of fine sediments and increased stream bed permeability. Salmon bioturbation probably increases normal fluvial bedload transport by creating a loose packing structure, and uniform bed which is easily disrupted as the stream redevelops a thalweg and reexcavates pools during the nival floods the following spring. The bedload transport rate from sockeye salmon bioturbation reported here may be significantly lower than under pristine conditions since approximately 70% of returning salmon are caught in various fisheries.

ANDREW GOUDIE & HEATHER VILES

Rapid weathering of rock blocks by salt in the Central Namib Desert

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In the hyper-arid Central Namib Desert near Swakopmund, Namibia, pre-weighed rock blocks were placed on the desert surface in a range of locations to investigate the rates and nature of weathering. After only two years, some of the blocks had almost totally disintegrated, demonstrating that this is a highly aggressive weathering environment. Detailed geochemical, Xrd and Sem studies showed that the degree of weathering was correlated with the amount of salts that had been absorbed by the blocks suggesting that salt weathering is the dominant weathering process. Investigation of naturally weathered rock and fine debris supported the hypothesis that salt weathering is a dominant process, allied in places with the action of lichens. The salts involved were primarily calcium sulphate and sodium chloride. Among the factors responsible for the rapid rate of weathering are proximity to the sea, the frequent occurrence of wetting fogs, and the large amounts of salts that have accumulated on the desert surface. Salt weathering is a very potent force in coastal deserts and is probably responsible for extensive planation and for the production of large quantities of fine debris that are then susceptible to wind and occasional water transport.

LAHCEN GOURARI[1] & MOUSSA BENJELLOUL[2]

Erosion active et conditions morpho-bioclimatiques et anthropiques dans le bassin synclinal d'Ain Nokrah et son piedmont (Moyen Atlas, Maroc)

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Des systèmes climatiques révolues ont laissé leurs traces morphologiques dans le bassin synclinal d'Ain Nokrah. Mais le climat actuel méditerranéen, subhumide ou humide remodèle activement ces formes héritées. Les conditions de l'érosion actuelle sont dominées par le grand rôle de l'action anthropique particulièrement sur le manteau forestier et les formations superficielles (de l'Holocène notamment).

Le fossé tectonique d'Almis du Guigou est une plaine de climat semi-aride, qui forme le piedmont de la cr te anticlinale faillée de Tajda-Ben IJ et du causse du Guigou. C'est une plaine d'inondation fluviatile, parsemée de dépressions liées à des systèmes de levées entre des chenaux et de depressions d'affaissements hydro-volcaniques de type volcano-karstique et / ou de tassement (Nicod, 1987). Ce milieu, particulièrement riche en formes et formations héritées, est le lieu d'étalement de cônes de déjection caillouteux mais aussi de dépôts des limons de crues en provenance du bassin-versant d'Ain Nokrah principalement et des carbonates et des sulfates par les eaux d'origine superficielle et souterraine. Toutefois, la réalisation d'un lit artificiel au cours de l'oued Guigou risque d'accélérer l'érosion dans le bassin .

Il importe de connaître aussi bien dans la montagne que dans le bassin intramontagnard, les processus d'érosion et leurs conditions morphologiques, bioclimatiques et humaines.

STEFAN W. GRAB

Thermal regime for a thufa and its adjacent depression, Mashai Valley, Lesotho

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Few observations have been published on the thermal characteristics of frost-induced mounds such as thufur. Accordingly, a 12-month study on the thermal regime for a thufa and its adjacent depression was undertaken in the Mashai Valley (~ 2950 m a.s.l.), Lesotho Highlands, during 1993/94. An overview of the annual air and ground temperature characteristics is presented. Seasonal ground temperatures, the mean daily temperature range and soil temperature re-

sponse times are examined for a thufa and depression. Results show that the mean depression temperatures are considerably warmer than the mean thufa temperatures at 12 cm depth. Pronounced temperature differentials occurred during the winter months when thufur were frozen for several weeks and depressions remained predominantly unfrozen. The findings indicate current thufur activity at favourable sites in the Lesotho Mountains under present climatic conditions.

VINCENT GRANDGIRARD

Géomorphologie et protection de la nature en Suisse. L'inventaire des géotopes d'importance nationale

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La nature, comprise dans le sens de «milieu physique», ne se limite pas au monde vivant. Les composants de la lithosphère, de l'hydrosphère et de l'atmosphère participent également à la dynamique du milieu naturel. En vertu de cette conception, la protection de la nature ne saurait se restreindre à la protection de la flore et de la faune.
Dans le domaine des sciences de la Terre, une discipline nouvelle est en train de naître: la «géoconservation». D'une manière générale, celle-ci se préoccupe de la protection des géotopes, c'est-à-dire des portions de la géosphère présentant une importance particulière pour la compréhension de l'histoire de la Terre. La géoconservation représente un important champ d'activité pour les géomorphologues. Nombre de formes du relief et de processus morphogéniques possèdent en effet une valeur scientifique et didactique qui en fait des géotopes dignes de protection. L'étude de ces phénomènes, leur évaluation et leur gestion sont autant de défis lancés aux géomorphologues.
En Suisse, les bases légales et les instruments de planification permettant la protection des géotopes sont insuffisants. Le Groupe de travail pour la protection des géotopes en Suisse, qui rassemble des spécialistes des différentes disciplines des sciences de la Terre, consacre beaucoup d'énergie à promouvoir la cause des géotopes. Ce groupe prépare actuellement un inventaire de géotopes d'importance nationale. La réalisation de cet instrument de gestion repose sur une large consultation, effectuée par le biais d'un questionnaire, auprès de tous les milieux intéressés (autorités, responsables de la protection de la nature, sociétés scientifiques, enseignants et chercheurs oeuvrant dans le domaine des sciences de la Terre, géologues praticiens, musées d'histoire naturelle, etc.). Outre une description détaillée des géotopes proposés, les informations concernant ces derniers, recueillies par le biais d'un questionnaire, permettent d'apprécier leur valeur, les menaces qui les affectent et les mesures de gestion existantes ou proposées.
Au terme d'une sélection, une centaine de géotopes d'importance nationale seront proposés. Complété par un guide sur la protection des géotopes, cet inventaire pourrait constituer un premier pas en direction de la réalisation d'une «Ordonnance sur la protection des géotopes d'importance nationale».

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Dating exhumation of orogenic belts using cosmogenic isotopes in cave deposits and alluvial terraces

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The exhumation rate of orogenic belts determines both the isostatic component of rock uplift and the timing of mountain landform development. Many orogenic belts are formed by folding and thrusting during a compressional phase, followed by normal faulting during extensional collapse. The compressional phase usually produces metamorphic minerals that can be radiometrically dated. By contrast, the timing and rate of extension and exhumation are often poorly constrained. Cosmogenic isotope methods can be used to date exposure ages and measure erosion rates over 10^3-10^5 years (Bierman, 1994; Cerling & Craig, 1994), and to date sediment burial over 0.3-5 million years (Granger & *alii*, in press). Here we propose that these techniques can be used to clarify the tectonic evolution of mountain belts, as we demonstrate for the Alpi Apuane mountains of Italy.
The Alpi Apuane are a rugged mountain range, developed on a metamorphic core complex exhumed from beneath unmetamorphosed sediments during post-Oligocene extension (Carmignani & Kligfield, 1990). Although these unmetamorphosed sediments currently flank the Alpi Apuane at low elevations, erosional remnants of these sediments can still be found as alluvial deposits in caves and river terraces at high elevations in the core of the range. Because these alluvial deposits lie up to 1000 m above modern outcrops of their parent lithologies, they must have been deposited during the unroofing of the core complex.
We are using the cosmogenic radionuclides ^{26}Al and ^{10}Be to date the emplacement of these erosional remnants, in order to constrain the Alpi Apuane exhumation rate. ^{26}Al and ^{10}Be are produced in quartz by cosmic rays near the

ground surface. The concentrations of these nuclides in mineral grains at the ground surface reflects their rate of erosion. If quartz grains exposed at the surface are subsequently buried (for example by deposition in a cave or deep within an alluvial terrace), then their ^{26}Al and ^{10}Be will decay at different rates. The $^{26}Al/^{10}Be$ ratio will therefore decrease exponentially through time, recording the time since burial. Thus the concentrations of ^{26}Al and ^{10}Be in buried sediment record both the time since sediment emplacement and the prevailing erosion rate at the time of sediment burial.

We are currently measuring ^{26}Al and ^{10}Be concentrations in cobbles of unmetamorphosed sediment, preserved high in the Alpi Apuane in deposits within the Corchia cave complex, and in alluvial terraces scattered throughout the region. We anticipate that these analyses will constrain the exhumation rate of these actively uplifting mountains, thus dating the unroofing of the Alpi Apuane and establishing the age of the developing mountain landforms.

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Anatomy of a flood: geomorphic and hydrologic controls on channel response to a major mountain flood

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The flood of February 5-9, 1996 in the U.S. Pacific Northwest provides unparalleled opportunities to examine the interrelated effects of hydrologic and geomorphic processes, landforms, and land use on watershed response to major storm events. We have examined how mass movements, including landslides and debris flows, small stream channels, and road networks interacted with mainstem channels and valley floors to produce the pattern and magnitude of flood disturbances observed.

A coordinated program of inventory, field mapping, and analysis of flood impacts on hillslopes, road networks, stream channels, and riparian zones in the western Oregon Cascades permits disentangling intrinsic and anthropogenic controls on channel response. Flood effects were not uniformly distributed either within or between watersheds. Dynamics of melting snowpacks, as controlled by elevation, determined the overall pattern of streamflows and mass movements. Forest land-use activities on hillslopes and in small and large channels contributed to channel response by influencing the availability of water, sediment, and wood delivered to mainstem channels. Mass failures associated with road networks were prominent hillslope disturbances, and delivered sediment and wood to downstream channels. Differences in the abundance of sediment and large woody debris stored in the channel before the flood and delivered during the event itself were primary factors controlling the type and distribution of channel responses. Large woody debris delivered to the channel by debris flows and entrained from streamside forests played multiple critical roles. At some sites, wood levies at the margins of the active channel confined streamflows, thereby increasing channel erosion while protecting riparian forests. Alternatively, wood also caused channel avulsions, battered and uprooted riparian forests, and promoted rapid sediment deposition behind debris dams. Flood effects were limited in narrow, bedrock-controlled channel sections but extensive along many wide valley floors, particularly where sediment supply was high.

Results from this flood analysis highlight the importance of interpreting flood response within an overall geomorphic context. Such a context includes recognizing the spatial distribution of flood processes, variability in hillslope and channel sensitivity to flood disturbances, and importance of biogenic processes. It also includes placing response to a particular flood within a larger temporal framework of previous floods and evolving landscape conditions due to changing land use patterns.

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Patterns of mountain and continental glaciation of the Torngat Mountains, Northern Québec-Labrador: the geomorphological evidence for cold-based ice

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Along the western flank of the Torngat Mountains, fronting onto Ungava Bay, geomorphic evidence of ice flows obtained from striae pits, and from erratic provenance studies, reveal that during the last glaciation, major lobes from the continental Laurentide ice sheet to the west impinged upon this uplifted mountain massif. In the northernmost part of the peninsula, this continental ice clearly has overridden the summits, situated at circa 500 m elevation. In the Sheppard Lake region lateral and terminal moraine complexes indicate late glacial stable phases near the eastern front of the continental ice sheet. Further south, in the vicinity of Abloviak Fjord, where relief is in excess of 1500 m, the striae evidence and erratic evidence, indicates important outflow to the north-west, of locally developed Torngat Mountain ice. Very well developed glacial lake shorelines, and de Geer moraines, provide irrefutable evi-

dence, however, that local Torngat ice tongues had retreated upvalley to the glacial cirque zone prior to disintegration of the Laurentide ice sheet filling Ungava Bay.
Extreme contrasts in sediment cover, and in weathering of bedrock at different altitudes in the Torngat Mountains were observed, as they have been by several researchers since the beginning of the century. Well preserved knife-edged cirques are also characteristic features of the high mountain zones, whereas subdued, worn down cirques characterise the lower plateaux edges. The hypothesis developed here is that these contrasts can be related to transitions from cold-based to warm-based thermal regimes at the base of local, thin and vigorously outflowing ice streams. In order to support this interpretation, and to provide chronological evidence for the latest, and possibly for previous glacial events, cosmogenic dating results of ^{10}Be in bedrock and erratic rock samples are presented.

FLORINA GRECU & IONEL BENEA

The risk availability of the hilly regions: mapping stages

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The Risk Map represents the final stage of a laborious analytical approach. For the hilly regions, this map expresses the vulnerability the lands have for degradation processes.
The most important variables that influence the risk availability of the hilly lands, under temperate climate, are: lithology, landforms (geomorphic processes, slopes, drainage density), soil and vegetation. The stages of the risk availability mapping are: geomorphic processes careful mapping, confronting this map with the geological, soil and soil erosion maps and with slopes, drainage density, fragmentation depth and vegetation maps as well.
Then we took into account the geomorphic state indices for the vertical erosion, areal erosion and the landslides. These have been identified on the basis of a 1 square km grid (scale 1:25000), considering the surfaces or the lengths affected by the processes (S_x) and the total area (S_t), and we used the formula $I_x=(S_x/S_t)x100$. The vulnerability has been graded, according to the risk factors, into five classes: 0.20; 0.21-0.40; 0.41-0.60; 0.61-0.80; 0.81-1.00.
We have selected for our study the Calva River Basin because of the somehow uniform lithology (i.e. Pontian deposits of sands with marl layers in-between) and a monodine structure that materialises into a cuestas-type relief. The size of the basin is 5 in the Horton-Strahler classification system. The confluence ratio is 4.32 and the achievement index is 1.34, these denoting a close-to-equilibrium stage that the system has reached. There is still a high potential for regressive erosion and valley deepening denoted by the great number of first order size segments within the basin.
The interaction of the system's variables vary from horizontal or merely horizontal surfaces to those of the slopes riverbeds and floodplains as well. The result is a different risk availability of each of these.
A. Flat interfluves and terraces (less than 5° inclination angle) are generally not exposed to risk. The narrow interfluves are incised by first order size torrents with regressive erosion. Such interfluves are noticed along the Steana and Valea Satului streams, under forests.
B. Hillslopes are the predominant landforms in the Calva river-basin.
Slopes having low risk availability extend on both sides of Calva, Valea Satului and Steaua rivers. They are represented by slightly inclined glacises - less than 5° - which are exposed to floods and coluvio-proluvial sedimentation from upslope.
Flat interfluves, terraces and glacises are not degraded lands and are used for agriculture.
Slopes having medium risk availability have different inclinations (from medium to high) and are covered by forests and brown luvic and albic luvic soils. This kind of slopes extend on the left side of Calva river in its upper course.
Slopes having medium to high risk availability are deforested slopes, very inclined, with deeply eroded soils. Geomorphic processes as sheetwash and superficial landslides affect them. Their agricultural potential is low and therefore they are used for pastures or hay-making. There are also old teracettes, all abandoned nowadays, that have favoured land degradation.
Slopes having very high risk availability are the most inclined ones, totally deforested, and the soils have been deeply eroded. Sheetwash is overpassed by gully erosion and agriculture is no longer possible on these slopes.
Slopes excessively eroded are also very abrupt, the free face showing the bare rock. Soils have been completely eroded away and torrents incised deep to 15-30 meters. Accacio trees have been planted on small surfaces, but not very successfully.
C. Floodplains present a medium risk availability mainly because of flooding processes, while talwegs have been cut into the floodplain deposits, being bordered by steep banks.

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Morphologie sous-marine et tectonique active. La partie méridionale du prisme d'accrétion des Petites Antilles

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Le prisme d'accrétion tectonique des Petites Antilles constitue l'un des modèles les plus spectaculaires de zone de

convergence lithosphérique. La subduction du plancher océanique atlantique sous la plaque caraïbe entraine l'accrétion d'un important prisme sédimentaire dont le développement croissant vers le Sud, est à mettre en relation avec la proximité des sources de matériels terrigènes en provenance du continent sudaméricain. Il se développe alors ume succession de structures tectoniques tout à fait particulières liées, à la convergence intra-plaques d'une part, à la présence d'un important niveau d'argiles miocènes d'autre part et entrainant le développement d'une vigoureuse activité argilocinétique.
Les deux campagnes océanographiques Diapisar et Diapisub dirigées par les chercheurs de l'Université de Bordeaux illustrent clairement ce propos et montrent les relations manifestes entre les structures de sub-surface, les éléments morphologiques et le cadre structural environnant. Parmi ces strutures nous retiendrons l'esistence:
– de rides diapiriques allongées NE-SW et qui sont d'anciennes écailles liées à l'accrétion initiale puis redressées et deformées par le jeu combiné de cisaillements E-W et de la remontée du matériel argilocinétique;
– de volcans de boues de forme conique alimentant des coulées de matériel allochtone et qui sont probablement récentes pour certaines. Ces volcans semblent se positionner préférentiellement suivant des axes N-S à N.10°;
– de dômes de boues aux sommets totalement indurés diagénétiquement et dont les positions peuvent tre comparées à celles des volcans mais dont le mode de mise en place est probablement différent (remontée d'un «bloc» sous l'effet d'un noyau diapirique);
– an niveau du front de déformation enfin, au droit du flanc chevauchant de la ride d'accrétion initiale des directions de fractures conjuguées qui peuvent se développer daus un domaine soumis à une transpression liée à l'obliquité de l'angle de convergence.
Des cartographies de détail des objets morphologiques ont été réalisées à partir d'enregistrements Sonar et d'un sondeur 3.5 Khz couplé au Sonar. Celles-ci illustrent en particulier le rôle fondamental de la tectonique à toutes les échelles. Ainsi des basculement des rides liés au mécanisme de l'accrétion induisent ume surrection des reliefs et le piégeage sur leur flanc NW, des apports sédimentaires sons forme de séquences dont la géométrie permet de montrer l'existence d'un basculement récent (120.000 ans) de l'ensemble de la structure.
La combinaison et l'enchainement de ces phénomènes (cisaillement, surrection, argilocinèse) conduit au développement d'instabilités gravitaires s'organisant autour des grandes directions régionales. Celle-ci conduit également au renforcement des courants de fonds qui favorisent la mise en place de fonds durcis sur les flancs sud-est des strucures. Elle contrôle d'autre part la remontée de fluides profonds dont les expulsions favorisent des processus de diagenèse précoce sous la forme d'encro tements carbonatés.
Les observations réalisées en plongées à partir du submersible le Nautile confirme l'essentiel de ces données et montrent en particulier que des biocénoses profondes s'installent le long des accidents actifs. D'une façon plus générale, cette étude montre l'importance des phénomènes d'ablation-érosion et de remobilisation dans l'alimentation des bassins. Cette sédimentation syn-tectonique est favorisée par la nature des matériaux, le drainage des fluides et la morphologie.

GJOVALIN GRUDA

Contribution a l'etude de glacis en Albanie

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Dans les plaines et les dépressions de l'Albania le glacis ont un éxtension considérable. Leur développement est défini par le systeme morphoclimatique et morphotectonique quaternaire très favorables.
Les ensembles de relief de l'Albanie se caractérisent par une hétérogenéité litologique (58% sont des flyschs et des molasses) et structural. Le decoupage des structures plissées et écaillées par des failles normaux récents, ont causé un certain compartimentage du relief et, corrélativement, une éxtension plus grande des dépressions et des massifs. Les niveaux de glacis en Albanie ont été élaborés durant les periodes froides de Quaternaire.
De grandes glacis ménagent la transition d'altitude entre les reliefs collinéen et montagneux avec celle des plaine et des dépressions. La Plaine de l'Ouest et les dépressions intérieurs sont recouvertes d'un manteau de débries provenamt des reliefs situés en amont et qui constituent les dépôt de glacis. Donc les glacis de toutes les dépressions (Korça, Bilishti, Kolonja, Butrinti, Shkodra ect) et de la Plaine d'Ouest de l'Albanie résultent uniquement du phénomén d'accumulation, qui a complétement fossilisé le relief façonné dans les roches en place. Ces glacis sont en position de piemont au pied d'escarpements vigoureux qui mettent en contact ces bassius d'effoudrement avec les massifs plissées et faillés. Le rejet qui explique ces vigoureux escarpements, dominant en particulier les dépressions de Korça, Kolonja, Shkodra et Delvina, excede 900 m.
Aujourd'hui les glacis sont en voie de dissection par l'érosion règressive déclanchée par le soulevement recènt des massifs.

JÖRG GRUNERT

A landslide susceptibility map of the area of Bonn, W-Germany, by using a Gis

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During several years, a lot of information about landslides in the study area has been collected. These are:

– a detailed geomorphological map with special regard to type and age of landslides, and, in addition, a multi-temporal interpretation of aerial photographs,
– geophysical and dendrogeomorphological investigations to reconstruct activity phases in the past,
– precipitation events and the special hydrology of slopes as the main triggering factors, and
– as much as available, data about groundprices in settlement areas threatened by mass movements.
All information will be stored in a data base.
Parallel to this project, a susceptibility map with the scale of 1:10 000 for the Katzenloch valley and the Melb valley, which are both highly affected by landslides, has been produced. Digital factor maps showing geology, relief forms (slope angle, compiled from a Deu), landslide distribution, hydrology (wells, bogs) and infrastructure (e.g. buildings, roads) were stored in a Geographic Information System. Analyses of the relative frequency of landslides in each geological formation and slope angle category (ino) generate weighting factors for a simple evaluation scheme to determine susceptibility classes (high, moderate, low). These are further modified according to the influences of hydrology and infrastructure.
The product, a well-structured computer-based landslide susceptibility map delineates potential landslide areas and is to be considered a useful tool for effective landuse planning.

VALERY N. GUBIN

Tectonic processes and relief's evolution of areas of ancient ice sheets

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The pleistocene morphogenisis stage at the west of the Eastern-European platform (Eep) was distinguished by high activity of tectonic processes. The earth crust structural forms as well as the rotational geodynamics elements had affected significantly the glacial covers dynamics and topography evolution. The crystal basement's high elevation (from +50 to –500 m) played a dominant role in thick moraine layers accumulation as well as in the main macroforms of Byelorussian Grjada formation. The glacial's load increased the basement's blocks differention in case of unsufficient thickness of the platform cover. As a result the intensive anthropogenic base surface separation took place.
Regional fractures (Vyzhevsko-Minsky, Oshmyansky) affected on spatial distribution of flanking morainal topography forms. The activation of linear structures occured in pleistocene had led to cracks in glacier's masses, especially in glacial cover periphery. The complicated dynamic glacier masses structure was formed at such conditions, which determinated the end moraine topography forms distribution.
Neotectonic structures such as blocks and rings which were subjected to positive motion with the amplitude to 80m. were the glacial subdividing zones of different size. The earth crust blocks played the dividing role at Disnenskaya, Polotskaya and Vitebskaya glacial blades at the EEP west. Local ring structures of tectonic genesis type were arranged to the frontiers of frontal glaciar complexes.

MAURO GUGLIELMIN

Methods of permafrost analysis in ice-free areas of the Northern Victoria Land (Antarctica)

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In 1994 a new research project about permafrost, ground ice analysis and periglacial geomorphology of Northern Victoria Land (Antarctica) has been started.
This project has as principal purposes the study of permafrost areas to identify the different types of ground ice and to understand their relationships and to analyse the thermal evolution of these areas.
In some ice free areas of Northern Victoria Land, near Terra Nova Bay station, on the basis of previous geomorphological researches (Baroni & Orombelli, 1987; Chinn & *alii*, 1989; Meneghel & *alii*, 1994), some landforms such as rock glaciers, raised beaches with patterned ground and debris-covered glaciers were investigated with the method of electrical prospection. Moreover, in correspondence of areas investigated with geophysical methods, some trenches were dug and some boreholes were drilled to sample permafrost and ground ice.
A good method to identify different types of ground ice (Selman & *alii*, 1988; Fournier & *alii*, 1990; Guglielmin & *alii*, 1997) has been revealed the electrical prospection, in particular, the method of vertical electrical soundings (Ves); while, to recognize the buried structures and the relationship among different types of ground ice, was better the method of resistivity profiles.
The samples collected in the trenches and boreholes are now analysing and will be useful to calibrate the geoelectric method and to identify the different conditions of formation of the ground ice.
The boreholes drilled have been used to measure the thermal profile and also to install an automatic station to record the variations of the temperature at different depth. This station measures also the air temperature and the global incident radiation and will let to study the relationships between climate and thermal regime of active layer and permafrost. From geoelectric prospecting performed is possible to recognize 5 different types of ground ice:
1. saline permafrost with an electrical resistivity ranging from 50 to 1,300 Wm;

2. permafrost very poor in ice with an electrical resistivity ranging from 13 to 26 kWm;
3. permafrost poor in ice with an electrical resistivity ranging from 45 to 80 kWm;
4. permafrost rich in ice or very rich in ice with an electrical resistivity ranging from 140 to 900 kWm;
5. pure glacier ice with an electrical resistivity over 1,500 kWm.

These different types of ground ice permitted to distinguish ice-cored rock glaciers from ice-cemented rock glaciers, to identify sub-sea permafrost in some raised beaches, and to suggest other interpretations about a debris-covered glacier.

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Pergélisol alpin et variations climatiques dans les Alpes Centrales (Valtellina, Italie)

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Pendant les dernieres cinq années on a realisé, en plusieurs localités de l'haute Valtellina occidentale et dans la région de Livigno (Sondrio), des récherches sur l'individuation et la distribution du pergélisol alpin. En particulier on a distingué et levé 79 glaciers rocheux dont 39 ont été considerés actifs. Quelqu'un a été étudié en détail pour en caractériser le contexte géomorphologique, les rapports avec les formes glaciaires, la chronologie de la dinamique, les caractéristiques du pergélisol, les reconstructions paléoclimatiques, etc.

Les mesures de Bts inferieures à - 3°C montrent que, dans les glaciers rocheux examinés (nommés La Foppa I, La Foppa II, Valaccia di Foscagno, Pizzo Filone I, II, III, IV, et M. Vago), la distribution du pergélisol est reliée dans la zone frontale et radicale des corps détritiques. Les nombreux sondages électriques executés (plus de 70 SEV) ont confirmé le pergélisol pas seulement dans les glaciers rocheux, mais aussi dans les lobes de solifluxion. Dans les glaciers rocheux le pergélisol montre des caractéristiques très variables: une résitivité électrique comprise entre 18.000-560.000 Ω m, une épaisseur qui varie entre 8-23,3 m et la couche active avec une épaisseur comprise entre 0,6-4,7 m. La distribution du pergélisol peut être résumée en quatre tipes de configuration stratigraphique (A,B,C et D) dont les premières trois signalent un seul amas du pergélisol plus o moins enrichi en glace et voisin à la surface. La configuration D, au contraire, montre deux amas surposés du pergélisol: le superieur est similaire aux configurations B et C tandis que le plus profond (situé plus de - 20 m de profondeur et riche en glace) on peut interpréter comme pergélisol relique.

Les nombreuses datations obtenues au moven de «buried soils» sous les glaciers rocheux actifs (La Foppa I, Vallaccia di Foscagno, Cima Rossa e Pizzo Filone IV) et inactifs (M. Castelletto et La Foppa II), témoignent que les deux tipes de glaciers rocheux ont eu des mouvements holocéniques; plus précisement les premiérs résultent actifs à 2200 et 1120 années BP et les seconds à 2700, 3330 et 5000 années BP. Le glacier rocheux inactif La Foppa II est, probablement, le seul qui a eu des mouvements dans le Tardiglaciare final.

L'étude des variations climatiques peut être supporté validement par l'analyse des régimes thermiques du pergélisol et de la couche active; la connaissance de la profondeur du pergélisol et la morphochronologie des glaciers rocheux sont aussi utilisées pour les reconstructions paléoclimatiques. L'analyse du régime thermique et l'épaisseur de la couche active, en particulier, peuvent fournir des informations à l'échelle annuelle ou décennale tandis que l'épaisseur du pergélisol et les dates de mouvement des glaciers rocheux à l'échelle séculaire ou millénaire.

Les donnés Sev (dans les glaciers rocheux actifs) signalent une épaisseur moyenne du pergélisol près de 11,7 m, tandis que la couche active montre une épaisseur movenne de 1,8 m. Si on utilise la théorie de la convection de la chaleur, résulte théoriquement que cette épaisseur du pergélisol peut se former avec une temperature moyenne annuelle de l'air (Tmaa) de - 0,4 °C. La station metéorologique automatique de la Regione Lombardia, située près du glacier rocheux actif La Foppa I (2665 m de haut), a enregistré (à partir de sept. 1993 jusqu'à aujourd'hui) le régime thermique de la couche active et du sol (jusqu'à - 3m de profondeur) et tous les autres paramètres climatiques qui peuvent déterminer leurs variations. Les donnés préliminaires indiquent que la Tmaa est égal à 0,31 °C et la temperature au sol (à - 2 cm) est égale à - 0,71 °C. Dans la région étudiée, supposé que les relations entre temperature de l'air et du sol se soient mantenues costantes dans les temps, le pergélisol se trouve en equilibre avec les conditions climatiques actuelles, avec une possible tendence à la dégradation. L'épaisseur du pergélisol, pourtant, est le résultat d'un accroissement à partir d'une phase de refroidissement que plusieurs Auteurs signalent, dans les Alpes, à 3000-2300 amnées BP environ. Les donnés rélatifs à l'evolution glaciaire des vallées examinées aussi confirment cette consideration.

Quant aux conditions thermiques actuelles enregistrés sur le glacier rocheux La Foppa I les relations entre temperature de l'air (TA), temperature du sol (TS) et épaisseur et temperature de la neige semblent fournir des indications significatives. On a observé que lorsque la TA descende vers O °C (ou dessous) et la surface du glacier rocheux est recouverte par une épaisse couche de neige, la TS descende avec un moderé et régulier gradient thermique jusqu'à - 3 m de profondeur. Pendant cette phase il ne semble pas que les abaissements rapides et prolongés de TA (par exemple - 20°C en cinq jours) produisent effects notables sur les temperatures dans le sol à cause de l'action cohibant de la neige. En février-mars, quand TA augmente progressivement, TS cesse de s'abaisser en commençant

une graduelle augmentation jusqu'à ce qu'on a l'effet de protection thermique neigeux. Au moment que la neige disparaît tout à fait, les variations de TS s'adaptent rapidement à celles de TA mais avec retard (3 jours environ à la profondeur de - 50 cm et 15 jours pour profondeur de - 150 cm). Au dessous de cette profondeur les variations sont trés faibles et les isothermes montrent une disposition réguliere. Enfin, on a relevés des écartements qui semblent être liés à la variabilité granulometrique superficiel du glacier rocheux, laquelle peut limiter ou faciliter la vitesse des variations thermiques de l'externe à l'interne.

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The rock glaciers of the Lombardy Alps (Italy) as indicators of mountain permafrost

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The paper presents the results of the first rock glaciers inventory of the Lombardy Alps (Italy). In this region by means of aerial photographs 498 rock glaciers were individuated; these landforms have been classified according to their apparent degree of morphological activity in: active (92) inactive (285), doubt (94); 27 landforms have been defined complex. The following morphological and morphometric parameters have been determined: the lowest altitude of the front; the highest altitude of the rock glacier, width; length; aspect; slope; form ratio defined as length/width. It was scheduled also the topographical location of the rock glaciers and the litology of the bedrock outcropping around the landforms.
The lowest altitude of the active rock glaciers, that could be used as the lowest boundary of the mountain permafrost ranges from 2850 to 2150 m a.s.l. with a mean value of 2537 m a.s.l. This altitude corresponds to a mean annul air temperature of about –1.3 °C. The mean value of the lowest altitude for the inactive rock glaciers is 2108 m a.s.l, but we think that is not correct to use this one as indicator of the relict boundary of the mountain permafrost: according to our field studies in fact, the inactive landforms can be aged very different. The morphometric parameters indicate that the widespread form is lobate (ratio L/l=2); the mean length is 535 m, the mean vidth is 326 m; the mean slope is 27° with a minimum of 2°.
The most part of the rock glaciers is located in a cirque (44.5%) and this percentage is still greater for the active forms (60%); the slope location is widespread in the inactive forms (50.3%).
The relationship with the glacial pbenomena has been preliminary approached indicating glaciers, glacierets and perennial snow banks near the rock glaciers: only the 2.6% of the rock glaciers is close to a glacier meanwhile is more frequent the occurrence of perennial snow banks or glacierets around the rock glaciers (20%).
Also the lithology of the bed rock is a significant factor: in fact more than the 76% of the rock glaciers in the Lombardy Alps overlies on metamorphic bedrock. The distribution of the rock glaciers in this region appears strongly conditioned also by the aspect; in fact more than the 60% of these landforms is located on the northward slope (NW to NE).
On the basis of our field observations and of the remote sensing analysis we can suggest moreover some other significant topics:
– in the Lombardy Alps the rock glaciers are the most important indicators of mountain permafrost, but permafrost occurs also in correspondence of other landforms not necessarily of periglacial kind;
– for permafrost mapping is probably more correct to classify the rock glaciers on the basis of the relationship between thickness of the active layer and the present climatic conditions;
– a very promising method for mountain permafrost mapping is the remote sensing mapping integrated with field observations and measurements collected in a data-base.
The relationship between the holocenic glaciers evoluton and the rock glaciers distribution and the importance of the lithology for the formation of the rock glaciers and for the permafrost thermal evolution will be certainly the two most important topics for the future research in the Lombardy Alps.

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Plate tectonics, erosion cycles and structural predesign. A tentative synthesis for southern India and Sri Lanka

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With the improvements of radiometric dating and offshore sediment stratigraphy, geomorphological research is increasingly involved in reapparaising theoretical models of continental landscape development.
Indian and Sri Lankan planation surfaces have recurrently been dealt with as «stratigraphic» markers to bracket denudation chronologies, but these need to be reinterpreted in the light of our contemporary understanding of plate tectonics. The present study incorporates apatite fission-track data from southern India to monitor the response of the South Indian shield to tectonic impulses of change.

Analytical results reveal that long-term cooling rates for the region could only be confidently resolved for the Mesozoic era. Due to the limitations of fission-track predictive models for critical temperatures lower than ~ 60 °C, Cenozoic trends were only inferred by extrapolation. Assuming a common geothermal gradient for the region, cooling rates suggest a slow, steady style of regional denudation with, however, different values according to sample elevation and lithology: on charnockites, which form South Asiàs relict highland surfaces, rates are one half to two thirds of the rates measured on upland tonalite-trondhjemite gneiss, and one third of the rates obtained for the Palghat Gap, locus of a major breach in the Western Ghats escarpment. This preliminary evidence confirms the idea, long-held by geomorphologists but insufficiently addressed in recent numerical models of plateau uplift, that lithology and geological structure exert an important control over denudation patterns. The findings also challenge the prevailing idea that the high-level charnockite massifs are horsts and that the South Indian and Sri Lankan palaeosurface staircases are related to Cenozoic fault reactivation.

The elevational consistency of planation levels throughout the entire region, highlighted by flat-lying topography indifferent to stratification, schistosity or foliation and often by characteristic palaeosol cappings, excludes interpreting the relative rates of surface lowering between different rock units as evidence for a purely «etchplanational» view of landscape evolution. Discrepancies between rates may have increased in the Cenozoic due to the growing isolation of charnockite palaoesurfaces from active drainage sytems. The timing and magnitude of tectonic events documented for Indiàs eastern and western passive margins vindicate the periodicity of peaks of continental erosion as a major factor of landscape development. A comprehensive and composite polycyclical denudation chronology, driven by regional uplift, is therefore proposed for southern India and Sri Lanka. The quasi-insular status of South India, as indeed Sri Lanka or Madagascar, may explain that the landscape exhibits a clearer expression of cyclical response to endogenic activity than other, larger continents with vast and remote hinterlands. This scale factor implies that the boundary conditions usually imposed on geomorphological modelling exercises for Atlantic, Antarctic or Australian passive margins cannot be straightforwardly adopted for southern India, where two competing base levels (Bay of Bengal since 100 Ma, Arabian Sea since 65 Ma), and two Mesozoic palaeosurfaces on charnockite have imbricated Cenozoic drainage and landscape evolution beyond the simplifying rift-shoulder uplift rationale of existing models. Structural heterogeneity in the Indian shield has enhanced, rather than obscured, the staircase morphology of episodic rejuvenation. In addition to its cyclical components, landscape change over time was also directional: while the periodicity between base level events became increasingly shorter than the relaxation time necessary to attain cycle completion, lithological contrast played an increasingly selective role in denudation patterns through geological time, possibly due to Cenozoic climatic regimes becoming less equable and promoting opportunities for poorly weathered debris to be transported and for bedrock channel scour and incision to increase. This proviso appears necessary to account for the lithology-dependent denudation rates. Ridge-and-valley relief in the Cuddapah Proterozoic basin also points to the growing control of rocks on erosion in South India.

Against the background of «slow variables» borne out by the cooling patterns, the «faster» variables of sea level fluctuation, climate change, domal uplift and medium wavelength lithospheric buckling, all documented with varying degrees of accuracy, are expected to have had an effect on headward erosion rates and surface lowering patterns unresolved by fission-tracks. In the crystalline shield of South India, the structural grain of the basement is generally transverse to the major river courses; matters are thus complicated by the likelihood that a single continental base level change will give rise to a flight of partial planation levels located at different elevations and controlled by local, structural base levels such as greenstone ridges. These prevail in the greenschist facies region of the Dharwar Craton but are absent in the granulite terrain of Tamil Nadu. Contemporary predictive modelling exercises in geomorphology need to address such issues of structural predesign.

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Geomorphology and the urban tropics

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The developing countries, located almost entirely within the tropics, are currently undergoing urbanisation at a rapid pace. Their urban population, measured as the percentage of the total population, rose from 16.9 in 1950 to approximately 34 in 1990; and is projected to climb to 57 by 2025. Although this growth occurs across a wide range of urban settlement sizes, it is the large cities with several million inhabitants which are growing at a particularly rapid rate.

In general, many of these cities are not older than a few centuries, being established to function as regional trading posts or administrative centres by either the colonial or the regional powers. It is doubtful that the site conditions were taken into consideration, and many of these cities were established in hazardous or difficult areas. As these cities developed over time, they spread across a wide range of terrain conditions much of which are unsuitable, being floodplains, coastal swamps, steep slopes or sand dunes. The original location of levees (Calcutta, Bangkok) or a Pleistocene terrace above the floodplain of an active river (Allahabad) are no longer spacious enough. For a number

of these cities, located near active plate margins and tropical cyclone belts, such problems are magnified many times by the recurrence of natural hazards which include earthquakes, volcanic activities, floods, and mass movements. Increased demand for water has required extraction from deep aquifers leading to problems of subsidence and quality.

We examine the range of these cities with reference to (1) their site-related problems, (2) the nature of geomorphological information required for specific ameliorating actions, and (3) the level of management required for city maintenance. Management requires interfacing of geomorphology with engineering practices and urban planning. We present a classification of cities ranging from those with limited problems and possible engineering and land-zoning solutions (Singapore) to cities where the hazards (either natural or anthropogenic) are so acute and widespread that a practical solution is difficult to achieve (Kingston, Bangkok). We list the types of geomorphological information needed for city management and hazard amelioration, and also review the nature of organisation or personnel currently available in the tropical cities of the developing countries to collect and process this information and act on it. Precise geomorphological and geological information and long-term data sets are not available for most of the cities. Furthermore, it is necessary to present the information in formats appreciated by the engineering and planning communities. Often a set of specialised maps as used for the tropical city of Hong Kong, are extremely useful. We complete the discussion with several examples of and recommendations for collection of geomorphological information and inventory preparation for communicating geomorphological data to city engineers and planners.

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Landslide hazard evaluation: an aid to a sustainable development

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In the recent years, the population growth and the expansion of settlements and life-lines over hazardous areas have largely increased the impact of natural disasters both in industrialised and developing countries. Third world countries have always been unable to face the high costs involved in controlling natural hazards through major engineering works and rationale land use planning. Owing to the global recession, industrialised societies are increasingly less eager to invest a great deal of money to reduce natural risks by means of structural measures. Hence, the new issue seems to be the implementation of warning systems and land utilisation regulations aimed at minimise the loss of lives and property without investing in long-term, costly projects of ground stabilisation.

Government and research institutions world-wide have attempted for years to assess landslide hazard and risk and to portray its spatial distribution. Countless landslide maps were produced by geomorphologists. Likewise, several methods for assessing hazard were proposed or implemented. The reliability of these maps and the criteria behind these hazard evaluations are ill formalised or poorly documented. Despite the efforts, geomorphological information remains largely descriptive and subjective. It is hence somewhat unsuitable to engineers, policy makers or developers when planning land resources and mitigating the effects of geological hazards.

In the Umbria and Marche Regions of Central Italy, attempts at testing the proficiency and limitations of multivariate statistical techiniques and of different methodologies for dividing the terrirory into suitable areas for landslide hazard assessment have been completed, or are in progress, at various scales. These experiments showed that, despite the operational and conceptual limitations, landslide hazard assessment may indeed constitute a suitable, cost-effective aid to land-use planning. Within this framework, engineering geomorphology may play a renewed role in assessing areas at high landslide hazard, and helping mitigating the associated risk.

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Weathering rates of Tertiary sedimentary bedrock in Japan

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The rates of weathering of bedrock have been considered to be one of the most important factors that influence the modes and rates of denudational processes such as erosion and mass movements. The weathering rates were investigated in the following way.

(1) The weathering rates were examined for two kinds of the definition: first the rate (dZ/dt) at which thickness of weathered zone of bedrock (Z) increases with time (t) and second the rate (dR/dt) at which strength of weathered materials at a given depth (R) decreases with time (t). (2) The emergence age of marine-erosional terrace is assumed to be equal to the weathering time (t) for the bedrock under the terrace surface. (3) The weathered materials except the soluble of bedrock under the terrace veneer are assumed to have scarcely been eroded away. (4) The weathering profiles were observed for the drilling cores obtained by the present authors. (5) The drilling cores were examined in the laboratory for the changes in the needle penetration hardness with depth. (6) The weathering profiles were divided into four weathered zones according to the change in the mechanical property: i.e. highly weathered zone (H), moderately (M), slightly (S) and faintly (F). (7) The thickness of weathered zones is defined as the depth from the bedrock surface to the weathering front of each of the four weathered zones.

The data were obtained for the bedrock of the marine erosional-terraces in the Boso Peninsula, Japan. The terraces are divided into five levels. The bedrock in this area is the Pliocene marine sedimentary rocks of the interbedded mudstone, sandstone and conglomerate. The drilling cores were obtained at the 11 sites for sandstone and at the 13 sites for mudstone on the terrace surfaces with three different ages.

Mode of deceleration in the weathering rates (dZ/dt) with weathering time (t) differs between mudstone and sandstone. In the faintly weathered zone, mudstone is weathered faster than sandstone at the beginning of weathering. After about 400 years in the weathering time, sandstone exceeds mudstone in the weathering rates.

The rates of decrease in mechanical properties (dR_S/dt) with weathering time (t) also differs between sandstone and mudstone. At the shallow zone, e.g. 3 cm and 10 cm deep, mudstone begins to be weathered earlier than sandstone, but after the certain elapsed time from the beginning of weathering, i.e. about 70 years for 3 cm deep and about 200 years for 10 cm deep, mudstone will be exceeded by sandstone in the rates of decrease in R_S. At the zone deeper than about 30 cm, however, sandstone starts to be weathered earlier and faster than mudstone.

KEVIN J. HALL

The impact of temperature record interval and sensor location on weathering inference in periglacial environments

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In many weathering studies, particularly those in periglacial regions, much emphasis is placed on the thermal conditions. The reality is that it is moisture, not temperature, that is the limiting factor. Nevertheless, with respect to the thermal conditions, many deductions are based on air temperatures which are, in reality, meaningless as a surrogate for rock conditions. This use of air temperatures has resulted in subjective interpretations of weathering environments/processes that have served to reinforce, rather than question, the presumption of freeze-thaw weathering in periglacial environments. Further, almost all available rock temperature data are inadequate for any meaningful deduction of process, particularly that of freeze-thaw. Without information regarding the presence of water within the rock (including its amount, distribution and chemistry) together with that on the rate of fall of temperature within the rock as well as the amplitudes of the freeze and thaw cycles, so it is impossible to assume the operation of freeze-thaw or to be able to deduce which freeze-thaw mechanism was active.

Detailed temperature data, obtained at 30 second or one minute intervals, from recent studies in Antarctica and the Canadian Rockies, show the importance of such high frequency data acquisition for the evaluation of weathering processes. Not only are such data necessary for the establishing of which freeze-thaw process is operative (if any) but they also show that mechanical processes other than that of freeze-thaw may be operative and, possibly, more important. Data analysis of freeze events allowed for the determination of the rate of fall of temperature and thus deduction of possible freeze-thaw mechanism(s). More importantly, the detailed data provide evidence for the operation of thermal shock ($\Delta t \geq 2$ C° min^{-1}) as well as thermal stress fatigue. The significant control of aspect on temperature, a factor often ignored in weathering process interpretation, can also have an impact on thermal stress fatigue. There are major thermal differences between aspects (≥ 18 C°) and these not only have implications for process differentiation but also for the implementation of buttressing that can enhance the role of thermal stress fatigue. It is suggested that in many periglacial environments processes other than freeze-thaw (e.g. thermal stress and/or wetting and drying) are more active and important in sediment and landform development . Data to indicate the impact of record interval and aspect will be presented together with examples of its importance for process understanding. The need for these type of data to replace the qualitative presumptions of cold (and other) region weathering will be emphasized.

ALI HAMZA

Crue et érosion des terres en Tunisie Centrale

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En Tunisie centrale à climat aride et Subaride, l'irrégularité inter amnuelle et intersaisonnière des preécipitations font que les crues et inondations constituent um phénomène très fréquent. Outre les implications sur le plan hydrologique et hydrogéologique, leurs conséquences sur le plan morphologique sont notables: extension des sebkhas, déplacement de lits d'oueds, apparition des cônes de déjections et de secteurs d'épandage en plus du déclenchement du ravinement. L'auteur développe en particulier le phénomène érosion des terres qui enregistre à l'occasion de ces crues une activation impressionnante aux dépens de milieux sensibles de nature et largement fragilisés par ume occupation humaine le plus souvent non conservatrice. Dans tous les cas des crues étudiées, l'érosion hydrique effectue le travail de plusieurs amnées en quelques jours. Quelques recommandations sur le plan de l'aménagement sont formulées afin d'éclairer les décideurs chargés de la mise en valeur de la région.

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Structural relief of the northern part of the Murmansk Upland (Kola Peninsula)

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Relief and geological structure interdependence manifests itself in a particularly distinctive way in fold mountains and in the vicinity of crystal rock uplands having a long history of development. The Murmansk Upland, being a part of the Precambrian Baltic Shield, belongs to the latter areas. The relief of the northern part of the upland, shaped by a long-lasting continental period includes elements of different genesis and age. Therefore it is occasionally described as structural - denudative or block - tectonic.

Murmansk Upland is built out of Archaic, microcline granite containing numerous veins of quartz. The granite belongs to the extensive tectonic structure called the Murmansk Block. The examined part of plutonium is divided on macro and mesoblocks by the net of dislocations of different ranks. SE-NW and SW-NE directions related to main tectonic zones of the Kola Peninsula are predominant. The separated tectonic blocks are broken by a dense net of splits, dislocations, and crevices of tensive character. The authors on the basis of the morphostructural analysis distinguish between two types of structural relief in the northern part of the Murmansk Upland: denudative relief conditioned by different plutonium rock resistance and a complicated system of joint cracks, and disjunctive relief connected with dislocational activity of supraregional rank and regional glaciisostatic movements of tensive character.

The oldest denudative element of the examined area is the highest part of the Murmansk Upland (240-260 m a.s.l.) which is a remnant of Mesozoic peneplane. Below the peneplane, the Murmansk Upland falls down with distinctive steps towards the Barents Sea within the precincts of which there are numerous inselberg forms. These steps are interpreted by the authors as pediments which originated in conditions of semi arid climate as a result of isostatic periodical movements. The denudative relief developed also in conditions of periglacial climate. In this climate the old edges of tectonic and denudative origin were remodelled by the weathering processes and mass movements. The destruction of edges was most effective in the places of a dense net of joint cracks. Also nowadays the edges are destroyed by frost weathering and mass movements. Sea cliffs retreat intensively as a result of undermining and falling off of weathered and cracked granite. Lithology of rocks and diversified density and direction of the net of cracks brings about uneven run of coast line.

There are the following elements of disjunctive tectonics in the relief of the analysed area: tectonic troughs, tectonic edges and open tensive crevices.

Troughs create long and narrow depressions in the relief. The length of forms of this type reaches from twenty to ninety kilometres maximally, the width being a few hundred meters and depth up to 100-200 m. These forms are characterised by rectilinearity with the dominant depressions running NW-SE and SW-NE. They divide the area of the northern part of the Murmansk Upland into a row of meso and microblocks.

Tectonic edges create trough-sides, semi-troughs and splits and are present within tectonic blocks, on the lines of ordinary faults. These edges are mostly of rectilinear run related to the characteristic directions of a given tectonic block. The height of the edges depends on the rank of the tectonic form. Open tensive crevices are characterised by the width of up to 15-20 m and depth reaching from eleven to nineteen meters. Sporadically they have the shape of canyons with vertical walls and narrow bottom. These are the youngest of the forms under discussion. The appearance of crevices is related to current tectonic activity resulting from the postglacial uprising of the Kola Peninsula.

Within the analysed area one can also meet other forms connected with disjunctive tectonics: rectilinear «valleys» and depressions created in the axes of dislocated zones and depressions with no outlet connected with tectonic loops located on the intersections of structural directions.

Dense net of tectonic cracks advance the processes of mechanical weathering. During the Pleistocene zones of tectonic dislocations were the object of intensive directed exaration and fluvioglacial erosion. Valleys and depressions are of diversified morphometry and morphology. Their length reaches several kilometres and depth does not

exceed 20-30 m. Presently, most of these depressions are taken over by lakes.
Disjunctive tectonics covered the denudative relief giving, as a result, a complicated system of denudative and tectonic elements. Exaration activity of Pleistocene continental glaciers led to the depreparation of structural relief and inconsiderable remodelling of its elements.

JON HARBOR

Engineering geomorphology at the cutting edge of land disturbance: erosion and sediment control on construction sites

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Construction site management, traditionally dominated by professional engineers, provides an important opportunity for engineers and geomorphologists to work together in minimizing the environmental impacts of land disturbance. Areas disturbed for construction activity have soil erosion rates 2 to 40,000 times greater than pre-construction conditions, and are an important component of nonpoint source pollution that degrades surface water quality. Despite significant local- to watershed-scale environmental and economic impacts from increased erosion and sedimentation, the lack of an individual economic incentive for land developers to control erosion has limited voluntary adoption of erosion and sediment control measures. However, increased regulatory requirements, combined with efforts to identify and publicize the benefits of erosion control, are increasing the number of construction sites on which erosion control efforts are being implemented.
Geomorphologists have the opportunity to play an active role in erosion and sediment control by implementing knowledge of erosion and sedimentation processes and of the variables that effect these processes. Pre-project geomorphological site assessments allow project designers to work around areas with high erosion potential, and to stage and schedule land disturbing activities to minimize erosion potential. Combined engineering and geomorphological analyses can increase the likelihood that on-site and off-site streams and drainage channels are stable under altered hydrologic conditions, both during and after land use change, and can be used to design a drainage plan that minimizes surface water flow in disturbed areas. A variety of temporary measures to reduce erosion and to trap sediment on site can be designed and implemented, such as temporary surface covers, silt fence and sedimentation basins. However, design and implementation of these measures requires an understanding of erosion and sedimentation processes, and in many cases incorrect installation and maintenance limits their effectiveness. Regular on-site inspections and training by geomorphologists specializing in erosion control can ensure that measures are being installed and maintained correctly, and allows the inspector to modify the erosion control plan to deal with changing conditions and unanticipated problems. In addition, geomorphologists and engineers can use their combined understanding of erosion processes and construction site realities to develop innovative, practical measures to improve erosion control.
Construction site erosion control is a field that relatively few academic geomorphologists have shown an interest in, yet has great potential both in terms of job opportunities and research. It is an area in which geomorphologists and engineers can work together, using their complementary knowledge both for the development and implementation of erosion control plans, and as the basis for developing innovative practices and for undertaking research on the effectiveness of traditional and new approaches to erosion control.

CAROL P. HARDEN

Effects of land-use change on hillslope hydrology: two contrasting cases

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Predicting and extrapolating rainfall runoff and soil erosion rates over entire drainage basins requires understanding the relationships between land-use and hillslope processes. To meet the increasing demand for spatially-extrapolated runoff and erosion rates in Gis applications and to support the development of more accurate environmental models, closer examination of the land-use variable will be required. Two cases from this author's experience reveal the need to determine land-use history as well as contemporary land-use and the need to develop land-use classification schemes that include hydrologically and erosionally relevant classes. One case is from a humid, hilly region of eastern Tennessee, in the southeastern USA; the other from a watershed in the Ecuadorian Andes in South America. In both cases, a hand-portable rainfall simulator-infiltrometer was used to replicate a standard rainstorm, and infiltration and sediment detachment were measured.
In the Tennessee case, the Copper Basin, 130 km^2 in area, had been dramatically eroded by more than 100 years of copper mining and smelting. The basin was so denuded of vegetation that it became a biological «desert,» and a feature clearly identifiable from space. Acidic fumes from copper smelting and sulfuric acid production, along with some grazing of livestock, maintained the barren state and impeded revegetation efforts for decades. Reforestation has been more successful since the 1970s, and, today, the basin is essentially revegetated. Rainfall simulation experiments in sections of the basin that were revegetated during

different decades show that hydrologic recovery lags significantly behind erosion during landscape restoration. Whereas soil detachment rates approached those of the forest (control) area outside the basin within the first decade after replanting, runoff generation decreased very gradually over time. Thus, contemporary land-use alone provides insufficient information for extrapolating runoff rates in this historically disturbed basin.

The Ecuadorian case demonstrates that abandonment of formerly cultivated lands significantly accelerates both rainfall runoff generation and soil detachment. Revegetation of abandoned lands in Andean Ecuador is hindered by degraded soil, drought, and/or informal grazing. Although the condition of abandoned lands (and lands in unmanaged fallow) varies considerably, the tendency is for abandoned lands to have high runoff coefficients and high soil erosion rates. Analysis of soil carbon also indicates significant organic matter depletion on these lands. Because abandoned lands can play such an important role in surface runoff generation, runoff conveyance and soil erosion, efforts to extrapolate hydrologic properties and erosion rates need to differentiate between active and inactive croplands and to investigate the actual hydrologic conditions of abandoned lands. Identification of abandoned lands as erosional «hot spots» challenges watershed managers to develop new management options for otherwise unmanaged lands. The Ecuadorian case also demonstrates that roads and footpaths in the Ecuadorian Andes play a hydrologic and erosional role far out of proportion to the area they occupy in the landscape.

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Active-layer detachment slides on Ellesmere Island, NWT Canada: movement mechanisms, stability thresholds and environmental controls

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Active-layer detachment slides are shallow translational slope failures triggered by late-summer melting of ice-rich soil near the base of the active layer, immediately above the permafrost table. Such slides, developed in low to medium plasticity clays and silts, are widespread in the Fosheim Peninsula, Ellesmere Island, where permafrost is continuous, the active layer ranges up to approximately 0.75 m in thickness, and summer temperatures are unusually high in comparison with much of the Canadian high arctic. Lewkowicz (1992) has shown that slope failures are triggered by rapid late-summer thawing of the ice-rich basal zone, and the last such event in the Fosheim Peninsula was in August 1988 when many new failures were initiated. Two-sided freezing of the active layer leads to the concentration of segregation ice at its base, and cryodesiccation of its middle and upper parts (Harris & Lewkowicz, 1993). Slope failures involve translational sliding of the rigid active layer over a thin basal shear zone in which thaw consolidation leads to elevated porewater pressures. Surface seepage was reported on flat plateau surfaces immediately prior to the initiation of widespread slope failures in 1988, suggesting high basal porewatare pressures.

Porewater pressures at the base of the active layer were recorded in late July and early August 1995 on a detachment slide at Hot Weather Creek and on a smooth slope at Big Slide Creek. There was no morphological evidence for past instability at the Big Slide Creek measurement site, but there were a number of slides immediately to the south. It was considered, therefore, that this location may allow assessment of pre-failure conditions. Geotechnical testing provided data on soil classification, and on shear strength and consolidation parameters allowing slope stability analysis to be undertaken in terms of effective stress conditions. Applying the thaw consolidation theory to an infinite slope model (McRoberts & Morgenstern, 1974), the thaw consolidation ratio R and the thaw rate necessary to initiate failure of these slopes were estimated. The significance of environmental and site factors to the triggering of active-layer landsliding is investigated by means of a sensitivity analysis, and results are discussed in the context of meteorological and ground thermal conditions during previous years.

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Nature and origin of a major congelifluction landform, Kunlun Pass, Qinghai-Zizang Plateau, People's Republic of China

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The military road to Tibet follows the Jing-Xian valley as it crosses the Kunlun Shan. On its west side, a major congelifluction deposit is slowly moving away from the ridge crest at 4800 m in a northerly and easterly direction. The material consists of middle Pleistocene till deposits and the underlying Pliocene alluvial gravels lying on the north slope of the ridge crest. Lithologies of the clasts include granite, granodiorite and pyroxenite of local origin. More than 10% of the material is composed of boulders longer than 2 m, with 45% of the material having long axes between 0.5 and 2 m. The matrix is sandy loam and the diamicton is poorly sorted.

The slopes have an estimated mean annual air temperature of –7 °C to –5 °C, and an estimated mean annual precipitation of under 300 mm/a. Most of the latter falls in summer, often as snow. The few plants that grow on the surface of the diamicton forming the landform exhibit elongation of stems and/or roots to accommodate congelifluction. The surrounding slopes have a more verdant meadow tundra which would form alpine meadow if not so heavily grazed. The surface of the mass is inclined at an average of about 19°, while the mean slope of the fronts is 21°. With one exception, the slope of the fronts does not exceed 25°, unlike true rock glaciers. The diamicton mantles the north slope of the ridge but splits into at least 16 separate tongues which are moving down fluvially graded valleys. The lowest front lies at 4630 m, but varies in thickness up to 40 m in valley number 4. The active layer was found to be between 12 and 30 cm in July at 4780 m, but increases to 1.5 to 2 m. at about 4650 m. Ice contents have been measured at up to 57% but they are usually under 30% in the upper layers of permafrost.

The larger boulders act as braking blocks on the upper slops of the landform and are frozen into the permafrost. The rates of advance of the lower parts of the landform measured by surveying range up to 3 cm/a, whereas the rate of movement of the fine-grained material in the active layer past braking blocks on the upper slopes ranges up to 30 cm/a. It is therefore concluded that the excess material moving down the steeper upper slopes must be causing thickening of the deposit on the more gentle lower slopes. There is no direct evidence for flowage of the icy diamicton forming the deposit.

This landform has been referred to by various names such as rock ice-cap, periglacial boulder tongue and Kunlunshan-type rock glaciers. Its dominant mode of downslope movement of material (congelifluction) distinguishes it from true rock glaciers (which move by flowage of the permafrost layer due to the presence of excess ice). It also lacks the over-steepened front which is a consequence of that movement, but exhibits braking blocks. None of the other terms have been properly defined and described. It is therefore best referred to as a massive congelifluction deposit, and is the longest and most spectacular of these deposits described so far in the world.

JANE K. HART

The deforming bed / debris-rich basal ice continuum and its implications for Glacial Geology

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It is shown that there are many similarities in processes between the subglacial deforming bed and the debris-rich basal ice layer, including: compression at the margin; longitudinal extension and simple shear upglacier; similar styles of shear zone and associated fabric development; and similar incorporation, transport and depositional processes. These have an important effect on glacier dynamics. However, the resultant layers will depend on the nature of the bedrock, the sediment supply and the thermal characteristics of the glacier. These ideas will be illustrated from contrasting glaciers in Greenland, Alaska and the European Alps.

The main differences include, rates of sediment movement processes and preservation potential. It is argued that there is little chance of the debris-rich basal ice layer being preserved, and this is demonstrated from modern examples, flutes studies and studies of Pleistocene «melt-out» tills from the UK, USA and Germany. It is argued instead that the debris-rich basal ice layer will melt-out to form a deforming layer, which will in turn be preserved once the ice sheet retreats.

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The impact of Quaternary sea level and climate change on coastal alluvial fans in the semi-arid Cabo de Gata ranges, southeast Spain

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Conventionally, base-level fall is seen as stimulating incision in the distal zones of alluvial fans. In the Cabo de Gata ranges of semi-arid southeast Spain there is evidence to the contrary. There, two sets of Quaternary alluvial fans demonstrate the interaction between climatically driven variations in sediment supply and eustatically driven base-level change. Both fan sets are fed by Miocene volcanic terrain within which there is no evidence for tectonic deformation during the period of fan development. The evolution of the east-coast fans has been affected by variations in both sediment supply and sea level change. The west-coast fans were buffered from the effects of sea level change by coastal barriers.

Two major phases of fan sedimentation can be identified, apparently coincident with global glacials (>c135 ka and

c85-10 ka, based on the stratigraphy and U/Th dating of the coastal sediments). On the east-coast fans high sea levels during the intervening interglacial and during the Holocene caused erosion of the distal fan zones which led to channel incision into the fan surfaces. On the west-coast fans no such incision occurred, simply proximal incision by small fanhead trenches. At least one minor phase of fan sedimentation has occurred during the Holocene.
The fan sediments show increasing fluvial dominance with time. Debris flows are largely restricted to the earliest phases or to side inputs in the fan proximal zones. The contrasting fan contexts have produced differing fan styles, with telescopic fan morphology characteristic of the east-coast and stacked morphology of the west-coast fans. These differences are reflected in the fan profiles, with steeper proximal gradients dominating the east-coast fans, and extensive lower gradient distal surfaces on the west-coast fans. Fan morphometry, based on analysis of the residuals from drainage area to fan area and gradient regressions, also differentiates between the fan contexts.
Fan building phases appear to be controlled proximally by sediment fed to the fans. The major sediment pulses were climatically driven, occurring during global glacials and at times of low sea levels, and caused fan progradation onto the exposed foreshore. The intervening global interglacials were times of little fan sedimentation, and on the east coast, where high sea levels were able to erode the fan toes, deep through-fan dissection ensued.

ULRIKE HASSLER, B. MAUZ & U. RADTKE

Late Pleistocene littoral sediments in Calabria (Southern Italy): first results of luminescence age determinations and morphostratigraphic meanings

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On the Crotone peninsula (Calabria) several marine terraces are unconformably overlying the Plio-Pleistocene clayey sediments of the Cenozoic Crotone Basin. The up to 15 meters thick littoral sediments of the terraces, situated at altitudes between 240 and 5 m a.s.l., are characterised by a siliciclasts-bearing carbonate facies giving evidence for a repeated restoration of a reef-bearing nearshore environment. Gliozzi (1987) used sedimentological, palaeontological and structural analysis and age determination by aminoacid racemisation and U-series dating techniques to recognise the high sea level episodes of the oxygen isotope stages 7, 5e, 5c and 5a in six morphological orders of terraces. However, reasonable doubt on the stratigraphic attribution of the deposits was given by the weak data of the U-series dating (basing on travertine, calcarenite and molluscs shells). Our study in the Crotone area aims to find out, whether luminescence dating could help to verify the correlations of the previous study. Furthermore, the presence of the, although weak, independent age control, should allow to assess the potential of luminescence dating on Mediterranean littoral deposits.
Due to different materials used in the age determination methods, samples could not be taken at the locations used in the previous investigations. Instead, samples were taken from deposits in different altidudinal positions, which could be correlated with the investigated outcrops by structural and morphological field evidence.
The luminescence dating was carried out using different methodological approaches each corresponding to the composition and structure of the sampled horizon. Namely, the single grain method (Lamothe, 1994) and the multiple aliquot additive dose method were used on infrared -stimulated (Ir-Osl) alkali feldspars. Thermoluminescence (Tl) measurements on quartz were applied when no alkali feldspars were available. The emissions were detected in narrow wavelength bands (the 350-490 nm emission of alkali feldspars and the 280-320 nm emission of quartz). The dose rates were determined using Naa and Aas measurements of radionuclides contents, β- and α-counting, attenuation factors given by Mejdahl (1979), conversion factors given by Nambi & Aitken (1986) and cosmic dose rate given by Prescott & Hutton (1994). However, accurate dose rate calculations are limited due to the unknown time of proceeding diagenesis and the unknown time of exposure to cosmic rays.
The received results are being critically discussed in terms of their morphostratigraphic meanings and the possibilities of further luminescence dating on this kind of sediment.

CLAS HÄTTESTRAND

Ribbed moraine formation

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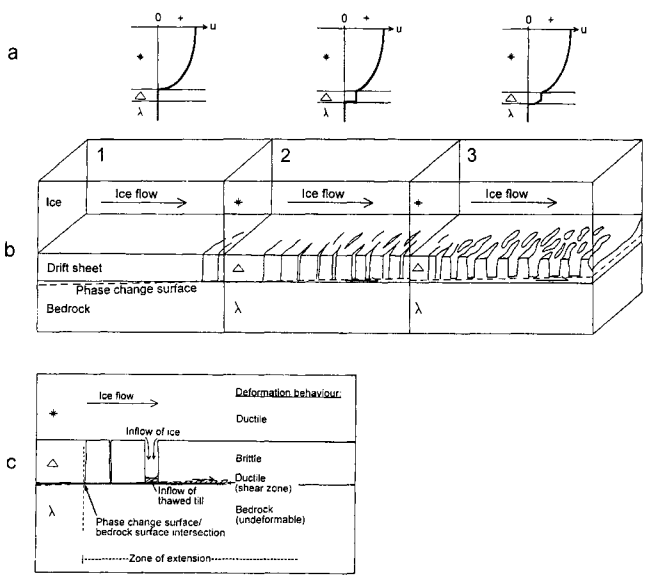
Ribbed (Rogen) moraines are characteristic features in the interior parts of formerly glaciated areas in the Northern Hemisphere. Their distribution is limited to the core areas of the glaciation centres; Keewatin, Labrador and Newfoundland for the Laurentide Ice Sheet and the central parts of Norway, Sweden and Finland for the Fennoscandian Ice Sheet. The most abundant and well developed ribbed moraines are situated in close connection to areas that were cold based during the retreat of the Late Wisconsinan and Late Weichselian Ice Sheets, respectively. Outer, fully warm-based areas, lack ribbed moraine.

Observations have also been made on a more local scale, where a «broken up» till cover, downstream of cold-based patches, grade into a ribbed moraine field. The frozen bed zones were covering larger areas during earlier stages of the glaciation, but are inferred to have been in contraction during the deglaciation. Thus, ribbed moraines are confined to areas that were subjected to a change from frozen to melting basal conditions, during the retreat of the last ice sheets. The interior stratigraphy of ribbed moraines is extremely diverse and almost anything from pure stratified sand to semi-consolidated lodgement till is observed in the ridges. This suggests that the construction of the ridges is separated from the deposition of the material, i.e. the ribbed moraine is formed from a pre-existing drift sheet.

A model of origin is presented here, focusing on the processes taking place during a contraction of a frozen bed core area of an ice sheet, and includes the following (see also figure): at the transition from non-sliding (frozen) to sliding (melting) conditions there will be an increase in the basal velocity (fig. a), leading to local extensional flow and high tensional stresses at the base of the ice sheet. The phase change surface (the border plane between frozen and thawed material) is gently rising down-ice (fig. b) and there will be zones, at the transition between cold-based and warm based areas, were there is a layering of: bedrock (undeformable) - thawed drift (deformable) - frozen drift (brittle) - ice (deformable) (fig. c). High extensional stresses within this layering will cause detachment and «boudinage-like» breaking up of the frozen drift layer into transverse segments (fig. b and c), i.e. ribbed moraine. Subsequent deformation of these drift ridges may cause superimposed drumlinization and form the typical Rogen moraine (*sensu stricto*).

In line with this model of formation, ribbed moraines may be used to track the minimum extent of frozen bed areas under former ice sheets.



CAIHUA HE, KANGNING XIONG, XING CHENG & XIAOLING LI

Karst geomorphology and agricultural implication in Guizhou, China

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Guizhou Province, with 73% areal extent of carbonate rocks, contains the most karstic upland of China. A suit of *fenglin* (peak-forest) karst and *fengcong* (peak-cluster) karst are well developed on the complicated structural background and the favourable subtropical environment. With large-scale uplift of the neotectonism, effects of the karst rejuvenation have not yet reached the plateau interfluves far from trunk rivers and the karst landforms are still evolving toward peneplanations, which constitute the plateau are as for the inherited karst development.

An assemblage of the karst landforms from watersheds to valleys is generally a fenglin karst systems changing from fengcong-depression, fenglin-depression, fenglin-valley, and to fenglin-plain. With strong uplift of the neotectonism, karstification around the plateau edges adjacent to the trunk rivers is rejuvenated under the conditions of increasing relief, which forms the gorge areas for the deepward developemnt of karst. The karst landforms from watershed to gorge are normally a fengcong karst system from fenglin-depression, fengcong-depression, fengcong-valley, and to fengcong-gorge. In the plateau areas are normally karst plains and hills in land type with zonal and red soils on carbonate weathering crust. The soil cover is thick with slight soil erosion and groundwater with diffuse flow, water-table 0-20 m deep, is easily exploited. Moisture conditions are good, access to surface and ground water. Good sunlight with high cumulative temperature is due to the open topography. Vegetation is zoned and changed with latitude and altitude. Cultivation is characterized by flat paddy field, non-irrigated land and terraced paddies, suitable for some agricultural machines. In contrast, the gorge areas mainly contain deep depressions and rocky hills with non-zonal calcareous soils in depression washing slope residuals. The soil cover is thin with very bad soil erosion, commonly bare rock on hill-sides. Groundwater with conduct flow, water-table 40-300 m deep under small dolines, is difficult to exploit, which gives rise to special karstic droughts or topographic floods. The high and close relief is responsible to shadows in depressions, low cumulative temperatureand high daily temperature range. Cultivation is featured by hard-irrigated farmland, hill farmland and slope terraces, very hard for agricultural machinary. However, from the gorge floors to the plateau interfluves are good conditions for verticaldistribution of agriculture due to huge range of elevations and for various productions of farming due to many types of landforms.

OLAVI HEIKKINEN & PETER BRUSILA

Field techniques employed in Finnish dune research

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Dune sand movements can be monitored either in the course of aeolian events or afterwards. Thus research techniques can be divided into active ones that form part of the processes or measure their progress and passive ones that measure the changes brought about as a result of the processes.

One obvious active technique is the marking of blown sand with a fluorescent tracer that can be distinguished by UV illumination in order to monitor the dissemination of the sand. Saltation can be studied either using traps of a certain kind or with strips of wood stuck into the ground and covered with vaseline or some other substance to which the sand will adhere easily. Other active approaches include the gathering of meteorological data, including wind speed and direction, air humidity, precipitation and temperature. This information, especially that concerned with winds, can be used to predict the likelihood of aeolian erosion and total transport of blown sand in a given area.

Passive methods include various traps, erosion gauges, levelling procedures and the measuring of the sand content of snow samples. The authors have recently tested a number of new traps for collecting blown sand, including the Annika, Alestalo, Erika and BP 1-2 models. Some of these measure the total amount of sand transported, some that transported by saltation and some the crawling sand, while some accept sand from all directions and others only from a certain direction. These traps are suitable for different purposes, and each has its good and bad points, but there is no one trap that is yet capable of providing a proper account of the spatial distribution of the sand.

The shapes and stratification of dunes provide information on wind directions at the time of their deposition, and changes in the morphology and vegetation of dune areas can often be assessed from historical documents, maps of different ages and repeated field or remote sensing surveys. The stratification of a dune, other aspects of its internal structure and variations in its water content can be determined by ground penetrating radar, a method in which the depth dimension and resolution can be varied by using antennae of different frequencies. Thin buried charcoal layers, which may provide evidence of earlier fires, can be identified by drilling if they cannot be distinguished by ground penetrating radar. These layers can be dated by radiocarbon and the sand horizons above and below them by the luminescence methods. Dendrochronological techniques can be employed in a wide variety of ways for dating accumulation and deflation events in dune areas. Features that can be particularly revealing in this sense are barrel-shaped growth, release and suppression in radial growth, annual ring eccentricities, reaction wood, the age of the trees and adventitious roots.

JÜRGEN HERGET

Anthropogenic influence on the development of the Holocene terraces of the River Lippe (W. Germany)

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The Holocene *Inselterrasse* (Island-terrace) of the river Lippe lying between the Westphalian bight and the northern rim of the central german hill country in the northwestern part of Germany was one of the focus points during studies on the development of the Lippe-valley system.

As terrace level the *Inselterrasse* is only existing between the city of Lünen and the mouth of the Lippe into the Rhine. It is diverging from the lowest floodplain level west of Lünen, reaches a higher level of about 3 m and converges again west of the city of Haltern in the direction of the Lippe mouth. In the headwaters east of Lünen the valley bottom below the Weichselian *Niederterrasse* (lower terrace) consists of a single broad level. West of Lünen the *Inselterrasse* builds the valley bottom and only dry abandoned river channels segregate the level of the *Inselterrasse* into several islands. In detail in some sections the *Inselterrasse* consists of two levels but due to the recent sediment dynamics with the accumulation of natural levees they usually are difficult to differentiate. The lowest level of the callow is a small sector following the river channel. Several samples of wood, humic loam and peat out of the terrace sediments and channel fills were dated by radiocarbon, pollen analysis and dendrochronology and show ages that vary between less than 300 years and 8230-8005 B.C. More detailed sediment studies could not be carried out because of the lack of exposures but the sandy terrace sediments seem to be cross-beded and deposited by a meandering river.

The origin of the level of the *Inselterrasse* is completely anthropogenic. Between the 13th and 19th century meanders were cut and the river channel was narrowed for reaching a higher depth of water. The aim was the improvement of the navigation of the river. Studies about the Roman activities on the river channel during their campaign against the german tribes are in process. The deep erosion of the river channel makes the mean water level fall deeper below the natural high-water bed. This relatively risen level is the recent *Inselterrasse*. The occurence of this anthropogenic terrace results from the river management which ended close to Lünen because of cliffs of harder rock there. The lowest terrace level close to the river channel developed out of the towing-path. It is extented by fluvial erosion but also covered by high-water sediments and natural levees. A research program on the character of the natural river channel of the Lippe, meandering or anastomosing (resp. a sectional divarication), is in progress.

IRÉNÉE HEYSE

The Middelkerke Sandbank in the Southern North Sea (Flemish Banks, Belgian continental shelf)

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The Flemish Banks are a group of parallel sandbanks or tidal current ridges (Off, 1993) situated on the French-Belgian North Sea coast and streching in a SW-NE direction, slightly oblique to the sandy macrotidal coastline. These banks are separated by swales that dip to the NE and generally do not reach below 30 m spring low waterlevel. Their morphology has been studied by Van Veen (1936), Off (1963), Houbolt (1968), Van Cauwenberghe (1971), Caston (1972), Bastin (1974), Kenyon & *alii* (1981) De Moor (198S), Ceuleneer & Lauwaert (1987), De Moor & Lanckneus (1988,1989), Vlaeminck & *alii* (1989), Lanckneus & *alii* (1989) and Heyse & De Moor (1996).
Each of these banks is about 20-30 km long, 10-20 m high and 1-2 km wide. These dimensions and the general size decrease to the east.
The Middelkerke Bank is the eastermost and the most shoreward of the Flemish Banks. The coast is at a distance of 11-14 km (Middelkerke-Ostend section) and the bank has a streamlined plan shape. The large-scale dimensions of the bank can be summarized as follows: 10 km long, 1 km wide, 10-11 m height, SW -NE orientation 36° north heading ant an angle of 20° with the coastline (56° north heading). The surroundings «deeps» have a more or less flat bottom, the Negenvaam channel to the NW is 2 to 3 km wide ant is 20 to 22 m deep, the Uitdiep to the SE is 1 to 3 km wide and 16 up to 19 m deep.
The cross-section of the Middelkerke Bank is typically asymmetric, the NW flank being clearly steeper than the SEC flank. The more or less flat top zone of the bank is situated at –5 m and has a width of about 200 m The flank profiles are mostly concave-convex with a middle slope straight section. The most common bedforms are sandwaves, subaqueous dunes of varying size and small scale ripples.
In the framework of European Projects (Resecused and Starfish), the Middelkerke Bank was selected to study the morphodynamic evolution of the entire bank environment. As well short time, medium term as long term evolution was studied. Detailed investigations could be performed in order to map in detail all the morphological bedform features, to monitor relevant near bottom sites in the watercolumn, to determine the hydrological conditions, to estimate the impact of sand mobility and to evaluate the sand budget evolution of the sandbank. Also the impact of extreme storm events upon the bottom morphology was investigated
Results of the 6 year multidisciplinary programme are presented.

DAVID L. HIGGITT & ROBERT J. ALLISON

The form and development of slope profiles and boulder pavements in the Eastern Badia, Jordan

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The Eastern Badia of Jordan includes 11 200 km^2 of arid and semi-arid desert, where the ground surface has developed on late Tertiary and Quaternary basalt lava flows. Topographically the region has a maximum altitudinal variation of around 800 m, with the highest ground in the north-west on the foot-slopes of the Druz mountains. Locally, differences in absolute relief between topographic highs and lows are small, being no more than 10 m on the oldest basalts but increasing to around 50 m for recent volcanic centres where remnant extrusive cones are still evident. The geomorphology of the Eastern Badia is dominated by three characteristics. First, slope profiles which range from concave to convex forms. Second, a rock boulder cover across much of the ground surface, with distinct spatial variations in the degree of boulder exposure or burial. Third, pans of fine grained sediment which accumulate at topographic lows and are known locally as Qa and Marab. Results are presented of a study which has investigated relationships between basalt lava flow type and age, the form of slope profiles and variations in the ground surface boulder cover. As lava flow dissection occurs as a consequence of landscape development, slope profiles change from convex forms, characteristic of flows > 8.45 million years old, to transects which are concave and characteristic of flows < 1.45 million years old. The boulder cover varies between the crest and the toe of slopes, the degree of exhumation or burial providing an indication of the flux of fine grained sediments as a consequence of sediment transfer processes, particularly overland flow.

ANNE C. HINTON

Tidal changes and their consequences

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Alterations to tidal levels are not necessarily the same as those to mean sea level. Holocene tidal changes have been shown to vary spatially in both magnitude and direction. This situation is continuing at the present day and has wide-ranging implications for future coastal development. Man has had a significant impact on present trends by his effect on nearshore zones.
An examination is made of tides in differing geomorphological contexts to assess the impacts of coastal and offshore morphology on the tidal regime. In open embayments, al-

terations to the coastline shape are found to influence the pattern of tidal heights recorded, whereas water depth changes modify the magnitude of tidal range within the embayment. The results are also examined in terms of their influence on the shape of the tidal curve. A similar study is made in a funnel-shaped embayment. In this case, altering the coastline shape is found to change the height of the tidal range.
The results of this study highlight the influence of coastal geomorphology on processes operating in the coastal zone and the feedback effects which occur. Their implications should be noted for planning future coastal protection and risk mitigation measures.

MASASHIGE HIRANO

Analysis of fault block movement by 1995 Kobe earthquake

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The 1995 Kobe earthquake, formally called the Hyogoken-Nanbu Earthquake, occurred on January 17th, 1995, at AM 5:46. Its magnitude was 7.2, and the epicenter at N34.595, E135.038 in the Akashi strait with the depth of 16.0 km. The earthquake killed over 6,000 persons and the houses destroyed and/or burnt exceeded 100,000.
A significant strike-slip fault, the Nojima fault, appeared in the northern Awaji island, and systematic, right-lateral offsets were associated with it. The situation has been much complicated in Kone area, but the faults moved by the earthquake can be traced also by systematic off-sets of urban architectures. The moved faults in Kobe district run obliquely across the urban areas at the foot of the Rokko mountains. The faults form a conjugate set under the tectonic E-W compression, which was also shown by the focal mechanism of the earthquake.
Geodesic data such as Gps positioning and leveling of benchmarks before and after the earthquake show a definite tendency by blocked areas, and the conjugate faults are situated at the boundaries of the rhombic blocks. A fault block thus shows horizontal movement to a particular direction associated with tilting by case.
Analysis of displacement vectors on the basis of irrotational shift of rigid rhombic blocks shows that the Harimanada block at the north-west side of the Nojima fault first moved eastward, and it pressed the Suma-West Rokko block neighboring at the northeast to north-east direction and the north-Awaji block at the south-east side of the Nojima fault to the southward. As the result, right lateral sense of movement was detected along NE-SW directed faults and left lateral one along NE-SW ones. It is remarked as one of conclusions that a boundary fault with the left lateral sense runs probably off the east Harima coast starting from the middle of the Akashi strait to northwest ward. This fault has brought the notable dislocation of the piers and anchors of the Akashi bridge which was under construction.
Kinetic process obtained here by the analysis is well corresponding to geomorphic and tectonic features which have been clarified by foregoing studies covering the areas concerned. Especially such model developmental process of the Rokko as a block mountain, that rhombic blocks with strike-slip faults at boundaries were initiated under regional E-W compression and the tilting with vertical displacement was followed, was confirmed this time. The change of focal mechanism from the main shock of quadrant (strike-slip) type to the aftershocks of dip-slip type also supports this.
Tilting of the Suma-West Rokko block by the earthquake is in harmony at its tendency but less at the amount with those of marine terraces developed on the block. This gives way to estimate frequency of a same earthquake over geologic age.

VOLKER HOCHSCHILD

Analysis of periglacial geomorphology with Ers-1 Sar Data: examples from Antarctic Peninsula

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OEA - Ocean, Environment, Atmosphere, was an interdisciplinary research project founded by the Bundesministerium für Forschung und Technologie (Bmft) dealing with remote sensing data of the European Remote Sensing Satellite Ers-1 from the receiving station of O'Higgins on Antarctic Peninsula.
Since the launch of the Ers-1 in Summer 1991 the aim of the project was to examine the applicability of the Ers-1 Sar (Synthetic Aperture Radar) data (C-Band, 5.3 Ghz) to geomorphological phenomena in ice-free periglacial areas, like beach terraces, glacioisostatic elevated shorelines, glaciofluvial zones in front of the glaciers, frost patterned ground, thaw dynamics of permafrost and coastal ice types. It integrates also analogous (aerial photographs) as well as other digital remote sensing systems such as Landsat Tm and Spot.
While the remote sensing data was acquired intensive field survey of the reference areas has been carried out. It consisted of large scale geomorphological mapping, measurements of surface roughness, soil moisture, soil temperature and substrata analysis. Mapping includes slope angles, exposition and altitude measurement. All these parameters are influencing the backscattered radar signal and were correlated with the grey values of the Ers-1 images.
Finally all the data (field data, existing maps, remote sensing data, digital terrain models, Gps-positioning) was

combined in a geographical information system to derive thematic maps which can be extrapolated to larger areas of the Antarctic Peninsula. The results beeing published by Hochschild 1995: Geomorphologische Kartierung und Untersuchung der Auftaudynamik mit Era-1-Sar-Daten im Bereich der Antarktischen Halbinsel Bremer, Beiträge zur Geographie und Raumplanung, show the potential of Ers-1 Sar data to observe changes in the periglacial environment by multitemporal analysis of 3 day cycle data. Composites and difference images detected changes of the condition of the snow cover or the moisture content due to short time weather conditions.
Classification of geomorphological mapping units according to the surface roughness has not been possible using not Dtm corrected Sar data. The reasons for this are probably the small scale inhomogeneous relief, the small differences between the roughness indices and the unknow correction factor for moisture differences.
This conclusions lead to the fact, that better results in the analysis of periglacial landscapes will be achieved when multifrequency Sar systems are on satellite platforms.

PETER HOLMES

Holocene geomorphic environments of the semi-arid interior of South Africa

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A variety of geomorphic evidence in the semi-arid interior of southern Africa (an area referred to as the Karoo), attests to changing environments during the late Pleistocene and on into the Holocene. This paper reviews the geomorphic evidence for environmental change as reflected in a number of upland depositional environments. The study area is situated along an east - west transect, spanning some 600 kilometres in the region of 32° south latitude. The majority of individual sites occur above an altitude of 1000 metres. Slope and pedogenic processes, as well as fluvial and aeolian action have contributed to shaping these environments. The paper goes on to review the significance of the chronology from these environments at a local and subregional scale. In particular, comparisons are made with the findings of investigators who have worked on colluvial deposits to the east of the Great Escarpment, where wetter conditions currently prevail.
The depositional record from the Karoo records a shorter time span of palaeoenvironmental change than do the depositional environments to the east of the Great Escarpment of southern Africa. Within the Karoo, it appears that little depositional evidence predating the Holocene has remained preserved within the landscape. Where deposits do occur, they are primarily in the form of sedimentary fills on valley floors. Many of these fills have been incised to bedrock by gullying, thus exposing profiles for detailed geomorphic analysis. The exception to the «valley fill» type environments are Pliocene river terraces along the Orange River, and isolated pockets of aeolian sand which were deposited against valley flanks some 20 000 BP. A number of shallow depressions or pans, with their associated lunette dunes, also provide evidence for palaeoenvironmental change.
The primary finding from this study is that the mid-Holocene climatic amelioration some 5000 years BP manifested itself in the semi-arid interior of South Africa in terms of rapid landscape response to wetter conditions. This may have resulted in the flushing out of any valley fills which predated the mid-Holocene, and has resulted in an accumulation of material from approximately 5000 years BP onwards. The only older material to survive is that of aeolian origin, presumably because of its sheltered position away from drainage lines.
In summary, the current Karoo landscape contains an interrupted, proxy geomorphic record of environmental change dating back to the last glacial maximum, with only the last 5000 years represented by what might be regarded as a depositional continuum.

JANET M. HOOKE

Decades of change; geomorphology in fluvial and coastal engineering and management

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Major developments in the contribution of geomorphology to engineering and environmental management have taken place over the past ten years in the United Kingdom, particularly in the coastal and fluvial spheres. Considerable achievements have been gained in raising awareness of the nature of geomorphic processes and their dynamics and of how understanding of geomorphology can help in effective management and decisions over engineering strategies. Specifically, this has meant gauging or understanding of interconnectedness in geomorphic systems and the long-term variability of processes and landforms. Radical changes in both policies and decision-making frameworks have taken place such that the approach to coastal and river management adopted by the British Government is now to 'work with nature'. Likewise, management structures have been emplaced to facilitate and encourage integrated planning. Such changes have not, of course, occurred from the influence of geomorphologists alone but they do align policy much more with geomorphological principles than in the past. Examples are presented of geomorphological involvement in coastal engineering in

Britain. Engineering geomorphology is now in a second phase of answering geomorphological questions, providing geomorphological information and implementing management in accordance with the principles advocated. This is involving much case-study work at specific locations. A third phase of major development in the future is envisaged in this paper, mainly stemming from major changes in geomorphology itself and underlain by radical alterations of scientific theories, philosophy and methods. This will involve modelling and predicting responses in ways that adequately deal with complexity, positive feedbacks, non-linearity and holism. Questions remain with regard to the links between geomorphology and engineering on the type of predictions that are possible and acceptable, and on the extent to which geomorphology will provide 'solutions', both nationally and internationally. Whatever strategies or solutions are suggested there remains the issue of political acceptability in specific applications and the need for mechanisms to make public gain compatible with private loss. Geomorphologists arguably have the potential for another major leap forward, stimulated by theoretical and technological developments, in which the results of research will feed directly into 'environmental engineering', providing the requisite spatial and temporal data are available.

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Unconventional methods for evaluating the magnitude and frequency of flash floods in ungaged desert watersheds: an example from Arizona

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The vast majority of streams draining small watersheds in desert areas throughout the world are ungaged. Typically, desert regions are also characterized by sparse or non-existent networks of meteorological stations. Thus, determining the magnitude and frequency of flash floods in these areas from the basis of real meteorological and hydrological data on flooding is often impossible. This situation prevails in many portions of the deserts of the southwestern United States where small, rugged desert watersheds are ubiquitous and commonly situated in physical settings that are preferred areas for suburban development along the outskirts of rapidly growing urban areas, thus posing a significant flood hazard.

A recently completed multidisciplinary study of the flood hydrology of a relatively remote portion of the Sonoran Desert in west-central Arizona has demonstrated the feasibility of developing a fairly detailed catalog of the magnitude and frequency of flash-flooding in a region with very little conventional data pertaining to floods. In the study, techniques of paleoflood hydrology, aerial photograph analysis, archeology, and historical research were combined with minimal regional hydrological and meteorological data to compile a regional flood chronology from 9 small drainage basins (7-70 km^2) in the Buckskin, Rawhide, and Artillery Mountains of western Arizona. The flood chronology documents flash-flood events that have occurred in the region over a time scale ranging from less than 1 to more than 1200 years.

The recent flood history of each site was preliminarily evaluated through comparison of a series of aerial photographs spanning 50 years. At least one set of photos was available for each decade. Occurrences of large floods were easily inferred from distinct photographic evidence for flood related channel change between photo dates. Tighter constraints on flood timing were obtained by comparison of dates bracketed by the photo analysis with sparse regional meteorological and hydrological information, production dates of beer cans found in flood deposits, presence of distinct anthropogenic horizons in flood sediments, post-bomb ^{14}C dates on flood transported organic detritus, and collection of anecdotal accounts from the few residents of the general area. Constraining the timing of recent events enables the determination of the most likely flood-producing hydrometeorological processes. In this region, intense precipitation from isolated thunderstorms and dissipating tropical cyclones appear to be of nearly equal importance. This pattern is likely to be reflected in the paleoflood record as well. Techniques of paleoflood hydrology were employed at each study site to extend the flood record significantly back in time and also to estimate flash-flood magnitudes. The paleoflood history of each site was established through stratigraphic analysis of flood deposits and ^{14}C dating of detrital and *in situ* charcoal collected from flood sediments. Flash-flood magnitudes were estimated by incorporating the relict high-water evidence (historical and paleo) into a step-backwater hydraulic modeling routine. Study sites were preferentially located in bedrock canyons with tight downstream constrictions to aid in the hydraulic modeling and to ensure the presence of paleoflood stratigraphy. Less ideal sites were also evaluated to broaden the spatial and temporal scope of the investigation.

The study results indicate a striking consistency among the magnitudes of the largest floods in both the historical and the paleoflood records. This accords with similarities noted among paleoflood and recent flood magnitudes in much larger drainage basins in this general region. The magnitudes and relative frequencies of the largest flash-floods documented in west-central Arizona are at variance with 100-year flood magnitudes predicted for the same region by conventional regional-regression methods. This indicates that the predictive equations do not accurately characterize the flood hydrology of this region and may not be appropriate for regulatory purposes. Collection of historical and paleoflood information from the region of interest is the only means for demonstrating such a discrepancy aside from instituting a gaging network and waiting for large

floods to occur. Augmenting conventional approaches to regional flood frequency analysis with actual flood information derived from the alternative methods described here is the most practical approach to developing realistic assessments of regional flood magnitude and frequency characteristics in sparsely gaged desert areas.

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The bio - and hydrodynamics of the intertidal pioneer zone along the dutch Wadden Sea

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The marshes along the mainland coast of the Dutch Wadden Sea have experienced substantial erosion on many places during the last two centuries. Since the ninety-thirties extensive land reclamation works have changed the erosional to an accretional situation. The set up of the reclamation works is mainly based on trial and error building up practical know how.
In recent years the threat of a possible sea level rise has posed the question whether the reclamation techniques could be improved by studying in more detail the dominant mechanisms for mud accumulation in and before the marshes. Very sensitive in this respect is the pioneer vegetation on the higher parts of the intertidal flats. Promotion of this pioneer vegetation may increase the net sedimentation rate and consequently the extension of the marsh zone.
The most important species in the pioneer zone of the Dutch Wadden Sea is *Salicornia dolichostachya* . The ultimate success of survival of *Salicornia dolichostachya* depends on biological factors as seed production, germination rate, growth of seedlings at the one hand and hydrodynamic factors as deposition rate, bed disturbances by currents and waves, washing away of seeds and seedlings on the other hand. This is especially true in spring time.
Two test sites along the Wadden Sea coast have been selected to investigate this hydro-biodynamic interaction. These sites differ in seaward extension of the pioneer zone over the last decade and in the erosional and accretional character.
It appears that the density of *Salicornia dolichostachya* at the end of the growing season is mainly determined by the amount of seeds which remain in the upper layer of the bed after seed fall and the growth of seedlings in spring and summer. This amount was determined by the shear strength of the upper bed layer. At low shear strength, below 0.10 Pa, the bed is easily disturbed and 90 % of the seeds and seedlings are washed away during storm conditions. In more resistive beds, having higher shear strengths, above 0.25 Pa, there is more chance for germination and the seed loss is reduced to 70%. The latter conditions are frequently found in the transition zone from unvegetated to vegetated areas in the upper tidal flats. Boundary conditions of currents and waves deterring the values of the shear strength of the bed in relation to the chance of seeds and seedlings to survive determine the possibilities for management practises. Reduction of the wave and currents action by engineering measures may promote the extension of the pioneer zone.

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Landslide magnitude-frequency distributions in New Zealand, Papua New Guinea and Taiwan

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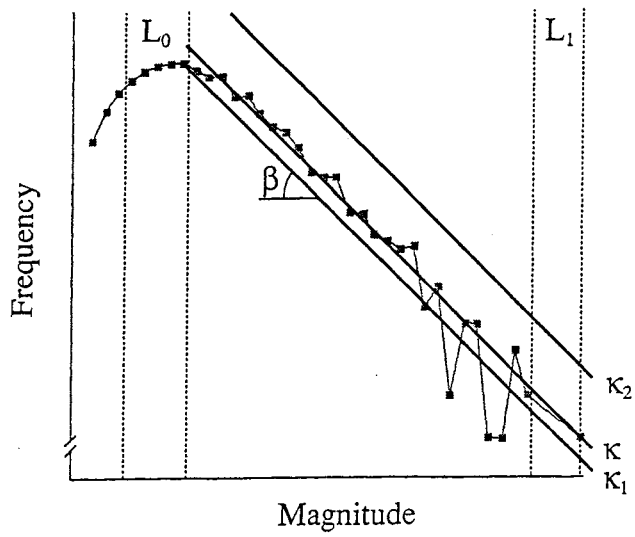
Landsliding involving bedrock dominates landscape evolution in mountain belts where weathering limited mass wasting is outpaced by rock uplift. We have used time series of airphotos to map landslides in the western Southern Alps of New Zealand. The surface areas of ~8000 mapped slide scars, ranging from 100 m^2 to 1 km^2, have yielded a very robust power-law magnitude-frequency distribution. Four variables constrain this distribution. They are the scaling exponent β, the rate constant κ, the lower length scale of the process L_0, and the upper length scale L_1. Additional studies of landsliding in the Central Range of Taiwan and the Finisterre Range of Papua New Guinea, using both remotely sensed data and field observations, serve to define the controls on each of these variables.



Our work, and independent studies from other regions in the Pacific Rim, suggest that scale invariance is a general property of landslides, probably with a globally uniform scaling exponent. The rate of landsliding may be considered at different time scales. At geological time scales, κ is controlled by the rate of rock uplift in conjunction with climate change. At shorter time scales, the probability distributions of landslide triggers, such as rainfall and seismicity, cause important fluctuations in the rate of mass wasting. The length scale at which transition occurs from local rock properties to bulk strength of the rock mass governs the lower length scale at which bedrock landslides exhibit scale invariance. The upper length scale of the process is constrained by the maximum local relief between valley floors and adjacent ridge crests.

MOJMÍR HRÁDEK

Zones of gravitational loosening on the convergent margin of the Bohemian Massif

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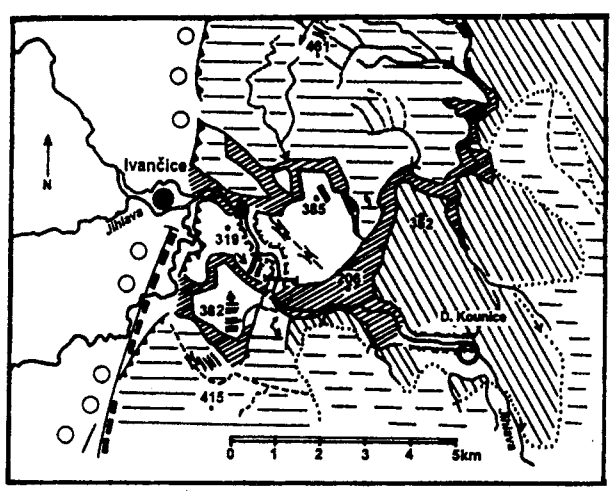
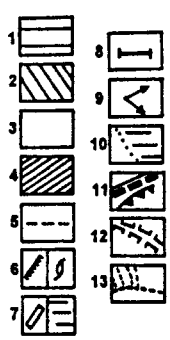
One of the aims of the project «The stability relations of supporting systems of bridges and tunnels in stress fields of gravitational loosening zones» [Gacr No. 103/95/1536] is the research of loosened zones at the southeastern margin of the Bohemian Massif, at the contact with the Western Carpathians. The massif margin has acquired convergent features after a collision with the Adriatic plate and the Carpathian-Pannonian microcontinent in Neogene. They got bent to form a flexure giving rise to collision foredeeps. The outer margins of the foredeeps were uplifted to form a forebulge with prevailing extensional regime. A typical feature of the tilted surface of the forebulge is block disintegration predestinated by the intensity of tectonic deformations in the course of the Variscan orogeny which, for its part, influenced the mechanical properties of igneous or metamorphic rocks and their cohesion in the course of the Alpine orogeny. In places of the forebulge built by the southern part of the Brno igneous massif (granodiorites and metabasites), the Late Miocene flexural bend has the form of a half-dome (1) consisting of partial blocks the dipping of which toward the southeast into the Carpathian foredeep is determined by antithetic faults (2). Zones of intensive failure accompanying deep-seated faults of the NW-SE, W-E and NNW-SSE directions passing across the Brno massif have been relatively subsided during the uplift, the less disturbed parts being relatively uplifted. In highly loosened zones of subsidence arose wide transversal tectonic valleys as the main feature of the block disintegration and tectonic loosening of the platform margin. In these zones became separated and downdropped the small blocks arising there (3). Those blocks which got separated as horsts from the uplifted parts of the forebulge by partial grabens (4) display vertical rotation along antithetic faults while the blocks that got separated by fault passes (5) rather undergo a synthetic normal-faulting towards the axis of the tectonic valley and tending towards filling it up. The partial blocs can be clearly delimited by geomorphological methods. The zones of deep-seated tectonic loosening in valleys constitute presuppositions for the process of creep of loosened slopes. Downward surfaces of segmented blocs are arranged steplike with quite a number of smaller gravitational landforms situated in stress fields of gravitational spreading (6,7). Downhill-facing scarps are located on inclined surfaces of middle slopes (a), tension gashes at the local divide between grabens (b), slope benches with backtilted surface tending towards the slope below the horst top (c) and multiple-crested ridges (not sagging) on the tops of horst ridges and its steps (d). Stability disturbance of bridge supports (8) in valleys are presented as related with gravitational processes. The depth of deep-seated gravitational tectonic deformations probably exceeds the depth of the valley, i.e. more than 200 m. The thickness of the rock mass affected by gravitational failures has been measured with the help of geophysical methods in the order of tens of meters.





Besides the above mentioned explanations are presented in the figure some other features important for the problem under question. They are as follows : 9. Prevailing directions of extensional stress; 10.Contact of tilted blocks with the Miocene sediments of the Carpathian foredeep; 11. Front of the forebulge; 12. Parts of the valley on the contact of two blocks; 13. Valleys on tension cracks.

FRANCIS HUGUET

Haute Ardenne et Hunsruck: Contribution à la question des *Piedmonttreppen* dans l'Europe varisque

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De part et d'autre du Golfe de Luxembourg, l'Ardenne et le Hunsrück montrent un dispositif géomorphologique étagé, de type *Piedmonttreppen.* Les vestiges d'une haute surface d'aplanissement S_1 (dominée par de lourdes coupoles résiduelles en Haute Ardenne et par des crêtes quartzitiques dans le Hunsrück) dominent par l'intermédiaire de talus cycliques, une basse surface S_2 d'une grande perfection, la plate-forme ardennaise. La surface supérieure dériverait par regradation de la pédiplaine permo-triasique tandis que le ploiement de S_1 porte témoignage de bombements à moyen rayon de courbure imputables aux premières manifestations de la tectonique alpine (phase pyrénéenne?). La pédimentation mésonummulitique aurait façonné la surface S_2, comme le suggèrent les données paléoclimatiques régionales et l'évolution géomorphologique des autres massifs anciens européens. Dans le Hunsrück, la dureté et l'épaisseur du quartzite du Waunus sont à l'origine d'un relief appalachien plus vigoureux qu'en Oesling ou en Haute Ardenne.

OLE HUMLUM

Rock glacier observations in Greenland

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Rock glaciers are located at the foot of free rock faces and take the form of 20-100 m thick tongue- or lobe-shaped bodies covered by coarse debris, often displaying a 2-5 m high transverse furrow-and-ridge surface topography. When active, rock glaciers flow 0.1-1 m per year, that is, considerable more sluggish than normal glaciers do. The term rock glacier is used below in this descriptive and non-genetic meaning. Rock glaciers are present in many cold-climate mountain regions and are often seen as characteristic features for continental mountain areas, although several rock glaciers have been described from maritime regions. Opinions as to their genesis are divided; some authors claim a non-glacial (periglacial), others argue that several examples of rock glaciers are glacier-derived, while other scientists suggest a landslide origin for some rock glaciers. During the last few years, several discussions on rock glacier origin, internal structure, rheology and nomenclature have originated from this diversity.

With these discussions in mind, surface and interior characteristics of a tongue-shaped rock glacier at Mellemfjord on Disko Island, central West Greenland, are described. Rock glaciers, common on Disko Island, encompass small lobate forms perched along valley walls and larger tongue-shaped forms that emanate from cirques. Along the southern shore of Mellemfjord numerous rock glaciers are present, tongue-shapes as well as lobate rock glaciers. Most rock glaciers are rather small, less than 200 m in length (measured parallel to the flow direction), but some are large, 1-2 km in length. One large tongue-shaped rock glacier was chosen for a more detailed study concerning the internal structure. This rock glacier, which originates in a deep cirque and terminates close by the coast, is about 1700 m in length, it measures about 500 m across, and is about 90 m high at the front. At this rock glacier a 500+ m long natural section shows the existence of a solid ice core. The implications for the origin of ice within the rock glacier and its surface debris layer are discussed and, from this, the rock glacier age is estimated to about 550 years, that is, it was probably initiated during the initial period of the Little Ice Age. It is suggested that the climatic control on especially ice cored rock glaciers are more pronounced than traditionally assumed. It is suggested that although the geomorphological feature described display many characteristics of a normal glacier, it should be classified as a true rock glacier. The above type of rock glacier is widespread on Disko Island.

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Large landslides triggered by caldera collapse events in Tenerife (Canary Islands)

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Large landslides are significant processes on volcanic edifices and can exceed several cubic kilometres in volume. The causes of such enormous mass movements and the relationship between landslides and volcanic activity is still poorly understood. Landslide events are an important factor in the evolution of volcanic island like Tenerife. Subaerial and submarine processes related to landslide events strongly control the morphology of the island.

In Tenerife there are three important valleys, the valleys of Güimar, Orotava and Icod, which have been created by various large landslides with ages ranging from Upper Pliocene to Middle Pleistocene. The landslides occurred during the construction of a central volcanic edifice, Las Cañadas. The Las Cañadas edifice has undergone several constructive-destructive cycles with at least three caldera collapse episodes during its formation.

We have focused our studies on the potential of caldera collapse events as a triggering mechanism for the initiation of landslides in Tenerife. Using a Geographic Information System (Gis) we have analysed various geological and morphologic models established by field geology, subaerial and submarine geophysical data and remote sensing information. Supplementary data on dyke trends, eruption vents and extension of pyroclastic deposits has been linked to the models and improved our understanding of the volcanic influence during the genesis of the island. The information obtained has been incorporated into a numerical model, which simulates a caldera collapse with its phases of pre-eruption tumescence, vertical collapse and associated explosive eruptions. We have calculated the stability of the volcano flank including the horizontal stresses in the changing stress field, the fractures inside the updoming area and the seismicity produced by the vertical collapse.
The results of Gis and numerical models indicate that fracturing, horizontal tensile stress and seismicity caused by caldera collapse can surpass the stabilising forces of a volcano flank and trigger a landslide. Therefore we propose that the caldera collapse events have also triggered large landslides on the previously weakened slopes of the Las Cañadas edifice.

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Simulation of possible climate change effects on soil water content

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The Epic (Erosion Productivity Impact Calculator - Sharpley and Williams, 1990) is applied to estimate soil water content consequences of the expected regional climate changes in a typical subcatchment, the Pécsely basin (24 km^2), selected for study on the northern catchment of Lake Balaton, according to climate scenarios (Mika, 1988). The study is based on the soil hydrology parameters included in Epic model, exhibiting relatively fast response to the climate variations. To specify regional climate scenarios for Hungary with a coarsely time resolution, two approaches are employed. The simpler one is the use of a geographical analogy which presumes correspondence of differences in monthly variance and even the daily behaviour to the established differences in the long-term means that correspond to the scenario. Based on this concept, climate data of Pápa (N of Lake Balaton) were selected as geographical analogues for the expected changes in the Pécsely basin, also considering the necessary similarities in the non-climatological conditions. The second approach is a search for statistical connections between semiannual and monthly anomalies, and also between monthly anomalies and daily statistics within the same month. For generating daily weather sequences, the built-in generator of the Epic is used. Results of the two approaches are compared. Climate differences generate considerable variation both in the soil water content and transpiration. Another source of variation is crop-rotation, responsible for the half of standard deviations.

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Sea floor engineering geomorphology: some recent achievements and future directions

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The development of coastal and offshore resources, such as oil and gas and minerals, involves sea floor engineering in remote, complex, and sometimes hazardous environments. New mapping technology is revealing that the world's ocean floors exhibit wide variety of relief, sediment properties, and active geologic processes such as erosion, faulting, fluid expulsion and landslides. Optimum engineering design and construction practice require detailed surveys of sea floor geomorphology, and geologic conditions on the sea bed and to various depths beneath it, combined with geotechnical properties of the sediments, and oceanographic information. Integrated site survey models attempt to predict conditions and process frequencies and magnitudes relevant to the engineering design lifetimes of sea floor installations such as cables, pipelines, production plafforms, as well as supporting coastal infrastructure such as jetties, wharves, bridges and harbours. Proper engineering solutions also contribute to sustainable development policy objectives by avoiding or minimising risk of adverse environmental impacts, particularly in coastal areas, where geoscience and engineering data are key inputs to Coastal Zone Management. Recent use of deep water areas for oil and gas production, pipelines and cable routes are also showing that the «frontier» regions beyond the continental shelves contain exciting, exotic and enigmatic geomorphological features and processes. Safe and cost-effective engineering use of these regions are requiring new technial and conceptual advances towards better understanding of sea floor geomorphology - tasks which have barely begun.

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Head scarps and toe heaves

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Where the historical archival record is poor, evidence of the temporal occurrence and frequency of mass movement must be derived from the identification and investigation of the landslides themselves. Inevitably, the geomorphologist must learn to recognise the significance of subtle elements of old landslide events, in order to correctly anticipate the necessary scope and scale of sub-surface geotechnical investigations.
Features described loosely as «head scarps» and «toe heaves» relating to a variety of landslide types are described in this paper, with examples drawn from small and medium size landslides. Accurate recognition of these features permits preliminary assessments of slip surface position and shape to be made using general guidelines. Related problems associated with graben geometry are also discussed, and the observations of Cruden & Thomson (1991) are extended.
It is often the case that the head scarp of a developing landslide is easier to distinguish than the toe heave. The reasons for this are discussed. The paper shows that the movements at both the head and toe of a landslide failure have virtually the same dimensions, indicating that the material has merely been displaced downslope.
Some of the results of this study explain the development of the composite landslide type termed a «slump earthflow». During the production of 'Landslide Recognition' (Dikau & *alii*, 1996), the authors came across the problem of defining the characteristics of a slump-earthflow. It was considered essentially a complex failure comprising an upper rotational section which extends into a mudslide. The reasons for this development are discussed in the paper in the context of the post initial failure of the toe of a rotational slide. The paper concludes with a number of observations on the degradation with time of head scarps and toe heaves, and the problems of assessing the temporal occurrence and frequency of movement from such geomorphological features.

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Les glissements de terrain de la Roumanie: étude de cas

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Les glissements de terrain se produissent dans presque toutes les regions de la Roumanie. La diversité des facteurs (la structure, les roches, les pentes, les defrichements, le degré d' humectation des dépôts), détermine des différences dans la répartition des glissements au niveau du pays. L'étude mis en evidence les regions ou les glissements ont une grande ampleur dans la modelation des versants (Les Subcarpates, le Plateau de la Moldavie, la Depression de la Transylvanie) et des regions ou les effets des glissements sont reduites (les plaines du sud et l'ouest). En fonction des types et de leur fréquence on distingue des regions avec une grande, moyenne et petite fréquence des glissements de terrain.

CATHERINE IMBANGULAYA IKHILE

Seasonal variation in water quality of Orle River Basin, S.W. Nigeria

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The Orle River Basin is one of the major River Basins providing both domestic and industrial water for communities around the northeastern fringes of South Western Nigeria. The seasonal variation in water quality of Orle River and its tributaries was based on samples obtained fortnightly from November 1987 to June 1988. The drainage basin is underlain by both Basement Complex and Sedimentary rocks. This geological difference in the terrains has been observed to affect the toxicity and other physico-chemical characteristics of the rivers within one season and from season to season.
The investigation revealed that true colour, total solids, chloride, sodium, biochemical oxygen demand (BOD_5) and dissolved oxygen (DO) vary significantly with seasonal changes. True colour, water temperature, taste, chloride, DO, BOD_5 and COD show increase in the wet season and decrease in the dry season. Conversely, air temperature, pH, total solids, sodium, potassium, calcium, magnesium, iron, aluminium, silica, nitrate, sulphate and total hardness show increase in the dry season and decrease in the wet season. The values of some of the parameters are beyond tolerable limits.
The degree of pollution observed in the rivers constituting the Orle River Basin is sufficiently significant enough to necessitate pre-treatment of the Basin water prior to domestic and industrial uses. Presently, the natives treat the water with alum before use, but this practice is not a sufficient biophysico-chemical treatment required to make the water safe for consumption.

ALEXANDER V. ILYIN

The world ocean floor relief evolution problem

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At present ocean floor relief development alongside the geological structure of the ocean floor as a whole are viewed from the two methodological standpoints. The first assumes the ocean morphostructure having been inherited from the spreading centres of mid-oceanic ridges (Mor). The second standpoint proceeds from heterogeneous origin of the oceanic morphostructure.
Distribution analysis performed on large sea mountains and oceanic rises attests that inheritance concept bears no grounds for this class of morphostructures. Mountains and rises 3-5 km in height are unique to deep-sea basins beyond the Mor area, and are nowhere to be seen at constructional boundaries of lithospheric plates. Selective distribution of large sea mountains and rises is correlated with the thickness of oceanic litosphere through the geochemical anomalies of magmatic rock, and peculiar features of the earth's crust magnetic field. Such relief forms occur on the thick litosphere marked by deep sea volcanism, undepleted Earth's mantle, alkaline magmatism, quiet magnetic field.
Oceanic morphostructure develops from primary formation of the massive volcanic relief on the thick Mesozoic litosphere to ensuing riftogenic relief of Mor. Evolution of the ocean floor morphostructure is determined by evolution of the earth's crust spreading from scattered to linear forms.

MOSHE INBAR

New trends in volcanic geomorphological studies

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Geomorphological processes in volcanic landforms have been reported traditionally by volcanologists analyzing volcanic events. Since Mount St Helen's eruption in 1980, there have been an increasing number of geomorphologists involved in the study of volcanic depositional material and dynamic processes in volcanic landforms. The evolution of landscape is a main theme in geomorphology and volcanic areas offer the opportunity to monitor landscape evolution from their beginning. Volcanic landscapes are characterized by two common features: there is a clear starting time of geomorphic development and the lithology is similar in the different climatic areas of the world. Volcanic morphology includes two main types of landscapes: basaltic and pyroclastic. Flood basalt plateaus composed of thick columnar jointed flows are characterized by deep incised channels into wide plateaus. In basaltic fields, sediment yield is low, permeability is high and erosion starts after a soil layer is developed on the lava flows. In pyroclastic areas, the rate of erosion is very high after the eruption stage and it declines rapidly with the developing of the fluvial system and increasing permeability in the pyroclastic material. Morphometric studies on cinder cones showed the possibility of establishing relative dating based on the erosional stages of the cones in different parts of the world. In all the sudied areas most of the declining trend of erosion rates was of several orders of magnitude during the first years after the eruption. Vegetation cover, soil development and integration of drainage systems are slower processes which may last hundreds or thousands of years. The erosional processes are affected by the different climatic conditions but are mainly determined by lithological factors.
Geomorphological studies carried on in different volcanic areas of the world, like the Canarias Islands, Mexico, the Southern Andes, Japan elsewhere are a promising basis for the developing volcanic branch in the geomorphological sciences.

IOAN AUREL IRIMUS & IOAN MAC

Les effets différenciés des structures des dômes dans la morphologie de la Dépression de la Transylvanie

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Les structures en dômes , représentant les plis de la mollasse néogène sont localisées dans les secteurs du plongement du soubassement de la Dépression de la Transylvanie où la couverture sédimentaire est très épaisse. La genèse des dômes représente un processus de longue durée, mais cet aspect invoque la possibilité que les unes de ces structures en dômes continuent leur évolution en présent. Le diapirisme tectonique c'est le phénomène qui explique la genèse des dômes en Transylvanie à côté du «jeu» des blocs du soubassement. La mobilité différencié du soubassement et de la couverture néogène (par le sel) est exprimée dans la morphostructure de la Dépression de la Transylvanie.
La sensibilité de processus de versants dans la configuration des grandes ensembles srtucturales et des mouvements néotectoniques mises en evidence par la nature des formes et par l'accélération de l'érosion ou de l'accumulation, représentent la modalité de surprendre le sens et l'intensité des mouvements qui ont généré les morphostructures et la morphologie de la Transylvanie.

MD. BADRUL ISLAM

Coastline morphology and its evolution in the Gulf of Cambay

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Forming a narrow entrant of the Arabian Sea, the Gulf of Cambay forms an important segment of the West Coast of India which divides the East Mainland Gujarat coast from

that of West Gujarat coast. It is characterized by a very high tidal range of approximately 12.5 m which in turn generates very strong tidal currents, constantly churn up the sediments from the shallow bottom, mix them up and depositing them along the gentle coast as well as at the bottom. The coastal areas of the Gulf are made up of geologically diverse rocks and provide a wide variety of landforms. These includes; recent mudflats, raised mudflats, salt-waste drylands, beaches, wave-cut platforms, rocky cliffs, recent coastal dunes, older dunal ridges, relict alluvial patches, river mouth bars and offshore banks, islands and point bars, alluvial cliffs and alluvial plains. The coastal areas on the Saurashtra side consists of landforms related to the Tertiary and Quaternary periods whereas the Mainland side the landforms are exclusively within the Quaternary deposits.
It is observed that the evolution of the coastal landscape of the Gulf of Cambay has been controlled by the factors of geology (structure and lithology), sea level changes, climatic variations (rainfall and wind) and strong tidal currents, which have acted in a variety of combinations giving rise to a wide variety of erosional and depositional landforms. The different combination of fluctuating sea level and differential tectonism along some major lineaments appear to be the factors responsible for generating contrasting landscapes.

ANTONÍN IVAN & KAREL KIRCHNER

Inselbergs in the eastern part of the Bohemian Massif, Czech Republic

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There are numerous isolated hills in the E marginal part of the Bohemian Massif and adjacent part of the Carpathian Foredeep, where they stand above unconsolidated molasse sediments. The hills are mostly composed of rocks of the crystalline basement, but the Paleozoic conglomerates, sandstones and limestones are also present.The hills have been explained as monadnocks, fault-block (horsts) or inselbergs. The problem of their origin, however, is very complex a no simple explanation seems to be admissible. The reason is longterm post-Paleozoic subaerial denudation and planation taking place in different climatic environments, accompanied by several marine transgressions resulting in burial and exhumation of landforms. The underthrusting of the Bohemian Massif towards SE below the Carpathian orogen (as result of plate collision in the Tertiary) was probably still more important. Owing to it, the whole eastern part of the massif subsided and was deformed into huge marginal flexure. In its downwarped part (today below the Carpathian Foredeep and flysch nappes), the Jurassic sediments buried an ancient probably Lower Mezozoic planation surface. On the other hand, in other places the Tertiary sediments under the foredeep and flysch nappes rest on weathered crystalline rocks of the Bohemian Massif from which oil is mined! The marginal flexure is complicated by narrow ridges composed of basement rocks. These ridges (upbulges, horsts ?) run parallel with fronts of nappes and some of their top parts, originally covered by the Miocene sediments, protrude above adjacent hilly country owing to subaerial denudation. Another complication on the marginal flexure are deep cross grabens trending NW (e.g. Nesvacilka Graben) filled by the Cretaceous, Paleogene and Neogene sediments. The block-faulted topography of small horsts and grabens is characteristic feature of these cross structures used by major rivers draining the eastern part of massif.
Thus, we can distinguish three topographic situations or relief types where the isolated hills occur:
1. low-lying marginal parts of the Bohemian Massif, as a upper part of the marginal flexure, with extensive parts of planation surface (stripped basal surface of weathering and roots of deep saprolite , up to 100 m thick, possibly of Cretaceous age). The isolated hills composed of granite or schists are believed to be true inselbergs;
2. top parts of longitudinal ridges in the Carpathian Foredeep. Both tectonic and erosional processes were possible mechanisms;
3. the Mezo-Cenozoic cross grabens penetrating as fault embayments into the Bohemian Massif. Some isolated hills seems to be true inselbergs (e.g. those composed of Devonian limestone with traces of fossile tropical karstification), other maintain their tectonic features.

MASARU KEN IWAMOTO

Geomorphological changes and hazard potential by eruption and debris discharge, Unzen Volcano, Japan

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The volcanic disaster at Unzen is the worst eruption in the modern history of Japan because it is located near the city and still continues the activity. In this disaster, pyroclastic flows were frequently generated by the fall of lava domes. Further worse, in a rainy day, debris flows easily occurred and damaged many facilities. However. these potential risk could be gradually predicted by the researches regarding to the characteristics of geomorphological changes. For instance, pyroclastic flow was predicted by the relationships among the earthquake, magma supply, lava dome growth and shape changes. On the pyroclastic plateau, erosion mechanism and river struggle were investigated by the decrement of permeability due to the volcanic ashes. Successively, the characteristics of debris flow was also simulated under the heavy rainfall conditions in a short period of time, and clarified the mechanical difference from pyroclasic flow. Since then, the evacuation system and countermeasures were alternatively conducted by using these geomorphological changes and hydrological conditions, namely the evacuation system for pyroclastic flow was strongly arranged in the midstream and the warning system for debris flow was arranged especially in a rainy day.

NANCY L. JACKSON[1] & KARL F. NORDSTROM[2]

Evolution of the developed shoreline of New Jersey, USA

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This study examines the effects of human actions on the physical evolution of the shoreline of New Jersey, USA. The objectives are to: 1) explain the changing physical attributes of coastal landscapes over large spatial scales (tens of kilometers), and long temporal scales (decades); 2) determine if there is a clearly identifiable pattern of evolution for coastal segments modified by human action; and 3) determine whether coastal storms or human actions are the dominant agents of landform evolution.

Geomorphic changes are examined by comparing the dimensions, configurations, topography, surface cover and mobility of representative coastal barrier systems prior to major human occupancy with conditions on subsequent maps and aerial photos that represent stages in evolution from natural to human-altered systems. Geomorphic settings at the end of discrete time periods are constructed and linked to public and private investment decisions, policy decisions, changes in land use practices, and growth patterns in communities identified in public documents and historical narratives. Classification of geomorphic assemblages during discrete time periods is accomplished through multivariate analysis of variables measured from aerial photographs, bathymetric maps and shoreline change maps at each of the three representative study reaches in the state. Assessment of storms includes both the short-term effects of storms and the long-term effects of restoration efforts as well as the susceptibility of the human-restored landscape to change in subsequent storms. Variables include dune width, height, volume, and crestline location; flood levels and debris lines; grain-size characteristics of deposits; depth of overwash sediments and bulldozed sediments; volume of sediment removed from streets, yards and driveways; internal structure (by trenching) and surface characteristics (natural and exotic vegetation, pavement) of landforms.

Results indicate a sequence of human alterations, including: 1) construction of the first buildings on the upland portions of the barrier islands at inlets and at locations where railway lines from the mainland first made contact with the barriers; 2) appearance of new isolated communities, with subsequent growth outward from these locations (both alongshore on the upland portion of the barriers and bayward onto the marsh surface); 3) grading of dunes to a flatter form to facilitate construction of buildings and roads; 4) filling of the marsh behind the upland on barrier islands; and 5) dredging of channels into the backbarrier marsh to accommodate boats. The sequence of development observed at the locations that developed early was followed at later time periods on other shoreline segments. Analysis of storms indicates that these events can have limited effect in re-establishing a natural coastal resource base of lasting significance because reconstruction of coastal landscapes by human action may be more rapid than natural restoration, decreasing the likelihood for geomorphic features to develop based on natural processes.

ALAN M. JACOBS[1], ANN G. HARRIS[2] & IKRAM U. KHAWAJA[2]

Using topographic indicators to prevent environmental damage from mine subsidence

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Natural landforms over glaciated and non-glaciated, upper Carboniferous (Pennsylvanian) terrain have been altered by both strip and underground coal mining in the northern Appalachian plateaus. Alteration of the landscape can adversely affect the environment for both strip and underground coal mining, but changes from underground mining produce environmental effects that are, in many cases, not anticipated or even recognized by non-geomorphologists. As a result, environmental hazards are not slated for remediation, reclamation, or proper design of structures or infra-structure to be built above the mined-out areas. This is especially true of land above room-and-pillar mining (as contrasted with longwall mining), where room and pillar collapse has been delayed decades after mining takes place.

Subsidence can be subtle in the Appalachian plateaus, especially if the mining depth is greater than 30 meters and where the coal seams are commonly only one to two meters thick. Cases where a stream has changed its course and where a rider on horseback was swallowed up, as was reported in Virginia for gypsum mining of beds 50 meters thick, get immediate media attention. Nevertheless, unsensational topographic effects from subsidence over mined-out coal have significant environmental consequences. Subtle topographic effects include the development of 10- to 150 centimeter troughs and closed depressions and increased fracturing in the near-surface bedrock.

These subtle topographic changes produce damage to buildings and highways, leakage of mine drainage (of low pH) to surface streams and ground-water aquifers, triggering of landslides, rupturing of sewage and pipelines, rupturing of underground and aboveground storage tanks, draining of wetlands, and disturbance of wildlife habitats.

The geomorphic processes that exacerbate the subsidence effects include piping of surface runoff into cracks and troughs, slope instability, increased erosion, increased rates of physical weathering, and increased rates of chemical weathering in areas of acid-mine drainage.

Field techniques that identify topographic changes from mine subsidence include air-photo interpretation, contour mapping, and mapping of changes in vegetation patterns,

landslides, and disruption of drainage. All these data are best evaluated using a geographic information system (Gis), where the topographic indicators along with other data can be located and superimposed. Data from thousands of abandoned mine locations have been evaluated in this manner. The results indicate that subtle topographic anomalies can identify potentially harmful impacts to the environment. Locating these anomalies leads to cost-effective, subsurface investigations and elimination of the environmental hazards.

DIETER JÄKEL

The formation of network and «*Kessel*» dunes in BWk deserts (Gobi)

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In September and early October 1995 we succeeded in crossing the Badain Jaran Desert in Inner Mongolia (China) four times (this desert is roughly the same size as Switzerland.) We had to cross >400 m high mega-dunes, composed of «dune ranges», aligned from southwest to northeast, separated by «interdune corridors». Such dune ranges are generally chains of star dunes; network and *Kessel* dunes occur on their flanks and in the interdune corridors. These secondary dunes consist of third-generation dune sands superimposed on the mega-dunes, i.e. recently and presently mobile loose sand overlies second-generation sand layers, which have a higher percentage of clay and silt and hence contain more moisture. The pattern of the secondary dunes shows that they were formed by multidirectional wind regimes.

Crossing the Badain Jaran Desert was made possible, or at least facilitated, by the fact that 1995 was a relatively rainy year. Records show six days with heavy zonal, monsoonal and cyclonic rainfall. The depth of moisture in the dune sand and the infiltration behaviour of rainwater were measured. Unique photographs were obtained because erosion of the uppermost sand revealed the internal structure of the mega-dunes, and the varying sand moisture resulted in unusual colour effects. Observations of wind circulation patterns after rainfall events helped to explain the formation of the network and *Kessel* dunes. It was discovered that the main controlling factor is the varying mobility of dry and wet sand. As soon as corrasion and deflation processes reached deeper, still-dry dune layers, hollows were blown out. The overlying wet layers subsided and their edges dried more quickly owing to greater exposure to the wind. Doline-like depressions were formed, which are the initial formation stage of either network or *Kessel* dunes, depending on local circulation patterns. Hence the decisive factors influencing the formation of such dunes are, first, the complex infiltration processes of rainfall entering dune sand and, second, the varying erodibility of dry and wet sand. This process is intensified during the winter months because the wet sand layers are then frozen.

OLEKSA JAKUBSKA

Tendencies of evolution of carbonate mid-mountain slopes. The Western Tatra Mts

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The area of investigation in the Polish Tatra Mts. is located in the limits: from the Mala Laka Valley to the Bystra Valley, below the upper forest belt. The analysed area, with features of a periglacial relief, is currently formed in the conditions of temperate cool and cool climate. In the carbonate rocks which outcrop there, four types of slopes have been recognized: near-vertical wall scars, rock slopes, rock-debris slopes, often termed mantle rock slopes, and scree slopes. Mantle rock slopes of poligenetic structure represent the commonest relief element.

The mechanical, mineralogical and petrographic compositions, and $CaCO_3$ content of the rock debris material were determined: Sarnia Skala, Dolinaza Bramka. The graphs of grain-size frequency distribution, grain-size statistics and $CaCO_3$ content are shown for using a laser. The values of the grain-size statistics, mean, standard deviation, skewness and kurtosis, have been determined using Folk and Ward's (1957) formulas. The material studied shows a considerable differentation of its mechanical composition in the individual slope sections, However, a boulder-gravel, poortly rounded fraction predominantes in each site. Slope deposits show weak and rather not much differentiated sorting, and positive, sometimes very positive skewness. The mean values are differentiated and irregularly distributed along the whole profile. It is assumed that the granulometric variation of the deposits results from the climatic-vegetational changes during late Pleistocene and Holocene. The material studied shows different content of the $CaCO_3$ in the individual fractions. The largest concentration of $CaCO_3$, occurs in the boulder-gravel fraction and it gradually decreases towards the smaller fractions. This relationship is very clear along the whole slope profile.

Gravitational processes, modelling mantle rock-debris slopes are the major ones-mainly of temperate activity including soil-debris creening and land sliding. Rocks-debris slopes are also modelled by outwash and mid-cover flow: the share of the processes, mainly temperate ones, is similar. The investigated groups of processes occur in majority in lower and middle parts of slope surfaces, located at the altitude 1000-1100 m a.s.l. with slope inclination 35-55°, exposed towards west or east; sliding and gravitational accumulation occur there also. The complete results of investigations were presented in a graphic form, as computer graphic programmes were applied.

The above analysis enabled to determine the share of particular processes in current transformation of the mid-mountain subsystem. Similar investigation have never been

carried out in this area. The above mentioned problems are the subject of further investigations.

ALLAN JAMES

Time and the effectiveness of alluvium: river engineering, fluvial geomorphology, and mining sediment in California

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River managers need to understand a fluvial system as it has changed and continues to change through time. Many modern river systems are presently in a state of flux due to substantial human-induced changes to water and sediment regimes and the hydraulics of channels. Yet, historical approaches to understanding river systems rarely receive adequate attention because historical methodologies are not conducive to the application of quantitative analysis such as numerical modeling. While there is a loss of precision in using most historical reconstructions, the information derived from these studies is essential to a full understanding of the behavior of fluvial systems.

This study presents examples of channel morphological changes brought about by two episodes of sedimentation from hydraulic gold mining. The primary event was the production of more than 1 billion m^3 of sediment from 1853 to 1884 which caused massive aggradation across the Sierra foothills and Sacramento Valley. Modern notions that geomorphic responses to this event were relatively ephemeral are not borne out by field and historical data.

The assumption that sediment loads have returned to previous levels and that deposits have stabilized is not supported by empirical evidence. A secondary sedimentation event, not previously studied, was the production of about 24 million m^3 of sediment during a period of licensed mining from 1893 to 1953.

This episode of sedimentation has been largely overlooked as a geomorphic, hydrologic, or water quality event. Yet, channel morphologic responses in phase with mining during this period are demonstrated in the Sacramento Valley.

MANTU M. JANA

Application of remote sensing techniques to study fluvial processes and associated landforms in the Terai of north Bengal, India

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The Terai of North Bengal lies between the mountains of the Himalaya and the plains of North Bengal. Geologically, it is a short of neutral country, being composed neither of the alluvium of the plains nor of the rocks of the mountains but most part of alternating beds of gravels, sands and boulders brought down by the numerous mountain rivers of the Himalaya. After cutting across the ridges, these rivers debouch into the Terai and carry huge load of sediments both in suspension and traction. Most of these bed loads are deposited as fan deposits. Moreover, gradual rise of river beds has resulted in severe bank erosion and causes overflow. The shifting or rivers from west to east in this region is due to tectonic activities in the recent past. As a result, numerous abandoned channels with various degree of aggradation in both older and the present flood plains, palaeo-channels, cut-off menders and ox-bow lakes were formed in different parts of the Terai.

The major agency shaping the morphology and landforms of the Terai is fluvial. A number of terraces composed with unassorted rocks which owe the origin to river action are found on both sides of major rivers and these are identified on satellite imagery. There are many extensive outwash gravel plains and piedmont plains in the Terai. Terraces of the Tista river are originated due to glacial or glacio-fluviatile processes. A number of marshy areas were formed due to channel instability. The geomorphic processes accompanied by tectonic movements have produced rugged hilly tracts, dissected slopes of hills and rejuvanated valleys. The nature of Quaternary sediments indicates the process of glacial activities in the past. The region experienced a multicyclic landscape due to varied soils, complex drainage systems and under fluvial and fluvio-glacial environments. The landscape in the region is most complex and such complications are influenced by neo-tectonics, variation of physio-chemical processes and climatic characteristics. Various fluvial landscapes in the region were sculptured by the fluvial actions in the recent past and the modifications are still going on to form the present landscape. Now-a-days, remote sensing techniques are most important tools for study the fluvial processes and resulted landforms in such a region like Terai of West Bengal.

JACEK JANIA

Linkages between dynamics of the hans glacier (Spitsbergen) and morphology of its marginal zone

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Differential dynamics of a tidewater glacier and geomorphic consequences in relief of its marginal zone has been studied. The Hans Glacier (57 km^2) is one of the best studied glaciers in Spitsbergen (Svalbard). Glacier velocity and front fluctuations has been surveyed by terrestral photogrammetry several times a year since 1982. Classic field geomorphological mapping and interpretation of aerial photos have been used for analysis of the spatial distribu-

tion of particular types of landforms. Relief of the submarine forefield of the glacier has been studied using sonar sounding. Frontal part of the glacier can be divided into three dynamic zones:

1. one zone of tension flow of ice stream ending down to the sea in the calving cliff with high flow velocity and distinct annual oscillations of the front position,
2. two zones of compression flow of the lateral part of the glacier terminated on land with low velocities and slower recession when compare to (1),
3. narrow transition zones between the both mentioned above.

The compression flow zone (2) can be devided into two subzones: (2a) where flow vectors are normal to the glacier front and (2b) where directions of vectors are oblique to the glacier edge.

Submarine annual push moraines and contacts fans are associated with slow winter advance and summer fast retreats of the calving cliff in the tension flow zone. Humocky moraine, characteristic for compression zone 2a and enlongated ice-cored humocks with crests oriented parallely to the glacier edge, represents zones of 2b. In narrow transitional zones (3) one can note fluted moraine and small annual moraines.

A model of sediment transfer and deposition rate in particular dynamic zones is developed basing upon flow velocity measurements and data on summer ablation near the glacier front (including the ablation by calving as well).

GRZEGORZ JANICKI[1] & WOJCIECH ZGLOBICKI[2]

The conditions of development of episodic channels in loess areas of the Lublin Upland (SE Poland)

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Nowadays in the area of loess uplands of Central Europe one can observe changes of conditions of functioning of geomorphologic systems. These changes are a reaction of the natural environment to human interference which upsets the balance of nature. In particular, agricultural activity which has lasted since the Neolithic Period contributed to almost total degradation of natural flora (mixed and deciduous forests) by giving considerable forest areas over to agriculture. The lack of flora in transitional seasons (spring, autumn) in agrocenosis of the temperate zone is the reason why these terrains, which are occasionally called «a cultural steppe», are modelled in a way similar to that occurring in the regions of semi-arid and cold zones.

Poor flora or its total absence favours fast forming of outflows and rapid surface flows of water, the energy of the latter being considerable. This shows in a particularly distinctive way during episodic phenomena such as violent rainfalls and flows of melted snow which lead to considerable reshaping of the existing relief forms and the origin of others (e.g. ravines). A single outflow can reach the level of 10-15 $m^3/s*km^2$. On loess uplands such phenomena repeat themselves every 30-50 years.

A characteristic feature of the Lublin Upland landscape is the occurrence of wavy plateaus with relative heights reaching 20-40 m. Branching erosive-denudative dry valleys are typical elements of relief in this area. Their bottom is flat and accumulative, its width reaching 50 m, its slope 1°, and its length up to 2 km. The area of drainage basins in dry erosive-denudative valleys reaches 2-3 km^2.

Episodic channels belong to the most interesting structures which form during violent rainfalls and thaws. The shape of these forms resembles that of river-beds. They are formed as a result of outflow concentration at the bottom of dry erosive-denudative and basin-shaped valleys. Episodic channels are therefore shaped by the same group of processes as flat-bottomed temporary valleys (wadi) in the semi-arid zone. One can distinguish two basic types of episodic channels: erosive and transportive-depositional. The character of the channels depends of the degree to what the terrain is covered with flora. In areas which are ploughed or are used for growing root crops erosive channels develop. These are shallow (0.1-0.15 m) and broad (2 m on average) forms, the indicator of channel shape w/d = 20. Erosive channels develop in the ploughing layer (about 0.2 m). Evorsion forms, which are 0.2-0.9 m deep, occur in their bottoms only sporadically. Where the flora is relative rich (crops, grass) material is deposited at first (considerable roughness of subsoil) [depositational channels]. Subsequently, when the speed of flows increases, the flora is laid, which causes a step decrease in roughness of subsoil (transportational channels). Where the inclination is diminished (local erosive bases, valley mouths), material is deposited among blades and stalks of plants (depositational channels). Flows in episodic channels which develop on loess uplands of south-eastern Poland reach the average level of 1 m^3/s (maximum 2-3 m^3/s), the average speed of flows being 1.5-1.8 m/s. The above-mentioned flows in episodic channels whose drainage basins have the area of the few hectares are comparable with flows of rivers whose drainage basins area is 300 km^2. Such high flows which are created during episodic phenomena last only for 2-3 hours.

Seasonal changeability of conditions of development of the forms under discussion is connected with human activity (anthropogenical factor). It manifests itself in a temporal lack of flora on plough-land. Therefore, episodic channels are usually formed in autumn or spring. Despite the fact that episodic channels develop in the same places every few years, they are not long-lasting forms. They are destroyed rather quickly as a result of ploughing.

Episodic channels are in a strict connection with episodic phenomena which, as the research shows, belong to factors that decide on the morphology of loess uplands of the temperate zone. Above all, they initiate the creation of new forms of configuration. The above facts confirm the opinion that episodic phenomena play a leading role in the contemporary development of relief in the areas under discussion.

JOHN D. JANSEN & GARY J. BRIERLEY

Late Holocene superfloods and riffle-pool morphodynamics in an arid zone gorge, Barrier Range, Australia

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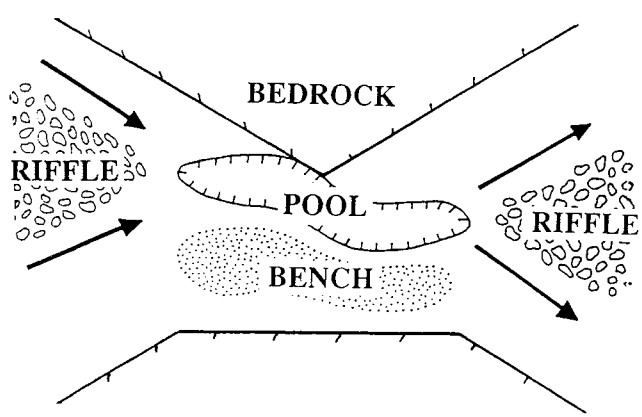
Riffle-pool landform assemblages provide useful insights into river behaviour and history in arid zone bedrock-confined valleys. Rather than simply focus on the magnitude and frequency of individual 'superfloods' through time, this study characterizes process-form relationships over the full spectrum of flow magnitudes: from superflood boulder-trains of imbricated clasts >2m in diameter, down to low-energy mud facies in ephemeral waterholes. Detailed stratigraphic and sedimentologic analyses, combined with radiocarbon dating have revealed an 1800-year alluvial history characterized by event-driven disequilibrious behaviour: three major erosional flood-episodes interspersed by long periods of relative quiescence and fine-grained sedimentation.

Sandy Creek gorge dissects a 60 km^2 upland catchment on the north-eastern flank of the Barrier Range in arid far western New South Wales, Australia. The well defined riffle-pool sequence strongly reflects structural control. A string of ephemeral pools (waterholes), each occupying valley constrictions 30-40 m wide correspond to resistant bedrock obstructions. Pools lie within convergent flow-scoured troughs up to 4.5 m below adjoining riffles and comprise bed materials of coarse sands and granules. Riffles are situated in flow-divergent valley expansions 60-80 m wide, marked by lobate boulder bars with median clast-sizes of 0.2-0.4 m, although some imbricated boulders exceed 2.5 m in diameter.

Geological structure, as expressed by valley width and bed slope has produced a repeated series of landform assemblages along the gorge - all fixed within the riffle-pool framework (see figure below). Adjacent to each pool, fine-grained benches lie inset within the coarse-grained flood plain and riffles. In accordance with accepted riffle-pool hydrodynamics, these pool reaches are preferentially scoured during large floods, but tend to aggrade during low flows. Bench stratigraphy holds a record of cut and fill episodes dating back to the last superflood clear out (>1800 a), when extreme bed shear stresses (>500 Nm^{-2}) generated would have destroyed benches and caused scour to bedrock.



Bench excavations reveal a marked consistency of sedimentation: the contemporary channel carries coarse sandy gravels, and lies entrenched within a relict mud facies which is now buried by actively aggrading (post-European) benches narrowing the channel. The muds are no longer accumulating in the upland valleys, but formerly accreted on well vegetated pool floors in periods of catchment stability between major floods. The muds are derived from extensive late Pleistocene aeolian mantles, now largely stripped from the steep slopes and stored in valley fills and piedmont fans. Accelerated bench construction and the depositional shift in pools probably reflects the increased rates of runoff and sediment supply apparent since the invasion by European pastoralists in the 1870's.

Landform assemblages along Sandy Creek gorge reflect an hierarchy of stability and activation by events of widely disparate magnitude and frequency. Active benches are juxtaposed alongside very stable boulder riffles which lie essentially dormant for many decades or even hundreds of years. Morphologic change is dominated by rare, high magnitude events that leave strong imprints on the landscape and constrain subsequent processes.

EMMANUEL JAURAND

Comparaison de l'altitude minimale des cirques glaciaires entre les Préalpes françaises du Sud et l'Apennin septentrional

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Les Préalpes Françaises du Sud et l'Apennin Septentrional (Italie) sont des moyennes montagnes méditerranéennes de même latitude (44°N) , situées de part et d'autre du Golfe de Gênes. Les cirques glaciaires hérités se situent à des altitudes minimales fort contrastées entre ces deux ensembles montagneux.

Dans les Préalpes Françaises du Sud, les plus bas cirques s'observent sur l'ubac de lignes de crêtes de 1900 m d'altitude environ : ainsi à la Montagne de Lure, au Mont Ventoux, ou dans les Alpes Maritimes. Il faut dépasser 2100 m pour voir se dessiner les premiers cirques dans les Préalpes de Digne, plus éloignées de la mer. Au Nord de l'Apennin, des cirques ourlent l'ubac des lignes de crêtes à des altitudes bien inférieures : 1700 m dans l'Apennin de Modène, 1600 m dans l'Apennin de Parme, 1500 m dans l'Apennin ligure et 1350 m dans les Alpes Apuanes. Dans ce dernier massif, véritable barrière dressée en arrière du rivage ligu-

rien, il existe même des cirques exposés plein sud le long de lignes de crête de 1600-1700 m. L'intensité de l'englacement est aussi attestée par des vallums situés jusqu'à moins de 700 m d'altitude (5 cas) alors que le plus haut sommet est de 1956 m.
Si l'on suit la «méthode des sommets» (*Vergletscherungsfläche*) qui consiste à rechercher l'altitude minimale des crêtes ayant permis l'alimentation glaciaire, il existait donc un décalage de l'ordre de 400 m en moyenne entre la position de la limite des neiges permanentes au-dessus des Préalpes Françaises du Sud et de l'Apennin Septentrional. La valeur plus basse de l'ancienne limite des neiges au-dessus de l'Apennin Septentrional est en accord avec la répartition actuelle des précipitations. Il tombe 1228 mm par an au sommet du Mont Ventoux contre plus de 2000 mm sur les sommets de l'Apennin ligure ou de celui de Parme, et même bien plus de 3000 mm sur le coeur des Alpes Apuanes. Ces abats d'eau de l'Apennin Septentrional s'expliquent par sa position de première barrière montagneuse face aux flux humides de SW associés à l'aire de cyclogenèse du Golfe de Gênes. Les analyses palynologiques confirment la nuance humide voire «océanique» du climat du maximum glaciaire du Würm récent : une sapinière pure recouvrait la plaine côtière au droit des Alpes Apuanes englacées.

LAWRENCE K. JEJE

Landuse changes and sediment yeld in parts of central Western Nigeria

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12, 3rd order basins were randomly selected from an area of similar geology (quartzite-quartschists) and relief (ridge and valley topography) in parts of Central Western Nigeria noted for upland rice cultivation which has involved the virtual transformation of a dry rain forest into contiguous farmlands. The basins were monitored for 1 year with emphasis on runoff and sediment yield.
The six forested basins had 55-81% forest cover while the farmed basins had 56-89% farm coverage. All the streams were perennial. The farmed basins had significantly higher values of specific suspended sediment yield at 3.7-46.5 tkm-2yr-1 and an average of 23.5 tkm-2yr-1 than the forested basins at values ranging from 0.9 tkm-2yr-1 to 14.0 tkm-2yr-1 with an average of 6.6 tkm-2yr-1 of which 54.82% were produced by Q1 storm runoff in contrast to the farmed basins where most of the suspended sediment yield were associated with Q10 and Q50 discharges.
Solute load was 0.75-15.9 times suspended sediment load in all thebasins, averaging 7.91 times in the forested and 2.03 times in the farmed basins. Specific solute load varied from 6.0 to 28.3 tkm-2yr-1 averaging 18.05 tkm-2yr-1 from the forested basins and 6.7 to 42.6 tkm-2yr-1 and averaging 19.65 tkm-2yr-1 in the farmed basins.
With a mean of 26.8 m3 km-2yr-1 denudation rate is significantly less in the forested than in the farmed basins with a mean of 41.35 m 3 km-2yr-1(cf. Douglas 1967 a & b, in the Cameron Hills of Malaysia).

VIBHASH C. JHA & U.K. MANDAL

Geo-engineering mapping of the Saintoli Gad Basin, Garhwal Himalaya

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In this paper, an attempt has been made to prepare a geoengineering map of the Saintoli Gad basin, Garhwal Himalaya, India. The Geoengineering map of basin warrants geographical investigation for three main aspects, namely: (i) existence of the drainage basin in the physical environment, (ii) its relation with various geomorphological processes, and (iii) its significance for human use. The drainage basins are mainly characterized by geo-engineering properties. Keeping the above facts into consideration the Saintoli Gad has been mapped.
The engineering properties such as landforms, rock units, tectnics, soil units and geomorphic processes (mass-movement and erosion) have been examined. The investigation also examines the joint spacing and rock mass strength of various rock types found in the basin.
After superimposition of all above data, a geoengineering map for the Saintoli Gad has been prepared. It is noted that the basin is characterized by four terrain stability units such as low, medium, high and very high, characterized by joint spacing of 5-10, 10-25, 25-50 and 50-100 cm and compressive rock strength of 650, 1100, 1350 and 3400 kg/cm^2 respectively. Applications of this map have also been discussed.

PETER JOHANSSON

Geomorphological evidences for the age of the esker chains in NE Finnish Lapland

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In the northeastern part of Finnish Lapland, at least three crossing esker systems of various ages exist, two of them till-covered. Weak glacial erosion and deposition prevailing in the Weichselian ice-divide zone have made possible the preservation of old esker ridges. These esker systems

include long ridges and isolated esker hummocks as well as erosional landforms, such as channels, bare-washed rocky slopes of hills and even gorges crossing water divides.
By aerial photo interpretation, geomorphological and stratigraphical studies it was possible to determine the age relations of these systems. The esker chains without a till cover are the youngest ones, because they cross-cut the other esker systems. They have been deposited in subglacial meltwater systems flowing in a fan-like pattern. In the southern part of the ice-divide they run from WNW to ESE (equals the flow direction of the meltwater that deposited the esker chain). In the central part of the ice divide they turn to a west-east direction and in the northern part from SW to NE. These meltwater systems were formed under the marginal zone of the receding Late-Weichselian ice sheet. The eskers vary in size from over 25 m high gravel and sand ridges with steep flanks to only a few metres high stony and gravelly mounds. The sediment is loosely packed and the walls of the gravel pits collapse readily. The esker ridges are often separated by distinct erosional forms, like subglacial gorges, where the meltwater action has eroded all surficial deposits away from the bedrock.
The two till-covered esker systems predate the latest deglaciation. The till cover is about 40-70 cm thick, and was formed either during the latest glaciation or during the previous one. The eskers that were deposited from the northern or north-northeastern direction, are small, only 5-15 m high, generally continuous ridges. An abundance of morphological details have been preserved such as steep ridges and kettles, ice-contact landforms and parallel ridges. Erosional landforms are gently sloping, elongated depressions, however frequently covered by younger deposits. The north-south trending eskers were possibly deposited during the deglaciation of the second stadial of the Early Weichseliam deglaciation phase, or may represent the early phase of the Late-Weichselian deglaciation with the ice margin still located far beyond the region.
The till-covered eskers deposited from northwest to southeast are the oldest ones. They consist of massive, over 25 m high erosional remnants of formerly coherent esker ridges. They are clearly reworked by glacial flow. The glaciofluvial material is compacted and coarser than that in younger eskers. The till cover is often lacking on the summits. The erosional landforms connecting the separate ridges are gentle and visible in the field as elongated valleys and depressions in the large-scale morphology. These systems were probably formed during the deglaciation of the first stadial of the Early Weichselian. The dates of the optically stimulated luminescence suggest that some of them may even have been formed during the Late-Saalian deglaciation.

MAURICE JULIAN

Mouvements de terrain en zones d'extraction et d'aménagement (France méridionale)

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En fonction d'activités diverses, en milieu urbain et non-urbain, mais toujours du fait de l'action humaine, dans des mines et des carrières ou sur des chantiers de construction et de travaux publics, un assez grand nombre de mouvements de masse se sont produits récemment, dans la région Provence-Alpes-Côte d'Azur ; ils ont eu des effets dommageables, sans occasionner, à une exception près (Saint-Cyr-les-Lecques,Var), de pertes de vies humaines.
Sauf le cas du Cap Sicié, près de Toulon, où la localisation d'une station d'épuration en bas d'un haute falaise, imposée par le tracé antérieur du collecteur, met en jeu une dynamique naturelle pré-existante, les autres cas correspondent à des modifications des pentes de versants en fronts de carrières d'extraction (bauxite du Thoronet, matériaux de construction, comme à Mougins) ou dans des chantiers de remodelage urbain (anciennes carrières d'argiles à Saint-Henri de Marseille). D'autres instabilités sont dues à des terrassements (la Trinité, près de Nice). Dans tous les cas, ces pentes non étayées subissent des effets de traction, auxquels s'ajoutent des pressions hydriques, en raison des nouvelles facilités d'infiltration. Leur stabilisation nécessite des travaux parfois très coûteux (galerie drainante du Thoronet).

ANNETTE KADEREIT & ANDREAS LANG

Colluvial sediments as a key to the holocene landscape evolution of early settled areas: a case study from the Kraichgau-Hills, southern Germany

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The loess areas of Middle-Europe have undergone enormous geomorphical changes since the onset of agriculture (ca. 7000 a BP), documented by partially or completely truncated soils in localities prone to erosion and thick colluvial and alluvial sediments in the depressions. Yet still unsolved is the question whether these changes were triggered dominantly by climatic or human impacts. Results from studies of large drainage basins can often not be interpreted in order to answer this question satisfyingly due to the great variety of the controlling factors and the complexity of the responding system at that scale of investigation.

In this respect small scale geomorphological studies in the direct neighbourhood of archaeological sites have become increasingly relevant in the context of palaeoecological and geoarchaeological analyses. Colluvial sediments on the lower hillslopes and in the drainage lines of zero order basins, as well as, alluvial sediments of first order basins represent important archives for the reconstruction of the Holocene landscape evolution. However, apart from geomorphological and palaeoecological analyses, high-resolution chronologies are required for precise correlations of these sediments to human activities or climatic fluctuations. The application of luminescence dating promises to being a powerful tool to close the chronometric gaps for the sediment layers free of organic material or archaeological finds. Especially the recently achieved progresses in optically stimulated luminescence (Osl) are of great advantage for the reliable dating of sediments with only short transportation distances.

First results of geoarchaeological investigations at the locality 'Bauerbach' in the loess covered Kraichgau-Hills in southern Germany will be presented and their possible implications for the human impact on the Holocene landscape evolution will be discussed. The test area stretches from the drainage divide down to the outlet of the first order to the second order basin. It is located between two archaeological sites: at the upper end remnants of Neolithic and Bronze to Iron age settlements and at the lower end remnants of roman buildings. While the younger Wurmian loess has been eroded on the upper slopes, not only the prehistoric concavities are filled with colluvial material but also the hill-foot and the drainage lines are buried deeply by colluvial and alluvial sediments up to several metres thickness. The colluvial sediments typically show coarsening upward with clay rich material borne from the Holocene climax luvisol at the bottom and loess-rich material on top. Apart from ^{14}C-dating of the available organic materials, infrared stimulated luminescence (Ir-Osl) dating provides the chronology for the feldspar rich, mainly fine grained, loessic sediments.

HIROSHI KADOMURA

Morpho-ecological response to recent climatic variations and human impacts in the Sahel: an overview for a geomorphological contribution to the convention to combat desertification

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In the tropical semi-arid areas on the south side of the Sahara, i.e. the Sahel Zone, desertification/land degradation has not occurred by the spreading of the Sahara but occurred in close connection with the local physical conditions, in particular landform types and superficial materials and/or underlying rocks, as well as kind and intensity of human impacts. Relative importance of wind or water erosion depends on both regional climatic and edaphic conditions. Gently sloping lands such as pediments and glacis, and plateau surfaces covered with hard ferrugineous cuirasses, gravels or sealed silty soils, are the landform types which are particularly prone to degradation processes. On these habitats, while the regression of woody vegetation is rapid, the recovery of it is very slow.

As observed in many areas of the Sahel Zone, the regrowth of natural woody vegetation in response to the return of good rains after the severe drought years has shown in good correlation with edaphic conditions, rather than the amount of rainfall. Sandy terrains, such as semi-fixed sand dunes and sand sheet areas with studded nebkhas, even if they are located in more arid area with less rainfall, have revealed rapid regeneration of woody species than cuirass-capped landscape in the area with more rainfall. The role of sandy soils, that can store viable seeds and sustain the rapid regrowth of vegetation, should deserve special attention. In contrast, it is the latter type of terrain where the continuous removal of top soils tends to result in a severely devastated landscape which is equalled to stony desert, i.e., reg landscape, and even to rocky desert.

Spatial differentiation in land degradation is more complicated in the dissected terrain composed of a variety of landform units, as exemplified by the dissected, cuirass-capped plateau of Ader Doutchi, near Keita Valley, Central Niger. In this area, types and intensity of degradation differ by landform/superficial material units, along with the topographic positions from the plateau surface through the scarp and glacis to the valley bottom. This segregation in degradation patterns has provided important information for planning the integrated rehabilitation works. In facts, much of the erosion control and water conservation works (e.g., Sombroek, 1992) have been carried out in clo-

se connection with the local morph-pedological characteristics of the land surface at the site level.
On the basis of the above observations, mention is made of the contribution of geomorphology to the implementation of the «United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa». The Convention, for the elaboration of which the author has committed as a member of International Panel of Expert on Desertification (Iped), stresses the importance of scientific know-how and information at all levels and bottom-up approach at local community level in implementing action programmes to combat desertification/land degradation and to mitigate the effects of drought. Major subjects to be discussed in relation to this are; indicators, monitoring, assessment, and the linkage with socio-economic aspects.

HIDEO KAGAMI

Accreted ridges

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In response to the Law of the Sea, Article 76, the technical guide for the continental shelf limit of the active margin will be discussed. There are difficulties to provide the natural prolongation of the continent in case of the accreted ridge across trenches. The accreted ridge can be divided into three categories: 1) an island arc having tonalite-granodiorite layer, 2) the inter-mediate ridge having a slower seismic velocity in the upper crustal layer, and 3) a seamount chain formed in the large igneous province of 'hot spot' origin having a high seismic velocity (7.0-7.6 km/s) in the lower crustal layer. The state of accretion can be classified into three stages: a) a pushing stage is the final stage of collision with very shallow boundary zone, b) a contact stage has rather broad condition from the beginning of touch to full affection of contact, and c) an approaching stage is just in touch and has influence on the continental slope. Examples are shown as follows:
1. and a). Accretion of full-developed ridge is shown by Izu-Ogasawara Ridge, and d' Entrecasteau Ridge,
2. and a). Accretion of the intermediate ridge with slower seismic velocity in the upper crustal layer is shown by the Tehuantepec Ridge,
3. and a). Accretion of seamount chain produced by 'hot spot' in a large igneous province is represented by the Ogasawara Plateau.
The Ogasawara plateau was called Marcus-Necker Rise, Marcus Rise, Michelson Seamounts, and Pigafetta Basin Flood Basalts (Piga). It was produced as a large igneous province (Lip) of the hot spot origin, which is characterized by the high seismic velocity in the lower crustal layer. In concluding remarks,
1. After compilation of thirteen examples of the accreted ridge, it becomes clear that accretion of the ridge is common phenomena across the plate-consumption boundary, and has topographic influences on the continental slope. Therefore, the accreted ridges are included to the continental shelf regime, including the contact and approaching stages.
2. In case of seamount chain or very long ridge, some kind of outer limitation shall be considered. Currently distance limit as being the edge of the continental margin, 350 miles from the base line, and 100 miles beyond the 2500 m isobath respectively may define the outer limit.
3. The same rule as to the Mid-oceanic ridge shall be applied to the accreted Mid-oceanic ridge such as the Chile Rise.

ARMAND D. KAGOU & M.F. TCHOUA

Evolution morphologique d'un volcan de la «Ligne du Cameroun» et son implication sur l'environnement: cas du mont Manengouba

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Le mont Manengouba est un volcan de la «Ligne du Cameroum» qui est ume structure majeure en Afrique Centrale formée par une succession de massifs volcaniques (38 Ma-Actuel) et de complexes anorogéniques (67-35 Ma). Le mont Manengouba couvre ume superficie d'environ 500 km^2 et culmine à 2411 m d'altitude. Il est localisé entre 9° 42' et 10°10' de longitude Est et 4°49' et 5°15' de latitude Nord et situé à l'intersection de deux systèmes de fractures de direction N 40 et N 130; les directions N 40 délimitent un fossé d'effondrement sur son versant Sud Ouest (Graben de Tombel).
La région du mont Mamengouba est très peuplée, avec plus d'un million d'habitants soit une densité de près de 100 habitants an km^2. La ville de Nkongsamba, qui se trouve directement à son pied, a près de 500000 habitants toute seule.
Le mont Manengouba montre ume structure complexe avec un ensemble d'édifices volcaniques qui dessinent des coluées stratoïdes, des dômes et des pics sur lesquels sont greffés des cônes stromboliens et des maars. A partir de la base du volcan qui se situe entre 600-800 m, les pentes augmentent progressivement de 10 à 15° jusqu'à 1200 m, ensuite, elles se redressent pour atteindre 40 à 50° dans la partie supérieure du volcan. Un trait caractérstique de la structure de ce volcan est la présence dans sa partie sommitale de deux caldeiras emboîtées dont la plus récente (Eboga) est bien conservée avec des pentes internes subverticales el la présence en son sein de deux cratères d'explosion contenant um lac. Cette morphologie a développé un réseau hydrographique très dense, rayonnant autour du sommet du massif où il prend ses sources.

Sur le plan volcanologique, le mont Manengouba est un volcan polyphasé qui a connu entre le Tertiaire et l'Actuel trois types d'éruptions volcaniques: a) les éruptions calmes et fluides, b) les éruptions calmes et visqueuses, c) les éruptions explosives et fortes.
Nous avons fait ume cartographie de ce massif en intégrant les zones à risques pour des éruptions futures. Ces zones sont principalement le nord-est du Manengouba du fait des pentes régionales favorables à une grande et rapide progression des coulées, ainsi qu'une forte concentration des cônes d'explosion; le sud-ouest du massif à cause de la proximité du graben de Tombel et enfin la caldeira d'Eboga du fait de la présence de deux volcaniques susceptible d'émanation gazeuse.

VINCENT KAKEMBO

The implications of land use change and geology on gully initiation in the Eastern Cape, South Africa

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The origins and development of gullies in a sub-catchment of the Great Fish and Keiskamma rivers, South Africa, are traced by analysis of sequential vertical aerial photographs and orthophoto maps from 1938 to 1992. Gully location in relation to slope position and the catchment's micro-geology is investigated using Pc Arc/Info Gis. Widespread gully initiation and intensification appears predominantly from the mid 1970's, coinciding with a period of extreme rainfall and flood events in the region. Conversely, gullying at four specific sites, identified as abandoned cultivation fields, is discerned to commence during the early 1950's followed by rapid incision in the mid 1970's. At the sites, a Dolerite Sill through the region, which marks a sharp break in slope, forms a zone of gully initiation. The Dolerite Sill is also identified during longitudinal and cross profile surveys as the limit to headward gully extension and boundary of thick unconsolidated colluvium accumulation. The implications of this relationship to erosion remedial measures and land management strategies are crucial.

TOMASZ KALICKI

Holocene development of the middle Vistula flood plain in the gap section (Poland)

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The study area is situated in the gap section of the Vistula valley between Kielse-Sandomierz and Lublin Upland in the middle Poland. In the narrow reache there are segments of the flood plain of various age. Here the paleomeanders are preserved only sporadically. A small width of the valley restrained free meandering so the river had likely a permanent tendency to anastomosing as well as to hindered preservation of the older series of channel alluvia. However records of changes in the type and rate of sedimentation on the flood plain are found in few preserved older fragments. The evidence of changes is provided by subsequent covers of overbank deposit separated by the buried soils. In these sections the muds of the same age are, therefore, facially diferentiated and occur at various levels. In the widening sections, the flood plain structure is analogous with that of Sandomierz Basin. A number of inserts of alluvia of various age, associated with the meandering river, occur here one beside the other at the same level. Moreover, the overbank deposits show here a facial differentiation related to the floodplain morphology and to the distance from the active channel.
The braided Vistula river formed medium terraces by the decline of the Pleniglacial, and likely at the beginning of the Late Glacial. In the Alleröd the concentration of the channel took place and resulted in the river incision. A very deep incision is indirectly confirmed by the lack of the Late Glacial overbank deposits and the development of eolian processes on the upper sandy terraces (11,020 BP). In the Atlantic the clayey overbank sediments (Mz = 7.0-7.5φ) were deposited on the flood plain with a small intensity (developing the soil). In the Atlantic-Subboreal border the intensified activity of the Vistula the faster sedimentation of silty muds (Mz = 6.1-6.7φ) resulted in the fossilization of the soils (5,170 BP). The changes in the river channel took place (cutt of 4,500 and 4,010 BP). The next changes of the Vistula channel took place at the beginning of the Subatlantic (2,550 BP). The following phase of the intensified accumulation of the silty overbank deposits (Mz = 5.8-6.5φ) was the Younger Medieval (700 BP) which resulted in the formation of the buried soil. A common change in the sedimentation conditions, caused by the human impact, is observed on the whole flood plain just in the recent centuries. At first, the river showed a tendency to braiding (from the 15th c.) and then changed to braided (from 19th c.). In the channel vicinity the overbank deposits are transformed into the sandy levee facies (Mz = 2.9-3.8φ). In the valley narrowings the muds of this type often cover the whole bottom. An increased frequency and magnitude of floods resulted in fossilization of the youngest soils in the uppermost located fragments of the flood plain by the silty-sandy overbank deposits (Mz = 5.4φ). In the wider parts of the valley the youngest muds of the levee facies were deposited along the Vistula river while clayey-silty overbank sediments (Mz = 7.0φ) were laid down on the organic deposits of paleomeanders and peatbogs in a far distance from the channel (200 BP).

ALEXANDRE M. KALININ

The types of slopes of the Lena River

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The following types of slopes can be found in the basins of the Upper Lena, the Aldan, the Vitim, the Olekma rivers: actively developing, episodically active and passively developing. The following slopes can be included in the actively developing group: rockfall, talus, rockfall-talus, structural, kurumes slopes.
The following slopes can be included in the episodically active group: rockfall-talus slopes leaning on the young river plain. The rockfall-talus, talus and kurumes slopes strengthened by the vegetation can be included in the passively developing group. They can become active in the result of fires and wash outs. The expansion of the kurumes slopes is tightly related with the lithology of the layer.
Average speed of the kurumes movement is equal to 5-10 centimeters a year according to long-standing phototheodolite data. The volume of the supplied material for one meter of the river bank is equal to 0,1 cu.m. Kurume-rockfall-talus slopes are steeper, have no vegetation. They supply most of the material for the bed, having the annual volume of 1,5-2 times more than the kurume slope.
The slope morphology can be determined by the intensity of the wash out of its base by the river. Large fragments get stuck in the river bed and, thus, form a «skeletone» base for a new level of the river plain. Thus, the forming of the river flat regulates the development of the river slopes. One can found some episodically active slopes, the activation of the movement of which is determined by the erosion activity of the river. In the basins of the Lena and Aldan rivers one can easily find the rockfall and talus slopes (like «Lenin's Columns» and «Palaces»).
The displacement of the detrital rocks is limited by the wood and bush vegetation of the rear stitch of the bush-rocks. The detrital rocks, being beyond this natural obstacle are getting their volume up to their critical volume, and after an overflow, the detrital material, cutting down the trees, rushes down the river bed.
When taluses reaches the angle of natural slope that will lead to the over growing with the beach-rocks. The talus, kurume slopes are base on the 1-11 levels of the over flood-plain terraces. Thus, one can say, that (*perestroyka*) reconstruction of the slopes takes a long time, having in mind the changing basis of the denudation.

D.E. KAPULE

Geomorphological hazards: a case study of the Nakuru Area, Central Rift Valley, Kenya

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The paper presents the causes and the effects of geomorphological hazards in the Nakuru area, Central part of the Rift Valley, Kenya. The study shows that the hazards are mainly caused by ground subsidence manifested on the surface by several linear depressions which are opened during heavy rainfall due to the collapse of loose unconsolidated deposits. The depressions are controlled by faults and fractures of tectonic origin currently forming part of the underground drainage systems developed during the last few years when the faults, controlling the fissures, were reactivated by erosion. The effect of these factors call for sensible planning so as to limit the extent of loss of property and life.
Geomorphological mapping using aerial photographs, satellite images and ground survey can greatly assist in monitoring the development of features which are the indicators of hazards in the area. Local knowledge from the people affected by hazards is of great importance in assessing geomorphological processes responsible for these hazards.

DAVID KARATSON

Two fundamental types of erosion calderas

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Two major types of erosion craters/calderas, characterized usually by a single or by several outlet valleys, respectively, can be distinguished by channel network development. The first is typical of temperate climates with no more than 1000-1500 mm/year annual precipitaion, and is characterized by a valley development which is directed by the breached crater/caldera interior as a drainage basin. The second seems to be formed above a climatic threshold (ca. 1500-2000 mm) where amphitheatre valleys can evolve. These are high-energy valleys, of which a number can penetrate into a closed crater/caldera, degrading it more intensely.
Erosionally transformed craters can be referred to as erosion craters, erosionally transformed calderas to as erosion calderas - the boundary seems tobe at around 3 km in diameter. Active craters and calderas are usually distinguished by a diameter of 1 km; by using the greater value, the definition can be extended also to inactive volcanoes.
Since temperate climates are characteristic of continents, craters/calderas of all volcano types (pyroclastic cones, stratocones, basalt domes, caldera volcanoes) can be transformed by the erosion process determined by drainage basin. On the contrary, development of amphitheatre valleys is confined largely to oceanic islands which are typically basaltic, so the second major crater/caldera type is connected primarily to basaltic volcanoes.

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Erosional environmental change due to the Kobe Earthquake inferred from pond sediments

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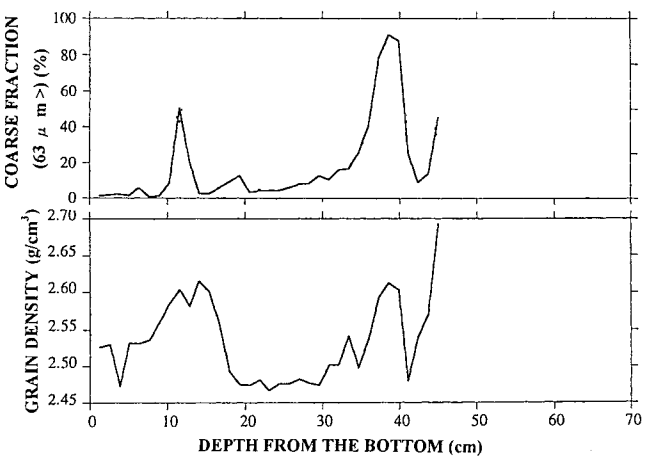
The Kobe Earthquake which killed more than 6,000 persons occurred in January, 1995 and caused many landslides in the Rokko Mountains. This may also change hydro-erosional conditions in the mountains. In the present study, pond sediments from an experimental pond in the mountains are used to check the change. Some core samples were obtained for reconstructing past erosional conditions and estimating sedimentary rate. Sediment traps have been set on the floor of the pond since the time just after the earthquake for checking the sedimentary conditions after the earthquake. Some physical properties of the sediment were analyzed to investigate changes in hydro-erosional conditions in the catchment area. ^{137}Cs concentration was used as a time marker for the core sediments of past some dozens of years.

Some sequences for physical properties of core samples are shown in figure. The first peak in the coarse fraction (from the bottom surface of the pond; ca. 12 cm) is corresponded to the heavy rainfall time in 1967, which is supported with ^{137}Cs concentration data. In the heavy rainfall time, in addition to grain size coarsening, grain density of sediments becomes large and loss on ignition becomes low, which suggests that detritus with low organic matter from the surrounding catchment accumulated in the center of pond bed.

Sedimentation rate for the interval before the earthquake is roughly estimated from the core sample dated with ^{137}Cs concentration and that for the interval after the earthquake is estimated with sediment trap. Estimated result shows that the sedimentation rate after the earthquake is much larger.



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Sediment distribution and transport processes on holocene lava fields in North-Eastern Iceland

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Large deposits of gravel, aeolian sand and loess blanket the barren Holocene lava fields in north-eastern Iceland *(Nordausturlandi)*, north of Vatnajökull. The postglacial history of the study area is governed by frequent eruptions from fissures and shield volcanoes, tephra falls and glacial floods *(jökulhlaups)*. Human impact on the landscape only occurs after the settlement of Iceland in *(circa)* 874 AD. Earlier studies in different parts of Iceland have indicated substantially accelerated soil erosion rates soon after the settlement, in the form of a four- to eight-fold increase in deposition rate of aeolian and tephra materials in soil profiles. At the margins of the current study region, advancing fronts of wind-blown sediment are destroying the vegetation cover and threatening the adjacent pastures and human settlements. No previous detailed studies on geomorphology and sediments in this remote area are known. The rationale of this pilot study was to 1) map the sediments that cover the lava fields using remotely sensed data, and 2) establishing sediment provenance and the processes governing the sediment distribution. The study was designed to serve as a basis for future work which will potentially pinpoint the environmental parameters, be they anthropogenic or natural, that account for this vegetationless semi-desert.

A preliminary classification of the ground features was made using Landsat TM data, and further analyses are in progress employing synthetic aperture radar (Sar) data. The results suggest that a combination of these two data sets creates a powerful tool for mapping geomorphological features in volcanic environments. Many sediment samples have been subjected to textural and geochemical analyses using electron probe microanalysis and Xrf. Aeolian sand transport processes investigations used sediment traps, high-precision levelling studies, and an automatic weather station.

It appears that the sediment distribution pattern is governed not only by aeolian processes, but also by source materials especially glaciofluvial deposits left behind by catastrophic glacial floods. Several new geomorphologic aspects have been identified. Lava morphology and texture seem to effectively control sediment transport in the region. The smooth pahoehoe lavas act as significant pathways for aeolian transport, whereas rough aa lavas cause sediment sinks, and hence barriers for advancing sand. Statistical analyses on the geochemical properties of the sediment samples have not yet revealed a meaningful sediment provenance pattern. Further analyses of the field data are in progress.

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Tectonics and landscape development in a passive margin setting: the Transantarctic Mountains

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Two contrasting approaches have generally been applied to the problem of long-term landscape development in passive continental margin settings. One involves the modelling of tectonic mechanisms on the basis of geophysical data on internal processes and lithospheric properties to yield coarse-scale predictions of changes in topography through time. The other approach utilises predominantly geomorphological data to reconstruct histories of landscape development without any explicit attempt to explain the tectonic events that have necessarily contributed to the inferred sequences of landscape change. The first strategy involves forward modelling in which the aim is to identify the particular combination of lithospheric properties and tectonic proceses responsible for creating the present large-scale topography. The second approach uses reverse modelling which starts with the present landscape and aims to reconstruct its history by identifying age relationships between different landscape elements. Over the past decade it has been increasingly appreciated that the internally-driven, tectonic mechanisms operating on passive margins do not operate independently, but rather interact with surface processes which re-distribute material through denudation and deposition. It is also becoming evident that the effective analysis of such interactions between the Earth's internal and external systems requires inputs from both the forward and reverse modelling strategies. Geomorphological evidence of landscape change, as well as geophysical data and tectonic models, are therefore necessary components of any comprehensive explanation of large-scale, long-term landscape evolution on passive margins. We assess the utility of these forward and reverse modelling approaches to landscape analysis in the context of the high-elevation passive margin represented by Transantarctic Mountains. Rising to elevations in excess of 4000 m and extending for more than 3000 km, the Transantarctic Mountains provide a particularly valuable case study for the assessment of the relative role of tectonic and surface processes in landscape development. This is because the persistence of a frigid polar environment throughout a significant part of the late Cenozoic has led to the detailed preservation of a range of ancient landscape features and associated terrestrial deposits to an extent that has not occurred elsewhere. It is likely that ice has been present as a geomorphic agent in Antarctica since at least the Oligocene, and the present-day dry, polar environment of the Transantarctic Mountains appears to have existed with little change since the Miocene. In constrast to virtually all other terrestrial environments, the role of running water as a geomorphic agent has been very largely surpressed for millions of years and consequently the Transantarctic Mountains also provide a setting within which to investigate the relationships between tectonics and an unusually limited suite of surface geomorphic processes. This region therefore constitutes a valuable benchmark against which to compare the morphotectonic evolution of other glaciated passive margins, notably those fringing the North Atlantic Ocean.

Morphological mapping combined with apatite fission-track analysis on outcrop samples (including near-vertical profiles) and in-situ produced cosmogenic isotope measurements on bedrock surfaces provide constraints on the long-term landscape history of specific sections of the the Transantarctic Mountains and allow some provisional conclusions to be drawn about long-term landscape development in these areas and its interaction with rift and post-rift tectonics:

1. A wedge of crustal section over 4 km thick at the coast and thinning inland has been removed from the coastal margin of the mountains.
2. Most of this erosion was accomplished under fluvial conditions before a full Antarctic ice sheet built up.
3. Dissection of the passive margin upwarp now represented by the Transantarctic Mountains was largely accomplished before the mid-Miocene. There is no firm geomorphological evidence for Plio-Pleistocene uplift, as envisaged by some researchers.
4. Glacial modification of the mountains has occurred selectively and generally only to a moderate degree with the main exception of the primary outlet glaciers and valley glaciers of northern Victoria Land.
5. Except at low altitudes, where there has been significant summer melting, rates of rock weathering under existing conditions are close to zero and have remained so for over 15 Ma.

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Continental morphology and East Antarctic Ice Sheet sensitivity

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This paper investigates the sensitivity of the East Antarctic Ice Sheet to the tectonic history of the Transantarctic Mountains. For some years there has been a debate as to whether during the Pliocene East Antarctica was largely deglaciated or whether the East Antarctic Ice Sheet remained in a similar state to that of today. The debate has fo-

cussed on the interpretation of Sirius Group glacial deposits which are distributed at high altitudes in the Transantarctic Mountains and which are intimately related to the landscape evolution and tectonic history of the region. The debate has drawn attention to the important link between tectonics and the growth and behaviour of the East Antarctic Ice Sheet.
This research uses a three-dimensional model of the East Antarctic Ice sheet coupled to a flexural model of the bedrock to explore the sensitivity of the ice sheet to the gross morphological characteristics of the continent. Since the tectonic evolution of the Transantarctic Mountains during the Cenozoic is poorly constrained, we treat the bedrock topography as a boundary condition and use a series of difference configurations.
The results of the modelling reveal how the sensitivity of the ice sheet at difference stages of its growth is influenced by topography. The results highlight the importance on ice sheet sensitivity of the span of the continent in relation to the elevation of coastal mountains.

ADÁM KERTÉSZ

Aridification - climate change in South-Eastern Europe

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In South-Eastern Central Europe climatic change has been leading to a situation approaching semiaridity. Climate change in this region can be described by the term *aridification.* Aridification means increasing semiaridity, manifested in the increase of mean annual temperature and in the decrease of yearly precipitation at the same time. A research programme was started as an extension of the Medalus II project (funded by the EU) with the following objectives: (i) Assessment of the impact of global change on the climate of the investigated area, including scenarios for future climates, (ii) Physical processes of aridification, including studies on ground water level change, soil moisture profie dynamics, soil development, vegetation change and soil erosion, (iii) Land use change, involving research on present land use and suggestions for the future.
Various methods were applied for the different research objectives, i.e. (i) statistical analysis of climatic oscillations and computer runs of scenarios, ii) analysis of ground water data, mapping and analysis of soils and vegetation, assessment of soil loss for present and for future and iii) land capability assessment through ranking environmental conditions according to the demands of the most widely grown arable crops in Hungary.
According to our results i) the average warming for the last 110 years is +0,0104 °C, precipitation decrease is 0,917 mm/year, ii) -2 to -4 m drops in the annual mean groundwater level can be detected in the most sensitive areas, with the gradual lowering of the water table in alkali ponds and with the complete desiccation of some of them the direct contact between groundwater and salt-affected soils is interrupted, the solonchak soil dynamics ceases, helophile and hygrophile plant associations disappear, the change of soil erosion regime will lead to disastrous erosion in the future. iii) The climatic changes induce a transformation in land use from arable crops to plantations, first of all orchards;
The above results lead to the conclusion that policy making should prepare for the environmental consequences of aridification first of all concerning and use change.
The research for this paper was carried out also as part of the Medalus II (Mediterranean Desertification and Land Use) collaborative research project.

HUSEIN A. KHALILOV

Geomorphological aspect of magmatism and «Concepiton of intralability»

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Magmatism being a leading motive power of litosphere's evolution plays an enormous role in formation of the Earth's relief and generation the magmatic morphostructure (morphomagmature) proper, directly connected with it. Primary (obvious) morphomagmatures are generated in the volcanic form of magmatism's activity and in Plutonic form - magmatic masses, hardening in entrails of the Earth, form cryptomorphostructures (they are characterized as morphomagmature only after emergence on the terrestrial surface).
Meanwhile, in estimation of the geomorphological role of magmatism, as a rule, limiting only by passive factors of magmatism, disregard thus its active factor, especially after transformation of plutonic melted down mobile masses in hardend solid «inert» bodies.
For the purpose of making up this deficiency in geomorphological researches, we develop the conception of intralability of definite magmatic bodies, such as intrusive, extrusive, dike, neck, etc. According to this conception, the intralability characterizing a particular occurrence of magmatism, implies the individual dynamic instability of similar bodies and supposes its independent «emergence» and "submergence» in the Earth's crust as alien hard body in heterogeneous litho and thermodynamic surroundings. It is assumed that the mobility of magmatic bodies is intensified in the period of stirring up of lithospheric plates' mobility and becomes apparent characteristic indications of dynamometamorphism in its contact zone and the formation of its specific, frequently, anomal forms in relief.
The factor of intralability is of great importance in following taking place alterations in relief and modification of

subterranean cryptomorphomagmatures in obvious intrusive morphomagmatures, and also in formation a series of central (focal) Plutono-and volcanotectonic heterogeneous typological varieties of morphostructures (domelike, circular, etc.).
The presence of magmatic bodies, in most cases, in seismic centres, permits under certain morphotectonic conditions to suppose the possible connection of seismodislocation with the conception of intralability: oscillations of the Earth's crust owing to the liberation of enormous potential energy, accumulated in consequence of dislocation of magmatic bodies.The universally recognized role of magmatism in formation of relief and at the same time the high degree of direct and indirect correlation of mineragenetic,deformational, transpositional and its other reguliarities with the form of relief, predetermine the great actuality and perspective of geomorphological researches in elaboration of morphostructural bases of the search of mineral deposites and study the seismotectonic phenomena in realization of paleogeomorphological reconstructions, in definition or concretization of thickness of de nudational section, depth of formation of plutonic bodies, etc.

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Old glaciation in the Caucasioni

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For quite a long period of time paleoglaciological study of the Caucasioni has been carried out according to the Alpine schemes, thus forming a little exaggerated notion on the glaciation range among scientists.Although the absolute height of the main ridge of the Caucasioni by 200-300 m exceeds the Alps, from the point of view of glaciation it falls much behind it.
The existing glaciers of the Caucasioni are mainly located in its central part between Ialbuz and Mkinvartsveri. Here is the Caucasioni's largest glacier Bebing (length 17,6 km, area 36,2 km^2). The height of permanent snow line oscillates between 2700-3800 m and increases from west to east.Absolute height 2000-3000 m is the lowest limit of expansion the Caucasioni glaciers, only two glaciers Tchalati-1850 m and Karaugomi -1830 m are beyond 2000 m.
The application of the latest data, petrographical and palynological methods give the different picture on the times and expansion of glaciation. It was stated two-old glaciation (Riss and Wurm). If the older (Mindel) glaciation really existed in the Caucasioni then its glaciation limits should not have exceeded Riss-Wurm glaciation and no traces of it should be remained in the relief. The maintained relief forms identify the expansion of Riss glaciation further than Wurm. During the last Wurm glaciation, glacier of the river Nenskri (the right tributary of the Inguri river) expanded to the lowest absolute height (700-750 m). Most of them ceased to exist in the mountains at the absolute height 1100-1400 m. Approximately the same is the picture on the North Slope, only Chereki glacier has surpassed the rocky ridge parallel to Caucasioni. The rest glaciers terminated at the foothill of the South Slope at the absolute height 1300-1400 m.
On this basis we assume that the old glaciers of the Caucasioni were not at all so colossal as to expand to piedmont valleys.

GUY KIEFFER

Volcanisme et tectonique sur la façade orientale de l'Etna (Sicile, Italie)

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L'Etna est divisé en deux domaines de part et d'autre d'une «rift zone» NNE-SSO: un domaine occidental relativement stable, avec peu d'accidents tectoniques et de manifestations volcaniques; un domaine oriental beaucoup plus instable, découpé par de nombreuses failles et où se produisent un plus grand nombre d'éruptions.
Cette disposition est liée au fonctionnement d'une grande structure de glissement vers la Mer Ionienne, qui affecte une bonne partie des versants est et sud-est de l'édifice volcanique (Kieffer, 1985). Les mouvements s'effectuent le long de failles actives qui décomposent la structure en plusieurs unités. La faille la plus nette est, coté nord, celle à rejet senestre, courbe à l'amont, puis orientée O-E le long du Piano Provenzana (ou Pernicana). Coté est-sud-est, la plus active paraît celle, N-NO-S-SE et à rejet dextre, qui détermine la «Timpa di Santa Tecla» et se prolonge vers la «Timpa di Macchia». Mais, plus au S, d'autres failles ou fissurations à rejet dextre, correspondent à autant de plans de glissement. L'une d'elles s'est révèlée lors de l'éruption de Septembre-Octobre 1989.
Cette structure est comparable aux structures de glissement des volcans hawaiiens. Mais, à l'Etna, elle présente la particularité d'incorporer le substratum sédimentaire. Son fonctionnement détermine un régime distensif dans sa partie amont, à l'O, en particulier avec les fissurations de la «rift zone», et compressif dans sa partie aval, à l'E, découpée par d'importantes failles normales.
Elle est interprétée comme la conséquence dc la destabilisation du versant tourné vers la mer sous l'effet de la force d'injection des intrusions magmatiques dans les axes éruptifs linéaires, principalement la «rift zone». Le poids des matériaux volcaniques empilés sur les argiles «sub-etnéennes» peut favoriser le processus. Mais, il paraît insuffisant pour justifier à lui seul l'importance et la raideur des escarpements tectoniques, qui présentent des analogies avec les

«Pali» d'Hawaii et supposent un enracinement plus profond, ou encore le basculement centripète de certaines unités de la structure. Une interaction des effets de la tectonique régionale et des processus liés au volcanisme paraît inévitable. Les failles impliquées dans le glissement se situent d'ailleurs généralement sur des directions régionales. Les conséquences du glissement se sont ajoutées à un phénomène plus large de bombement et de baseulement du N-NO vers le S-SE du substratum de l'Etna.
Cette interaction a joué un rôle dans le découpage du versant oriental par les «Timpe», mais aussi dans la vigueur des mouvements pendant les périodes d'activité de l'Etna. Cette vigueur est illustrée, sur la bordure littorale, par l'étagement de plusieurs niveaux marins et un soulèvement qui a localement atteint plusieurs mètres à l'époque historique.

JONG-WOOK KIM

Studies of the functional fluvial geomorphology in Young-Dong, Korea

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The aim of this study is to analyze the fluvial morphological characteristics of streams of Young-Dong area in Korea especially in terms of functional geomorphology. These streams originate on the east slope of Tae Back Mountain (the backbone mountain of Korea Peninsular), which was uplifted during Miocene, and flow into the East Sea.
Three of those streams were chosen for this research : Shilli, Sachun, Gunsun. The bedrock of the drainage basin of Shilli and Sachun is relatively homogeneous, consisting of granite and gneiss, but the one of Gunsun is more complicated, consisting of granite and the various kinds of Paleozoic sedimentary rocks. Compared to the streams on the west slope of Tae Back, the length of these streams is relatively short : Shilli 15.8 km, Sachun 18.6 km, and Gunsun 18.5 km. And the drainage basin area is also relatively small : Shilli 42.3 km^2, Sachun 55.6 km^2 and Gunsun 68.9 km^2.
Currently these streams are arousing special interest in terms of functional geomorphology. This is because they are considered to have some remarkable features which can be traced to streams which flow relatively rapidly down from higher elevations, contrary to streams on the west slope of Tae Back. To facilitate of this study, some components of the drainage basin system, the valley system, and the stream channel system were surveyed using field work and map analysis. Especially, the characteristics of the hydraulic geometry of streams were more intensively researched. The principal results are as follows:

1. The morphological characteristics of the drainage basin and the channel network changed remarkably depending upon the lithology of the bedrock. Streams, Shilli and Sachun, which flow on the same bedrock, granite and gneiss, show almost the same characteristics especially in terms of the shape and relief of the drainage basin, valley shape, drainage network pattern, etc.
2. The hydraulic geometry and bed materials of the streams on granite and gneiss, Shilli and Sachun, show similar characteristics, contrary to streams on sedimentary rock, Gunsun. So, it might be reasonable to conclude that the lithological condition strongly influences the fluvial morphology in the study area.
3. The functional fluvial morphology is quite different between the upper reaches of streams and the lower reaches. The upper reaches show characteristics similar to those of mountains, but the lower reaches resemble more alluvial channels. Also, the change in stream characteristics from the upper reaches to the lower reaches is relatively rapid. This might be caused by the uplift of the Tae Back Mountain and the change in the sea level.

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Rates and mechanisms of change in hard rock steep slopes on the Colorado Plateau, USA

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The development of steep slopes in hard jointed rock has been studied on the Colorado Plateau, USA. Advances made in other scientific disciplines have meant that the material properties of a rock mass are well understood and have been combined with geomorphological information in a distinct element computer program to develop models of cliff evolution. It is demonstrated in a theoretical study how the material properties in a rock mass, particularly the geometry of the discontinuities, affect the mechanisms of slope failure and therefore the development of steep slopes. Results of the modelling completed using geotechnical data from the Canyonlands, Utah district of the Colorado Plateau, establish the approach in the understanding of hard rock slope development. High, vertical cliffs of horizontally bedded Jurassic sandstone are topped by a jointed cap rock to form mesas and buttes in this region of spectacular rock landforms. While discontinuity orientation remains relatively constant spatially, spacing between sets varies, leading to differences in cliff development. Where the discontinuity spacing is greatest, buttes have become detached from the main cliff. The modelling demonstrates how the distinct element technique can be used to elucidate landform evolution.

ALASTAIR J. KIRK

A field-based rainfall simulation experiment to examine the movement of fines into arid soil profiles during the development of a soil crust

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The formation of soil crusts in arid landscapes has important effects upon the short term sediment mobility and the hydrological fluxes acting at the soil surface. The research to be reported examines the processes of soil crust development in arid environments, where land has recently been cleared of basalt boulders and is now being used for agriculture. Soil crust formation in arid regions is endemic of soil structural instability. The phenomenon of soil crusting involves the break-up of soil aggregates by a combination of physical and chemical processes. Once developed, soil crusts reduce infiltration and gaseous exchange, increase runoff and are therefore seen as indicators of soil degradation. They do, however, act as a sedimentary indicator for the movement of fine material over the soil surface. Rainfall simulation experiments were carried out in the Northern Badia area of Jordan during the spring of 1995. Silt-sized hematite particles, acting as physical tracers, were deposited over the soil surface to examine the effect of the washing-in of fines during rainfall events. Fabric analysis using thin sections of the resultant soil crusts has been carried out and image analysis has been used to quantify the amount and distance of sediment movement.

MIKE KIRKBY

A model for downstream changes in grainsize

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Stream grainsize characteristics are related to source materials, long profile form, and rates of erosion or deposition. Where there is net channel erosion, abrasion and other breakdown processes are thought to be dominant, whereas in depositional environments selective transportation is much more important.

The model presented here first considers a simplified scheme describing the processes of sediment breakdown and selective transportation. Breakdown is considered in terms of rates of change over time and downstream. Abrasion weight loss over time is related to grain area, curvature within the grain, and the relative velocities of other grains in motion. Weight loss over time is linked to via grain velocity, which is also dependent on diameter. Abrasion rates therefore respond to size, shape and, to a less extent, size distribution. Abrasion also produces fines from the grinding process. Breakdown also occurs rapidly by grain partition in suitable lithologies. Selective transportation is separated into detachment and grain travel. The detachment process is considered to take place under conditions of equal mobility, in response to flow power in relation to average surface grain size. Grain travel is treated as highly size-selective, with weak interactions between the various grain sizes present. These processes are considered for both a specified distribution of grains and through changes in an assumed log-normal distribution, or mixture of distributions.

The integrated finite difference model then budgets, breaks down and routes sediment from its sources as hillslope basal sediment delivery. Sediment is routed through the channel and flood plain system under a variety of regimes for flow variability, using the flood event as the iteration time unit. Uniform source material throughout the catchment, or simple contrasts of lithologies are used at this stage. The linearised stream systems are placed in stable or simple tectonic settings which provide base level boundary conditions of uniform erosion or deposition rate. The models are being applied to the evolution and change in semi-arid gully systems in S.E. Spain, as part of the EU-funded Medalus project.

It is argued that, in «graded» time spans, hillslope sediment supply and channel gradient strongly influence the prevailing grainsize by sorting between channel and floodplain, and also control local rates of erosion or deposition with the possibility of variations in Sediment Delivery Ratios (Sdr). Over «cyclic» time spans, however, in which appreciable net change occurs,

1. grain size is more strongly constrained by lithology,
2. Sdr is generally close to Unity and
3. abrasion has a much more dominant effect on the typical patterns of downstream fining.

Exceptional conditions are found for rivers passing through arid areas, where, with decreasing discharge downstream, grain size and gradient trends may depart from the normal pattern. Similarly river profiles respond in apparently anomalous ways when passing across lithological contrasts.

KAZIMIERZ KLIMEK

Historical phases of human impact in upper Odra Valley System, Upper Silesia, Poland

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The Upper Odra Catchment, Upper Silesia, drains an area filled primarily by Quaternary deposits overlaying the older sedimentary rocks. The maximum extent of scandinavian ice-sheet during the Middle Polish (Saalian) glaciation

is located near the southern margin of this area. In the periglacial condition of the last scandinavian glaciation (Vistulian) the drainage basin topography has been smoothed. Simultaneously loess like deposits covered the elavated plateaus. The present river channels are inset within Pleistocene fluvioglacial deposits or Holocene alluvia.
The fertile soils, dense network of streams and favourable climatic conditions caused a long history of intensive human occupation. The area has been inhabited since ancient times. By the end of thirteenth century a lot of new settlements has been founded here. As a result, an intensive deforestation and subsequent soil erosion started here. The eastern tributaries of the Odra river drain area of Upper Silesia coalfield developed in early nineteenth century as an industrial area.
There is evidence that an extensive agricultural settlement of loess plateaus caused their nearly complete deforestation. As a result, considerable slope erosion an overbank deposition on the valley floor took place. Vertical sequences of these alluvial series are usually 1 to 1.5 m thick with organic remnants at the base dated back 900-1000 A.D. The higher irregularity composition of fine grain sediments upwards of these deposit and simultaneous 2-3 times increasing of zinc concentration are typical here.
The overbank units build up a youngermost inset terraces in tributaries draining the coalfield regions are rhytmically stratifield and contain coal admixture. Here lead and especially cadmium concentrations rise drastically by near order of magnitude. This peak levels of Pb and Cd recorded here are atributed to nineteenth century rapid growth of mining industry and urbanization.

NINA T. KOCHNEVA & VICTOR YU. ALEKSEYEV

Structural and geomorphological investigations in studies of ore distribution

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Structures of the present relief are inherited, and their features can be used for metallogenic investigations. In the Laboratory of Metallogeny of Ore Regions, the special method was worked out by the authors in collaboration with I.N. Tomson and V.S. Kravtsov to represent structures of the period of magmatic reactivation and great ore formation through the analysis of present-relief forms. To do this, linear and area structural elements of the present relief were studied in ore regions with regard to their geotectinic and phisico-climatic features. Data on endogene and exogene agents forming a present-day relief were of especial significance to recognize tectonic elements. Area structures were recognized with the Method of Generalized Horizontals in combination with the analysis of distribution of different genetic types of relief; linear elements were primarily identified with decoding of aerial and cosmic photographs through both typical pictures of river system and many other indirect signs.
The area and linear elements identified were used to compound a generalized scheme of the present tectonic appearance which had often been composed of fragments of structures differed in foundation age. To find out the principle structures which were contemporary with ore formation, a complicated combination of different-age tectonic elements was compared with geological data.
Studies of several large regions, the Carpathians-Dinars-Balkans, the Andes, the Sierra Madre, the Caucasus and Transcaucasus, the Central Asia, the Chuckchee Peninsulla, the Transbaikalia, the Bulgarian (in cooperation with I. Vaptsarov, and the Serbian (in cooperation with M. Petkovich), were carryed out and the great significance of structures superimposed on more ancient structural zones was revealed for ore distribution. Arch uplifts, focus structures, and linear penetrating zones are some of them. As all these structures have some morphological features they can be recognized in the present relief.
A cross demention of arch uplifts ranges from 5000 to 100 km. Their feature is development of peripheral and central depressions. A metallogenic zoning is usually determined by large arch uplifts while smaller structures (200-50 km) control ore regions. The East Transbaikalian Arch Uplift (it has developed since Cretaceous) was identified and studied in detail with the Structural and Geomorphological Method. Concentric elements of the uplift control fluorite and antimony-mercury mineralization belts.
Focus structires (their usual cross dimentions are less than 100 km) are often distinguished by radial-circular fault systems. Their structural features are usually related to areas of magmatic rocks which the structures are built of. To identify them, all the geomorphological signes are applied. Ore centers of different metallogenic characters are usually placed within focus structures. For instance, the Lashkerek Focus Structure (volcanic, complex-built), the Central Asia, is reviewed below. Its central section is occupyed with the youngest volcanic rocks (C_3-P_1) of acid composition while the oldest rocks (C_2-C_3) are developed along its periphery. Daughter domes complicating the periphery are centres for the development of intrusions, extrusions, and explosions and hold gold and base-metal ore occurences and deposits.
Linear penetrating zones of faults are hardly decoded through geological data: they are of shadowy character and can be only identified with complex studies [Metallogeny of Shadowy Lineaments and Concentric Structures, 1984]. A hypsometric anomalies and a specific structural plans are developed in the present relief along these structures. For instance, the Klichka-Darasun Penetratung Zone, the Eastern Transbaikalia, is characterized by the highest (in the surroundings) hypsometric level and composed of small linear structural elements striked as the general structure. The zone cuts the general structural plan of the area and controls all the largest mineral deposits of the Transbaikalia.

YOSHINORI KODAMA & KEIGO NAKAMURA

An effect of large boulders on forming a longitudinal profile of bedrock channel

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We often observe that large boulder reaches in a gorge show steeper gradients than reaches without large boulders. The purposes of this study are 1) to illustrate a good relation between bedrock channel gradients and large boulder distribution pattern in a gorge, and 2) to consider an effect of large boulders on gradient forming processes in a bedrock channel through simple flume experiments on sediment transport.

The Oshika River, 17 km long, drains 45 km^2 in Tottori Prefecture, southwest Japan. The drainage area mainly consists of three kinds of geology; andesite (Pliocene), tuff breccia (Miocene), and granite (late Mesozoic). The 3-km-long Oshika Gorge occurs in the granite area at the center of the drainage basin, and has mean gradient of 0.08 (1/12), and channel width of 10-25 meters.

Along the Oshika Gorge, a number of large granite boulders (more than 2 m diameter) suddenly come into view in many places, but they usually disappear within one hundred meters downstream. A tributary or a large pool, which might be source of large boulders, usually exists in the upstream ends of the large boulder scatter zones. Even a flood period, the Oshika does not seem to transport these large boulders. They rest on bedrock for a long time.

In addition to large boulder scatter zones, step-pool sequence zones and a waterfall-pool sequence zone are observed in the Ojika Gorge. According to topographic maps (1:2,500 scale) and field survey, gradients of each zone show regularity: step-pool zone, 0.04-0.05; large boulder zone, 0.08; waterfall-pool zone, 0.13. Abrupt channel slope changes are observed in four places between adjacent step-pool zone and large boulder zone. Why are bedrock channel gradients of large boulder zones steeper than those of step-pool zones?

An experiment was performed in order to investigate the effect of large boulders on sediment transport rate. In 10 cm wide, 5 cm deep, 3.6 m long flume, sand was spread to make the initial channel bed. At a constant water discharge (60 cc /sec), an adequate quantity of sand was fed by hand at the upstream end to maintain the dynamic equilibrium state. In three different channel slopes and three different densities of rocks on bed, sand transport rates were examined. The result shows that the higher the density of rocks, the less the sediment transport rate.

Sediment transport rate along the Oshika Gorge must be constant, because we could not observe any alluvial reaches in the gorge. This means that the longitudinal profile of the Oshika Gorge could be created on the way of bedrock erosion so as to make the sediment transport rate constant between adjacent reaches of different channel morphologies.

YOSUKE KOMATSU[1] & YUICHI ONDA[2]

The hydrological characteristics and valley morphology among serpentinite and other lithologies in Oe-yama region, Japan

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The runoff response to rainfall is known to vary between underlying geologies (*e.g.* Freeze, 1972; Onda, 1994), and the drainage density and valley form also differ between geologies (*e.g.* Abrahams & Flint, 1983). The landform underlain by serpentinite in humid regions, for example Japan, is characterized by low valley density and convex slopes profiles, which is significantly different from surrounding mountains underlain by other geologies. To study the cause of the landform difference in serpentinite area, spatial variations of specific discharge of baseflow among geologies were investigated, and runoff response from small basins and precipitation were measured in serpentinite and surrounding geology.

The study area is Mt. Oe-yama regions, Kyoto Prefecture, western Japan. The geology of this area is serpentinite, granite, and Paleozoic argillite. In serpentinite area, few deeply dissected valleys, many shallow valleys and some well-defined earthslide landforms are found. In contrast, landform in granite area is characterized by high drainage frequency, and landform in Paleozoic argillite shows lower drainage frequency with straight longitudinal profiles. Specific discharge of baseflow were measured at 15 to 27 tributaries in three large basins (about 1 km^2) in snow melt season (April) and summer dry season (August). A measurement of baseflow discharge was carried on in each tributary outlet in the large basin. Three drainage basin areas of runoff observation site (all about 0.05 km^2) was located and discharge were measured with 6-inch parshall flume.

In the serpentinite area, the spatial variations of base flow is large, and many zero flux tributaries are found. In contrast, the spatial variations in granite and Paleozoic argillite areas are much smaller than serpentinite areas. Specific discharge in serpentinite areas decreased in summer dry season, when the relationships between specific discharge and altitude of measuring site had strong negative correlation (fig. 1). This suggest that the groundwater surface in serpentinite mountain body lowered in summer dry season (Komatsu & Onda, 1996).

The runoff response in serpentinite basin shows that the lag time from rainfall event to runoff peak is long (more than 5 hours), followed by small and quick initial peak. In Paleozoic argillite basin, runoff peak is tenuated and slow (more than 4 hours), but in strong spike of rainfall after dry period, runoff peak is evident and respond quickly to the rain. Runoff peak to rainfall in granite basin are higher and quicker (less than 1 hour). These results show that deep groundwater runoff in bedrock would contribute to runoff in serpentinite and Paleozoic argillite basin, and not in granite basin. The large spatial variation of springs in

serpentinite basin would be explained by uneven distribution of fissures in bedrock where subsurface water would flow through which will cause earthflow in serpentinite area together with slippy clay minerals. Occurrence of earthflow reset the surface channel system, resulting in be characterized unique landforms in serpentinite.

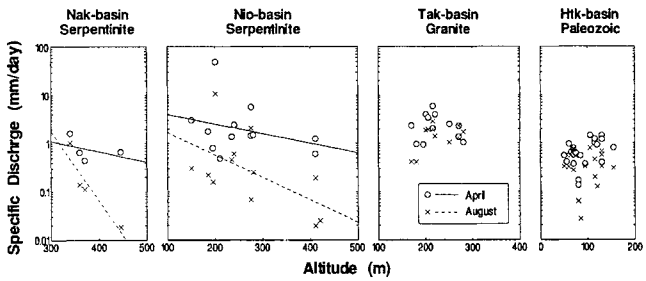

FIG. 1 - Relationships between specific discharge and altitude of the measuring site.

G. MATHIAS KONDOLF

Geomorphic effects of gravel mining on Cache Creek, California, USA

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Gravel and sand (for construction aggregate) are extracted from alluvial deposits in California on a massive scale. Over 100 million tonnes are mined annually, an order of magnitude greater than the natural rates of bedload production from catchment areas upstream. The sediment deficit created by gravel mining is exacerbated in many rivers by a reduction in sediment supply by upstream reservoirs. In response, channels have incised, resulting in failures of bridges and other structures, loss of salmon spawning gravels, and loss of alluvial aquifer storage due to declining water tables. In most cases, this on-going, large-scale geomorphic experiment in California rivers is going essentially undocumented due to a lack of basic data or funding to compile existing information.

Cache Creek drains 3000 km^2 of the Coast Ranges, about 200 km north of San Francisco. The lithologies exposed in the catchment produce abundant gravel-sized particles of sandstone and chert, which make excellent quality aggregates. As a result, Cache Creek has been exploited for aggregate since the earliest industrial activity in northern California, with 19th century railroad spurs running directly to gravel mines on the river bed. The rates of gravel extraction from Cache Creek increased substantially after 1950, resulting in a cumulative sediment deficit estimated at over 70 million tonnes as of 1994. This is equivalent to about 500 years worth of bedload sediment supply from the catchment. The bed of Cache Creek has incised 7-10 m, destabilizing bridges and contributing to a decline in groundwater levels. In many reaches, the formerly wide (>1000-m), braided channel has been converted to a narrow (<500-m), incised, single-thread channel. Elsewhere, annual extraction maintains a wide, flat bed, across which shallow water flows without confinement by natural bar forms.

In California, regulation of gravel mining in rivers is shared by some fifteen different federal, state, and local agencies, each with its own mandate (some conflicting with the mandates of other agencies) and none with adequate expertise or funds to conduct a comprehensive analysis of the cumulative impacts of mining. The County of Yolo, primarily responsible for regulating gravel mining on Cache Creek, developed an Aggregate Resources Management Plan in 1980. This plan proved unrealistic, largely because it did not account for the geomorphic response of the river, and a new plan is now being developed.

ANDRZEJ KOSTRZEWSKI & ZBIGNIEW ZWOLIŃSKI

Shoreline dynamics of the cliff coast, Wolin Island, Poland

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An exceptional place in the Wolin landscape is occupied by its morphologically diversified coastal zone on the Baltic Sea with very well developed cliffs. The field studies devoted to the functioning of the modern denudation system of the Wolin cliff coasts which have been carried out since 1977 embrace the following issues:

1. the impact of the lithology, plant cover and slope angle of the cliff on the genesis of evolving forms and coast development,
2. qualitative and quantitative estimations of effects of morphogenetic processes on the cliff coast,
3. morphological variability of the cliff coast in a yearly observation cycle,
4. morphodynamic functions of the cliff coast and their variations in the yearly weather cycle,
5. rate of retreat of the cliff coast.

The field studies covering the above problems are carried out along 6 test sections of the Wolin Island cliff coast. Morphological maps of the cliffs are being prepared using a specially devised set of conventional signs. A morphological map shows in detail the current state of the cliff coasts and provides a basis for a morphodynamic map. As the maps show, morphodynamic functions of till cliffs are more diversified than those of sandy cliffs. Our observations seem to indicate that the retreat of the Wolin Island cliff coasts is cyclic. Periods of relative dynamic equilibrium of the cliff alternate with periods of intensive abrasion of the coast.

This normal evolution cycle of cliff coast is overlapping by catastrophic processes which occur in a few years intervals. The last strom event took place in November 1995. It caused general metamorphosis of cliff slopes. The cliff wall retreated significantly in many sites. The highest changes was observed on sandy sections (over 8 m during this single strom event).

The systematic and multiyear studies of Wolin cliff coast give good opportunity to establish regularities of present-day morphodynamics and its trends within this morphogenetic environment.

ADAM KOTARBA

Termination of Pleistocene glaciation and Holocene environmental changes in the High Tatra Mountains, Poland

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Late Pleistocene and Holocene changes in both glacial and other geomorphic processes have been studied in the High Tatra Mountains. These efforts are based on the interpretation of glacial forms and deposits, peat bog palynological studies, and lacustrine sediments analysis. Distinct links between alpine glacial forms, geomorphic processes and lacustrine sedimentation exist. The main argument for defining the time of the full retreat of Late-Vistulian (Würm) glaciers are lacustrine sediments of alpine lakes of the High Tatra. Successive stages of valley glaciers retreat from terminal position are topographically marked by a system of eight recessional moraines. Lacustrine sediment record reflects climatic and floristic changes. Three stages of the development of the Tatra environment have been distinguished:

1. the stage of recession of valley glacier tongues - period probably lasted ca. 4 ka, i.e. to the alpine Gschnitz stade,
2. the stage of Gschnitz-Daun-Egesen recession has been reconstructed based on the sediments of dead-ice depressions and lacustrine deposits in the valleys free from the ice,
3. the early Holocene stage of warming and glacier decay in majority of the Tatra valleys lasted until alpine oscillation-Venediger. Small glaciers were preserved only in the uppermost parts of the mountains (above 2000 m a.s.l.). Relict rock glaciers are common features at altitudes ranging from 1450 m to 1950 mm. Boundary conditions for their development (existence of alpine discontinuous permafrost) existed in this altitudinal belt during the Younger Dryas and probably were active until the Venediger phase. Subbotom profiles of the Holocene lake basins provide additional information regarding the relationship between non-glacial changes in the environment which was under the influence of periglacial climate. The data collected in several lakes indicate that lake sedmientation rates differ significantly from

– ca. 0.1 mm/yr to 1.29 mm/yr. Generally, the Holocene cores showed that calm, slow sedimentation of organic silts predominated during the first phase of the Holocene, i.e. in the Preboreal and Boreal. Massive mineral sediments were formed in the period preceding the radiocarbon date – ca. 8300 BP. The high sedimentation rate is correlated with global event-the Joux phase (8700-8300 BP). During the Atlantic period, lasting until

– ca. 5000 BP, sedimentation was calm. The Subboreal period manifested in a more vigorous processes of the Tatra environment (mineral gravel-sandy inserts in the cores) predominated. The last, large scale reactivation of slope geomorphic processes occurred during the Little Ice Age.

LYUDMILA M. KRUCHININA

Environmental problems: ecological conditions in coal mining areas in Primorsky Territory, Russia

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Solving the problems of environmental nature, restoration of disturbed territories and prediction of developing situations is an actual need for the territories of economic development. The coal mining poses environmental problems. In this regard, zones of transition from the land towards the sea in the Russian Far East are poorly known, the most vulnerable and unstable to the anthropogenic loads.

The ecological conditions including qualitative and quantitative changes inside environmental systems give rise to a series of problems, which are conditionally divided as follows:

– geologic and geomorphological; land; soil; water; atmospheric; biotic; landscape and recreational.

The analysis of environmental problems allows distinguishing hydrodynamic processes of the anthropogenic nature as well as territories concerning limitation on types of man's economic activity. Anthropogenic processes of catastrophic nature have evolved on the vulnerable, in view of their natural features, minor Artem-Tavrichanskaya, Shkotovskaya, Rettikhovskaya, Pavlovskaya depressions.

The environmental situation is conditionally taken as favorable, normal, tense, critical and catastrophic. Recommendations are given for solving the environmental problems of coal fields.

FARUDIN KRUTAJ & ELDA FRASHERI

Some particular features of the Albanian Karst

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The Albanian karstic landscape, depending on a complex of factors, is so particular as it orients the morphogenese. We see this type of relief in all big natural regions, from the sea level to the highest altitudes but the intensity, the density of the forms and the sizes are different. The typical karstic morphology is seen at the altitudes 600-2000 m especially at the naked carbonatic rocks by the vegetation and the soils, with low steepness of the slopes.

The formations which are submitted to the solvability (limestones, dolomites, gyps, conglomerates with limestones content, travertines as well as the slopes materials) all together occupy about a quarter of the total area. The limestones and dolomites reveal the main category of the karstificated rocks where besides the created forms in actual climatic conditions are also preserved the traces of the older periods of karst, after territory's appearance over the water (Olig-Miocene).
The testimony of the paleokarst is the existence of the old plain surfaces (peneplena) which are different in time and space. By the studies results that the karst is new (after Plio-Quaternary) dynamic and very active in the actual stage. There exist all sorts of karstic forms (superficial and underground) from the initial ones till those of big sizes. The mediterranean karst, naked by the vegetation and oriented to the tectonic, predominates.
The age of the rocks, the structural organization and the fall of the layers, the quantity of the unsolvent remains, the solvent dynamic and the splitting as the conditions of the karst development change from one tectonic area to one another and as a consequence changes also the karstic morphology. The highest number of the faults ($40/m^2$) is seen at the Jurassic limestones. They have a definited orientation by the regional or local tectonic lines of breakings, which leads us to think it is an oriented karst.

ALEKSEY P. KULAKOV

Gigantic ring-morphostructures of earth and problem of evolution of our planet

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Gigantic ring-morphostructures (Grm) has been identified on the Earth near 15-20 years ago. They have diameter some thousand kms (from 1.5-2.0 to 4.0-6.0 th. kms), radial-concentric geological and geomorphological structure, very ancient geological age (mainly Precambrian) and very long geological history with repeated tectonic-magmatic activity. The most of them are the endogenic structures of Earth. Grm are very good expressed in geological structure and relief of Earth's surface and has been deshiphering with confidence on the space photos. They has been identified in Eurasia, North and South America, Australia as well as in Western and North Pacific. In Precambrian the all Grm were the gigantic uplifts with mountainous relief, but subsidence of their central parts took place in Phanerozoic. The Grm of Pacific western margin has been transformed in to basins of marginal seas in Mesozoic-Cenozoic. There are some Grm in the West and North Pacific floor which are the subsiding megastructures. Many Grm on continents has been destroyed to a marked degree in Paleozoic-Cenozoic, for example Australian, East China, Amur, Aldan, Yano-Kolyma, Amazonka and so on. This process - subsidence and destruction - is characteristic also for ring-morphostructures of the 2nd-3th order (some hundred kms in diameter).
Thus in the crust and relief of Earth the most large and ancient megastructures has been expressed. At the same time the intensive tectonic-magmatic activity and subsidence and destruction took place in the long geological history of them. This phenomenon testify about global extension of Earth's crust (continental and oceanic) and together with other data (subsidence of oceanic and seas floor, the wide development of fault and rift zones and so on) may be explain, on author's opinion, only by hypothesis of expanding Earth.

Z. KULIKOVA

The map of the general danger of natural processes of Russia

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The map of the general danger of natural processes of Russia was compiled on the basis of 13 initial hazardous geological and hydrometeorological processes maps (scale 1:500,000), including: karst, mud flows, erosion, avalanches, earthquakes, landslides and ets. More than 250 different combinations of hazardous processes have been distinguished. Combinations of various genetic processes depend on complex of geological, climatic and antropogenic factors.
Evidently degree of danger is connected with the scale of development, and intensity of processes, so as probability of their occurrence. 6 categories of danger (from 1 to 6 degree) have been distinguished by means combination these characteristics.
The map of the general danger of natural processes may be used for environmental monitoring and different types of risk estimations.

SIMON I. KULOSHVILI

The relief of the Caucasus in connection with its geological evolution

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It has been suggested that the main trend of the Alpine geologic evolution of the Caucasus is the transformation of a Pacific-type active continental margin of Tethys into an intracontinental high-mountain foldbelt. This process proceeded against a background of the continuous convergence of the Arabian and Eurasian plates. The purpose of this report is to show that this process was responsible for the formation of the main large-scaled landforms of the region.

The following major tectonic units comprise the present-day morphostructures in the Caucasus (from N to S) - the Pre-Caucasian foredeeps, the Greater Caucasian ridge, the Transcaucasian intermountain depression, the Lesser Caucasian fold system and the South Armenian-Nakhichevan subplatform. Now welded together these units (terrains) were once separated from one another by intervening basins with oceanic or suboceanic crust.
The progressive elimination of these oceanic areas took place throughout the Late Mesozoic-Early Paleogene and completed by the end of the Eocene. Thereafter, further compression led to deformation, shortening and thickening of the Earth's crust, the latter process being due to underthrusting southern continental blocks beneath the northern ones. The boundary zones between terrains now represent belts of increased geodynamics activity where the intensity of tectogenesis, volcanism and seismicity is most evident. These zones are also the places of the most active morphogenesis.
The main positive morphostructural elements of the region, the Greater and the Lesser Caucasus, are associated with zones of maximal crustal thickening and thrusting. Their formation was mainly caused by isostatic uplifting and differential movements of the upthrusting blocks. The total neotectonic uplift (since Late Sarmatian) reaches 8-9 km in G.Caucasus and 5-6 km in. L. Caucasus that implies average uplift rate ~1 and ~0.6 mm yr^{-1} correspondingly. The following denudational cutting, therefore, was no less than 4 km for the G. Caucasus and 3 km for the L. Caucasus.
Formation of intermountain depressions can be linked with frontal parts of the underthrusting plates. Molasse sequences (up to 5 km thick) accumulating within their limits created additional isostatic loading resulting in further sinking. Thus, the amplitude of vertical differential movements in the Caucasus was more than 10 km, locally even 13-14 km.
The main orogenic phases which form the present-day structure and relief of the Caucasus have been the Pyrenean, Attic, Rhodanian and Vallachian, the second and the fourth being most important. These phases show good accordance with the interaction between the Arabian and Eurasian plates and epochs of the Red Sea opening.

JURIJ KUNAVER

On morphogenesis of the superimposed valley of Soča River (Isonzo), Western Julian Alps

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After Czhoemig, Desio and Melik, who were dealing with the valley of Soča River (Isonzo) in the first half of this century, this area still offers some new views on the major geomorphological development. In the meantime new local studies were made which have to be taken in account in attempt for the new improved explanation of the valley morphogenesis. New geomorphological technics and new views on neotectonics also help in the explanation of the region.
The present Upper Soča Valley is typical for its composition of short gorges crossing the geological belts and of longer valley parts, being paralel or subsequent to them. The whole valley of Soča River has therefore a typical zig zag course because it is composed of a succession of many paralel and transverse valley parts. Each of them has its own development, with special regard to the initial phase of development.
The older geomorphological development of this part of Julian Alps shows a completely different situation in comparison with the present one. Desio and Melik (1926, 1956) have already supposed the existence of separate consequent rivers, which in pliocene used to flow directly to the Adriatic sea.
Beside dry valleys known before some new ones were found. A system of erosion teracces also explains the geomorphological history. The dry valleys are just a short transverse incisions in a nanow and very long monocline or anticline ridges which are typical for the middle part of the Soča valley.
The former consequent drainage was of the superimposed type because of its discordant position to the geological structure. It is believed that the beginning of uplifting of the Julian Alps at the end of pliocene and in older pleistocene and the activation of the Idrija fault line enabled the older rivers to deepen and accomodate their valleys to the geological structure. That process has also caused that in a relatively short time a new valley of Soča River originates out of many independant and separate paleorivers. The only exception is the gorge of Nadiža River (Natisore) which is still a geomorphological enigma. It is supposed that with the help of river capturing it opened the direct connection between Friuli plain and the valley of Soča River. At this interesting locality the gathering of upper Soča waters was not completed.

YOSHIMASA KURASHIGE

Source of river suspended sediment after selective logging in a Headwater Basin

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Selective logging was performed from April to June 1992 in the Hiyamizusawa Brook basin (basin area of 0.93 km2) in Hokkaido, Japan. An unpaved road was at first constructed in the basin in 1989, and further part of the slope was cut by bulldozer to carry out logs in 1992. During the logging in 1992, the sediment cut from the slope was wasted on the slope, in particular in the hollows. The road crosses the brook at one site at the lower reach of the brook, and the road surface water with high content of suspended sediment flows into the river at the crossing during a storm event. Accordingly, both wasted sediment fines (Wsf) and suspended sediment in the road surface

flow (Ssr) act as the major sources of the river suspended sediment (Rss) in the summer rainy season. Further from July to October 1995, another selective logging was performed in a neighboring basin, and about 10 cars passed the road per day to carry out the logs. In contrast, in 1992 and 1993, only one or two cars passed the road per day during the measuring period.

The previous studies on the mechanism of suspended sediment supply in this basin revealed that the peak of suspended sediment concentration (Ssc) appeared earlier than the peak of discharge when the suspended sediment was supplied from the river bed sediment. On the other hand, when the suspended sediment was supplied from the hillslope, the peak of Ssc appears close to the peak discharge in this brook.

Suspended sediment flux (Ssf) was obtained at downstream of the crossing during some rainfall events in summer of 1992, 1993 and 1995, and also in some snowmelt events in 1993. Further, the ratio between Ssf from Wsf and that from Ssr (Wsf:Ssr) was estimated from grain-size distribution of Rss based on nonparametric statistical test. The grains supplied from Wsf was sorted while they were supplied into the river, the ratio between two sub-distributions (Ws1 and Ws2) which represent the grain-size distribution of Wsf was changed to estimate the grain-size distribution of grains supplied from Wsf. Further, it was combined with the grain-size distribution of Ssr at the various Wsf:Ssr ratios, and the ratio whose combined distribution is the most similar to the grain-size distribution of Rss was detected to be an analytical result.

In the summer rainy season of 1992, the peak of Ssc appeared close to the peak discharge. The Wsf:Ssr ranged between 60:40 and 80:20. These ratios are almost equal to actually measured ratios with an error range of about 10%. In the snowmelt season of 1993, both Wsf and Ssr do not act as major source of suspended sediment, because the road and the hillslope were covered with deep snow. Consequently, the suspended sediment is supplied from the river bed in this season, thus the peak of Ssc appeared earlier than the peak discharge. The grain-size distribution of the bed sediment fines can be represented by two sub-distributions Bs1 and Bs2, and the grain-size distribution of Rss in this season was similar to the combined distribution at Bs1:Bs2 of ca. 50:50. In addition, in an event in the summer rainy season of 1993, the peak of Ssc also appeared earlier than the peak discharge. The grain-size distribution of Rss at the peak Ssc was judged to be supplied from the river bed, whereas the following Rss had Wsf:Ssr of 60:40 to 100:0. This indicates that much fine grains still had remained in the river bed in this season, and the fine grains from the river bed was washed out during the rising limb of the hydrograph. In contrast, in some event in the summer rainy season of 1995, the peak of Ssc appeared close to the peak discharge. The bed sediment fines were likely already exhausted in this season. The ratio Wsf:Ssr of Rssranged from 10:90 to 40:60 in this event. The values of Ssf supplied from Wsf were similar to those in the events in 1992, whereas Ssf from Ssr was very higher than that in 1992. This suggests that the intensive traffic of the road increased the suspended sediment supply from the road.

MICHAEL S. KUZNETSOV[1], V.M. GENDUGOV[2] & M.S. KHALILOV[1]

Theoretical and experimental approach to analysis of soil erosion process

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The theoretical analysis of the soil detachment process by water flow gave rise to the following equation:

$$q = A\frac{\tau}{\upsilon}\exp(-\alpha\frac{\upsilon_{sc}^2}{\upsilon^2}) + b \qquad (1)$$

where q is a rate of soil detachment (kg m^{-2} s^{-1}), τ is a tangential stress at the bottom of flow (Nm^{-2}), υ is an average flow velocity (ms^{-1}), υ_{sc} is a scouring flow velocity (ms^{-1}), A, a and b are constants.

The values of coefficient A, a and b were determined experimentally. The investigation were conducted in an erosion trough on water-saturated monolithic samples taken at various depths from chestnut soil, light-chestnut soil and mountain cinnamonic soil of south-east slope of the Large Caucasus. A standard depth of 2 cm was used by studying the dependence of soil erosion rate (q) on stream velocity (υ). The scouring velocity (υ_{sc}) was determined by Kuznetsov's method.

Tangential stress at the bottom of flow (t) was calculated according to the equation:

$$\tau = 0{,}02\rho_0\upsilon_\Delta^2,$$

where ρ_0 is the water density (kg m^{-3}), υ_Δ is the bottom velocity (ms^{-1}).

The Goncharov's equation was used for the transition from the average velocity (υ) to the bottom velocity υ_Δ:

$$\upsilon_\Delta = \frac{1{,}25\upsilon}{\lg\frac{6\cdot 15H}{\Delta}},$$

where H is the depth of flow, Δ is the height of roughness protuberances.

The soil detachment equation (1) will accept the following form for pre-mountain soils of south-east slope of the Large Caucasus:

$$q = (0{,}32\cdot 10^{-6}\frac{\tau}{\upsilon})\cdot[5{,}0\exp(-2{,}4\frac{\upsilon_{sc}^2}{\upsilon^2}) + 1]$$

The relative error of calculation under this formula makes 29,0%.

F.S. LAI & W. MALANDI

Particulate organic matter in streams under natural and logged conditions with reference to steep forest watersheds in Selangor, Peninsular Malaysia

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This study assesses the effects of logging on particulate organic matter (Pom) in four step watersheds based on data collected at various times (Sg. Batangsi, 19,8 sq. km-logging on going; Sg. Chongkak, 12,7 sq. km, logging ceased; Sg. Lui, 68,1 sq. km-80% forested and Sg. Lawing, 4,7 sq.km-undisturbed but 40% logged in 1993). POM varied between 0,2 to 1238 mg/l (n = 380) for Sg. Batangsi, 0,7 to 85,5 mg/l (n = 88) for Sg. Chongkak A, 1,2 to 56,1 mg/l (n = 300) for Sg. Chongkak B, 0,5 to 45,5 mg/l (n = 270) for Sg Lui, 0,1 to 53,0 mg/l (n = 300) in Sg Lawing, unlogged and 6,0 to 276,4 mg/l (n = 330) during logging.
Using analysis of variance, Pom during low flow conditions was not significantly different between streams. In contrast, Pom varied significantly different between rising and falling stream discharge in individual streams suggesting that storm flows are important in trasporting fine organics. Further analysis suggests that logging increases the export of Pom compared to undisturbed watersheds Pom transport were highest during rising stream discharges.

ADAM LAJCZAK

Slope remodelling in areas exploited by skiers: case study of the Polish Carpathian Mts.

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Skiing is one of most recent forms of anthropopression in the mountains. Development of ski-resorts in the recent years connected with increasing number of hikers in summer period has activitated the degradation of vegetation and accelerated soil erosion. The result is quick local slope remodelling due to much more effective all morphogenetic processes. In the writings on the subject the problem of ski-trail degradation appears much less than that the slope degradation due to other forms of anthropopression. During the last several years have seen a growing number of ski-trails in mountains in Southern Poland, most of them situated on the terrains with insufficient thickness of snow cover for skiing. Since the time when sheep grazing has been banned, skiing and hiking have become the principal causes of the slope degradation over about 700 m alt.
The aim of the examinations conducted in few places with ski-trails in the Polish Carpathian Mts. is to establish the size of slope degradation and the way of its remodelling due to skiing and hiking, with regard to the bedrock resistance, climate and the time of being in service. The study is focussed on the northern flysch slope of Pilsko Mt. (Western Beskidy Mts.) as one of areas with longest ski-trails in Poland.
Earthworks connected with slope profiling for ski-trails and alternately occuring eroded and overbuilt zones leads to smoothing of the longitudinal slope profile. In areas used exclusively by skiers and additionally smoothed by snow-levelling machines the linear erosion of slope does not occur. However, in ski areas penetrated by hikers morphological effects produced by skiing are intensified by effects diversifying microrelief, which result from rill erosion. When erosion cuts reach the bedrock, their further development consists in their broadening. With time rubble, and next bare bedrock becomes to be exposed on large areas. Further degradation of these areas by hikers may effectively prevent their stabilization by plant cover. The described tendencies of slope development is fixed by the activation in such places, and particularly in the subalpine zone, of morphogenetic processes, the range and intensity of which was small before tourists appeared in this area.
Skiing has a moderate direct influence on the ski-trail degradation. As a result of the combined impact of skiing and hiking the slope morphology changes and effectiveness of all morphogenetic processes increases. The volume of soil eroded from ski-trails depends on the number of hikers using particular paths, mainly during their descending down the hill. The present rate of erosion depends on the developmental phase of a slope gully and on the lithology of bedrock. However, it is impossible to determine the effect of slope inclination on the extent of erosion in the scale of the whole investigated area. This effect is visible only in small areas of uniform granulometric composition of slope waste. In areas degraded exclusively by skiing no such effect was found

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Fault tectonics of Asian - Pacific Ocean Transition Zone

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The Asian - Pacific Ocean Transition Zone in the triad «Sea-Arc-Trench» is characterized by tectonic - mobile zones girdling the Pacific Ocean. This is clearly manifested in the morphostructural and geological formation, geophysical fields and fault tectonics. The lineaments of a fault character are distinguished on a basis of the complex analysis of geomorphological and geologic - geophysical data. The

procedure of revealing the faults is discussed in Bersenev's, Lipkin's & Sigova's works (1979, 1980 & *alii*). The statistical analysis of frequency of faults of different orientation is performed, the evaluation of their morpho-kinematics is given and the age of their laying is determined. Based on the hypothetical mechanism of laying the faults on the disintegrating crest of the resonant wave in tectonosphere and an idea of the destructive rebuilding of the Earth's crust and the structural plan of faults, the axis of the principal stress for the prevailing part of the marginal seas is assumed to be of the north-eastern direction (40-60) with steep sublatitudinal folds (80-90) in the north (Bering Sea) and (240-260) in the southern part of the Sea of Japan. The faults coinciding with the axis of the principal stress are interpreted as fractures of separation - gaping faults and state-line faults. They are connected with tensile stresses. The shear fractures oriented diagonally to the axis of the principal stress are connected to a large extent with compressive stresses, conjugated with the tension. These faults are of fan - like direction. The third system of the faults isoriented perpendicular to the principal direction of the stress axis. Most commonly, they are of the north - western strikes (300 - 320) by which shear slips of blocks of the continental and subcontinental crust are determined.

The orientation of principal faults corresponds to the recent contours of morphostructures of the bottom of the marginal seas, island arcs and oceanic trenches indicating to their genetic link in formation of structures of Asian - Pacific Ocean Transition Zone. It is suggested that the most part of the faults of the north-western directions was laid on the continental crust of Asian continent at a period preceding the formation of sea trenches, that is at the age of pre-Late Cretaceous. During the succeeding periods the faults were activated and transformed into the shears of tension. According to Bersenev (1978) the period of formation of gaping faults coincides with that of intensive folded movements on the continent, the beginning of which is referred to the Late Cretaceous. At Miocene - Quaternary the gaping fault were transformed into the slip-faults, shear faults and slip-faults-shear thrusts framing continental and island steps down which the subsidence of blocks of the Earth's crust occured and oceanic basins and trenches were formed. This is evidenced by the facts on deep-sea drilling and data of the sea expeditionary studies (Geological Maps), 1981, 1991, 1992, 1982. At a recent period many of faults are activated and a focus of tension predicting the earthquake is formed in the knots of their intersections.

The wavy processes in the mantle and tectonosphere with periods of large and small resonances are global geological movements of the Earth. On the crest of resonant wave developing in the mantle and being destroyed in tectonosphere the reconstruction of the Earth's crust occurs, vertical and horizontal movements of its blocks develop and ancient faults are activated and new ones arise. These phenomena are likely to originate on the boundary of structure suture and within the zones of depth faults in the mobile medium on the contacts of the largest heterogeneities «Continent-Ocean». This is usually accompanied by high seismic and volcanic activity.

NICHOLAS LANCASTER

Influence of natural vegetation cover on sediment transport by wind

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Natural vegetation (shrubs and grasses) plays an important role in determining the dynamics and morphology of desert and coastal sand dune environments via its influence on the entrainment and transport of sand by the wind. Quantification of the effect of vegetation on sediment transport can be used to assess the effects of climatic change and human disturbance on such areas, as well as aiding sand stabilization and environmental restoration efforts.

Field studies conducted at Owens Lake, California provide direct measurements of sand flux on sand sheets with zero to 20% cover of salt grass. Results from 12 different sand transport events show that aerodynamic roughness length and threshold wind shear velocity increase with vegetation cover as measured by vertically-projected cover and roughness density (l). The presence of vegetation on sand sheet surfaces on the Owens River delta acts to increase the aerodynamic roughness length by two orders of magnitude from bare sand to 20% vegetation cover. The threshold wind shear velocity for transport increases by a factor of almost two in comparison with adjacent unvegetated surfaces. The average sediment flux for each event increases as a power function of the ratio between the average u* value for the event and the threshold u* value for bare sand (fig. 1). Despite increases in average wind shear velocity with increasing vegetation cover, sand flux decreases exponentially with vegetation cover (fig. 2) because of the strong influence of vegetation on transport threshold. Sand transport is effectively eliminated when the vertically-projected cover of salt grass is greater than 15%. A general empirical model for the relation between sand flux and vegetation cover has been derived:

$$Qn = 0.95\ e^{-0.20\ C}$$

where Qn is the sand flux normalized with respect to an equivalent unvegetated sand surface and C is the percent vegetation cover. This model can be used to: (1) predict the amount of vegetation required to stabilize sand dune areas and (2) assess the effect of climate change and human disturbance on the stability of vegetated sand surfaces via changes in plant cover.

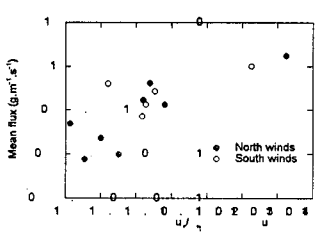

FIG. 1 - Sand transport event magnitude as function of u^*/u^*_t ratio.

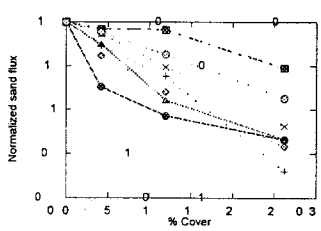

FIG. 2 - Relations between sand flux and vegetation cover (data for N winds).

ANDREAS LANG

Optical-dating of Late Glacial and Holocene sediments: test cases of water born sediments from central Europe

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Accurate dating is essential for any time-related question in geomorphology. For Late Glacial and Holocene sediments usually this is achieved by ^{14}C or dendrochronological-dating, if organic materials are present. Unfortunately, such lucky cases are rare.

Luminescence dating methods allow age determination of a mineral grain's last exposure to daylight. This requires sufficient bleaching during transportation and sedimentation before a grain is buried. Due to the poor light conditions during the formation of many water laid sediments, thermoluminescence (Tl) dating is hardly promising. The major advantage of optical - and infrared-stimulated luminescence (Osl/Irsl) over Tl is the restriction to very light-sensitive electron traps. This results in an improved dating precision and, in many cases, allows applications to sediments, which were only shortly exposed to light. Daylight exposure of mineral grains during transportation and sedimentation is highly complex at the «single grain» - scale and it is hard to determine deterministical. Between others, it is dependent on sunlight spectrum and flux (e.g. geographical location, weather conditions, time of the day), transport conditions (i.e. water depth, turbulences, suspended sediment, coagulation of grains) and the duration of the exposure.

In this study an empirical approach was chosen: optical dating was tried on sediments of various depositional environments, for which independent age control were available. The aim of the study is to find out for which types of sediments optical dating may be applied successfully and to further develop a powerful tool for resolving time-related questions in geomorphology.

The sediment types range from fluvial, colluvial, limnic to littoral deposits. The results show that Irsl and Osl are suitable for dating colluvial, limnic, littoral and, in many cases, fluvial sediments in the time span up to several 10 ka. These deposits represent specific characteristics which can easily be determined by geomorphologists.

ABDELLAH LAOUINA

Desertification of eastern Moroccan steppes: geomorphological aspects

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In the steppic environment of the eastern Moroccan high plains, a wide variety of complex ecosystems coexist and are in relation with both natural and human factors. The morphological aspects are important to explain the surface changes in term of available resources and of stability of the whole geosystem.

Many methods have been applicated to assess these surface changes and namely the desertification process. To describe the environmental potential, morpho-pedological survey permits the delimitation of units in term of quality of soils with a special mention about the eroded horizons. The survey of the sanded up and of the eroded surfaces permit to make a relation between processes wich affect the same region, but with selective action. The assess of the soil biomass production, the vegetation cover density and the loss observed in this production and density during the last years attest the loss of soil and of fertility, wich has also been evaluated by the measurement of the runoff and soil erosion. By aerial photo remote sensing, the increase of surfaces affected by hydric or eolian erosion, permits to assess the speed of degradation and to establish a map of risks and of critical situations.

The process of desertification, in this weakly inhabited region, is linked to the important changes observed in the land occupation and in the systems of soil utilisation. In this arid region, where the land is covered by *Artemisia herba alba* for the low surfaces affected by sheet wash and by *Stipa tenacissima* for the drained plateaux and pediments, already eroded with the outcrop of hard calcretes and of pebbles, the sedentarisation of the nomades and the progress of cultivated areas changed the water balance of the surface in some spaces and explain the increase of soil loss. The barley cultivations, wich seem to be a success in the first years, decline rapidly in productivity and explain the frequent abandon of bare lands, after a short period of erosion, namely in case of the occurence of a high magnitude event. The constitution of crusts on the surface leads to more runoff and more erosion. The wind affects wider spaces and explains the constitution of two kinds of surfaces: gravel ones and sandy ones. The question of sustainability is then formulated. The second question is the choice of adapted technics to this hard milieu, to prevent erosion and to ensure water infiltration and to the complex social context.

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Geomorphology of the Pacaas Novos Range, Southwestern Amazonia, Brazil,

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The geomorphologv of the Pacaas Novos range was surveyed. The Pacaas Novos range is situated in the state of

Rondonia, Southwestern Amazonia, near the bords of Brazil and Bolivia. The range is formed by sedimentary Precambrian rocks of the Pacaas Novos Formation and bordered by Precambrian crystalline rocks of the Brazilian Shield. The range has an elongate arch shape in the WSW-WNW to WNW-WSW direction, forming a broad syncline. The research focused on piedmont geomorphology and some deep weathering profiles in the rocks of the Brasilian Shield.

The landscape sequence begins with the occurrence of thick saprolites that developed through chemical weathering in the granitic rocks of the shield.

The septentrional flank of the range shows a 150 m high cliff and a continuous detrital talus with a thickness of 70-80 m and a declivity of 34° along the piedmont. The base of the talus is related to a pediment which was developed on the strongly chemically weathered of the crystalline rock basement. The formation of the detrital talus and a pediment level in the piedmont area indicates a change toward a semiarid climate. The thin alluvial sediments «in transit» of the pediment suffered laterization which resulted in a duricrust during a subhumid climate. A new climatic change activated the linear erosion of the drainage networks encasing the pediment and dismantling the duricrust. During a subsequent semiarid period, alluvial fans were deposited on the piedmont. Today, the rain forest inhibits the development of all paleoforms.

The geomorphologic analysis of the Pacaas Novos range provides strong evidence that the morphogenetic systems changed drastically in Amazonia during the Quaternary.

STANISLAV A. LAUKHIN

Relief evolution of Asia continent's margin in connection with forming amerasian subbasin of the Arctic Ocean in the Cenozoic

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In a continental part of Amerasian subbasin traces of the Palaeocenic riftogenetic are reflected less clearly, than in Eurasian one, where structures of rift penetrated a long way into continent in Verkhoyanye.

Before neotectonic stage a continental regime predominated on the outer shelf. The sea almost did not penetrate to the South of 75(N in the Paleocene (although world ocean level was 150-300 m higher than at present) high plains predominated and mountainous relief spreaded most widely on outer shelf (on continent to the North from the Polar Circle it was spreaded least widely) on the Cenozoic in the whole. Already in the Early Eocene a sea spreaded to 72(N and its gulfs penetrated the recent dryland till 68(N. On the whole, risings predominated during the Eocene. On outer shelf lowlands spreaded, mountainous relief narrowed his spreading on the shelf and widened on the dryland. In the 1st half of the Eocene weathering crusts formed South from 70 N. In the conditions of warm climate (annual temperatures near 71° N were 15-19° C). Reliefforming role of the crust is not clear. Mainly inner shelf was drawn in subsidence the subbasin.

In the Oligocene, at the beginning of neotectonic stage, the subsidence area shifted to the North from the flexure separating hershelf from the outer one. On the outershelf lowerings along sublatitudinal faults leaded to multiple sea transgressions, which penetrated into recent dryland in Yakutia even in end of the Oligocene, when the world ocean level was 100-150 m lowerthan the recent one. A differentiation of relief abruptly gorew . Mendeleev Ridge (in subbasin) and his morphostructural and its orogenic continuation on the shelf and continent formed. In the North of continent in end of the Oligocene high mountain relief spreaded, and the alpine of relief appear forthe first time. Till middle of the Oligocene on continent low and middle mountains predominated.

In the Neogene on the outershelf subsidence continued, sea transgressions penetrated in to the recent dryland not less than 7 times. In middle of the Miocene relief of Chukotka was a like to recent; Momo-Selennyakh rift lays (it's northern offshoots penetrates to NE Yakutya). In the Late Miocene-Pliocene to the North from the Polar Circle rising activated in mountains, the high mountainrelief formed, on E Chukotka basalts outlawed. In the end of the Miocene on continental lowlands landscapes of tundra raised to the first time; permafrost becomes reliefforming factor. In middle of the Pliocene mountain-valley glaciers in the first time went out on the lowlands of Chukotka (and lowlands of Eurasia in the whole).

In the Pleistocene a relief is arming under an influence of differented tectonic movements, glaciations (sea regression-transgressions, isostasy etc., producing by ones) and arctic-subarctic climate.

STEIN-ERIK LAURITZEN

A simple growth model for limestone pedestals: determination of surface karst denudation

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Limestone pedestals (*Karrentische*) are believed to develop by differential corrosion beneath and around the protecting boulder. The height of the pedestal is a function of time and of the shielding effect of the perched boulder. This work develops mathematical models for the size (i.e. height) of limestone pedestals as a function of time and the properties of the perched boulder. These properties are the shortest horizontal axis of the boulder (x), its shape factor (ß) and the amount of condensation corrosion be-

neath it (y). The height of pedestals as a function of boulder size in a given time-slice is:

$$h(x) = \begin{cases} 0 & ; x \le x_{\min} \\ \alpha\left(1 - e^{-\beta x}\right) - \gamma ; x > x_{\min} \end{cases} \quad (1)$$

where

$$x_{\min} = -\frac{1}{\beta} \ln\left[\frac{\alpha - \gamma}{\alpha}\right] \quad (2)$$

Because the shielding effect will decrease with increasing pedestal height, we may predict that pedestals over time will attain a finite, steady-state height. The time needed to aquire the steady-state height is considerable, and probably longer than the Holocene (10,000 years) for most sites. The present-day height of pedestals in a given site, is dependent of the shape-factor of the boulder (ß) that is likely to vary within a pedestal population. Hence, the model also explain the variability observed in pedestal heights within a site. The model (equ. 1) has only 3 adjustable parameters (a, 5, y), which can be calibrated from a large sample of pedestals. A method for estimating the total denudation outside the boulder (cc) by means of measurable pedestal properties (h and x) was developed and tested with favorable outcome on pedestal populations at the Svartisen karst, north Norway.

HANOCH LAVEE[1], P. SARAH[1] & A. PEREVOLOTSKY[2]

The effect of traditional grazing on eco-geomorphic properties in semi-arid areas in Israel

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In Mediterranean and semi-arid areas grazing is one of the main land use activities and it affects soil and surface properties and hydrological processes. The removal of plant cover and trampling can lead to an increase in soil compaction and soil crusting and a decrease in soil organic matter content and aggradation which in turn magnify runoff and soil erosion.
The objective of this study was to assess the resilience of semi-arid eco-geomorphic systems to traditional grazing. The study was carried out on hillslopes at two research sites in Israel: one site is located 12 km north to Be'er Sheva and the other one is located 20 km east to Jerusalem. Both sites have southeast exposure and calcareous bedrock.The mean annual rainfall and temperature are 260 mm and 20(C respectively. The sites are traditionaly grazed by sheep and goats.
At each site experimental plots were fenced and grazing was prevented for 3-4 years. Surface and soil properties were measured at the ungrazed and at the grazed areas twice a year, in April (the peack of vegetation cover) and in September (the end of the dry season), during two years. At each season the cover percentage of green vegetation, dry vegetation, biogenic crust, stones, bare rock and bare soil were mapped along 6 transects, 3 in the grazed areas and 3 in the ungrazed area. In addition, soil samples were taken at 25 cm intervals along each transect and soil moisture, organic matter content, aggregate size and stability and microaggregation were determined.
The results show differences in eco-geomorphological characteristics between grazed and ungrazed areas, between seasons and between the research sites. These results are explained by differences in grazing intensity as expressed by the frequency of the grazing and herd size and type.
Although the long history of grazing at the research sites, after a relatively very short period (4 years) without grazing, vegetation cover and soil structure were improved to the level which characterize ungrazed areas in these climatic conditions. These facts indicate a high resilience (recovery capacity) of semi-arid eco-geomorphological systems to grazing (i.e. their modification does not enhance desertification in the sense of hydrological processes).

SERGUEI B. LAVROV

Relief as geopolitical factor

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Usually geopolitical characteristic and its spatial amplifications fall out of analysis during the practical utilisation. Carried out analysis is the evidence that stability of some modern countries and some countries of the ancient world was caused especially by natural peculiarities and first of all by relief of a country and its borders. Geopolitical character of relief is reflected in quite different ways on different levels of its organisation. It's possible to call global (America, Australia which are separated from the rest of the world by the oceans), regional (China-stricted in the South by Himalayan and Tibet) and local form of geopolitical character of relief (many countries are divided inside themselves by mountain chains). Analysis of borders of some countries and their steadiness in time in connection with specifications of relief is also interesting. In the indicated plan was carried out an analysis of military and political importance of different relief and its spatial combinations. Geopolitical character of relief used to be reflected on the expansion of countries and extending their colonies.

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Image recognition in geomorphological zoning

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The phenomenon of variety and spatial organization of geomorphological objects is the function of interaction of the relief forming factors: endogenous, exogenous and technogenous. The geomorphological objects classification is one of the most important problems, the difficulty of which becomes especially evident in search for classification property criteria in the case of low expressive relief forms.
From the formal position the geomorphological space may be regarded as some set of objects consisting of subsets (classes) such that to every one corresponds the unique family of characteristics - some conjunction of coordinates of parameter vector.
This simple conceptual model may be presented in discreet form for different description accuracy.This means that for various scales of realization it may be regarded as an aggregate of elementary (in specific scale) volumes that are characterized by vector of parameters, representing our knowledge about the morphology and morphometry of the relief.
The problem of taxonomy of geomorphological objects is solved with the help of image recognition algorithm. Taking the Hamming distance as the measure of subsets (clusters) similarity, on the random sample from the general set of the objects the training set was evaluated and used as a school for image recognition and further classification of general object set.
Using 33 parameters vector length, the geomorphological objects, formed in inhomogeneous geodynamic conditions, were separated in three classes. This approach was used in Transcarpathian test field for geodynamic and morphostructural zoning and also as a proof for a seismic one in the joint zone of interior depression and organic region of Eastern Carpathians.

CATHERINE V. LEBEDEVA

The development of the river systems of the Western Okhotsk Region in the Late Cenozoic: times and causes of their reorganisations

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The territory under research includes deeply dissected ridges Jugjur and Pribrezhny. They are parallel ridges but Pribrezhny is closer to the Okhotsk sea. Low-mountain Lantaro-Nemuyskaya depression divides the ridges.Jugjur is the watershed of the Arctic and the Pacific oceans. The structure of the river network of the territory is rather original, traces of reorganisations of the river basins are numerous.
The rivers beginning from the north-western slopes of Jugjur are long, cut weakly and have wide plane valleys. The rivers of the south-eastern slopes are short, rough, with many rapids. Their valleys are like gorges in the headwaters, but in the lower course they become U-shaped. The watershed of Jugjur is approached to the Okhotsk sea as a whole and frequently does not coincide with the maximum marks of the tops. The traces of decapitation of the headwaters of the rivers of the Aldan basin by the rivers of the Okhotsk sea basin are numerous. As a result the line of the Jugjurian watershed displaces to the north-west.
The ridge Pribrezhny is cut through by the river valleys of the Okhotsk sea basin. The active uplift of granitic domes of this ridge during the Pleistocene has resulted in formation of a specific centrifugal drawing of a river network, asymmetric cross structure of some river valleys and numerous reorganisations of the river basins.
Smooth outlines of the relief with mainly flatly and rounded summit surfaces of watershed are characteristic for Lantaro-Nemuyskaya depression. Degraded bald mountains divided by flat saddles are found here. The fragments of alluvial deposits of Pliocene and Pleistocene age preserved on the saddles testify to significant reorganisations of the river network within the limits of the depression.
The coastal zone has numerous traces of decapitation too. The interception of the confluent of the river Lantar' (the river Negay) by the sea are the most evident. Small streams running in the sea often come to the end by falls with the height of 2-3m because the abrasion coast retreat outstrips the stream erosion.
So we can see that reorganisation of the river systems of the Western Okhotsk region took place very often during the Late Cenozoic. The reasons of these reorganisations were different tectonic movements, formation and degradation of glaciations and aggradation of glacial and fluvioglacial deposits, alternation of epoches of aggradation and deepening in the development of the river valleys, regressive erosion, abrasion and also combination of the several factors.
The territory represented peneplain with sites of low-mountain relief at an axial part of ridge Jugjur during the Oligocene. The rare fragments of the lowland river network of this temporary interval were kept only on the modern watersheds and it is obviously not possible to make the reconstruction of its configuration.
The Neogene is a period of active tectonic movements having, however, faltering character. At the Middle - the beginning of the Late Pliocene there was the radical reorganisation of the surface of the region with formation of low-middle-mountain relief close to modern one. The river network of the territory was generated in general at the same time: deposits of the end of the Late Pliocene -

the beginning of the Early Pleistocene are discovered within the limits many of modern valleys. The depth of the stream cutting was of hundreds of meters at separate sites.
The river basins reorganisations of N_2^3-Q_1^1 were caused mainly by the tectonic reasons: by different block movements as within the limits of the depression, so of the neighbouring ridges (including the uplift of the granitic domes), and also sharp fluctuations of humidity of a climate, causing alternation of stages of deepening and aggradation of river valleys.
At the beginning of the Middle Pleistocene (Q_2^1) the reorganisations of the lower and middle courses of the rivers were caused powerful aggradation of alluvial and alluvial fan deposits there. Erosion and cutting were proceeding in the headwaters. At the end of the Middle and the beginning of the Late Pleistocene (Q_2^4-Q_3^1) numerous beheading of the Aldan basin rivers were generated. The formation of these interceptions has taken place in the period of degradation of the semisheet glaciation of the territory and has become possible due to the displacement of the ice divide relatively the orographic one. At the feet of the ridges and within the limits of the depression the reorganisations of the river basins were caused by aggradation of glacial and fluvioglacial deposits and also by dividing the lower river valleys with a partition by glaciers, descending from ridge Pribrezhny. Active abrasion on the coast and interceptions of the rivers by sea are connected with transgression of the Okhotsk sea basin (up to +10-12m higher than modern sea level) at the beginning of the Late Pleistocene (Q_3^1)

MILAN LEHOTSKY

Exhumed karst. Geomorphic and environmental aspects (case study Hybe Village surroundings, Slovakia)

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In the central Slovakia one of basins is Liptovska kotlina basin. It s developmnet is in the very narrow connection with the development of mountains around it. For Liptovska kotlina basin development in its southern part is typical contact of mesozoic and paleozoic rocks. During Quaternary eastern part of basin was covered by glacifluvial sediments (Günz) which covered probably Pliocene karst landforms. Today we can study some particularities concerning development of exhumation of old karst forms. Field identifying of the system of sinkholes, its measurement and comparation with geologic (Choc nappe) structure and presumed faults gives us particular view of rare karst exhumation not only in this part of Liptovska kotlina basin, but also in Central Europe.

MARINA O. LEIBMAN & IRINA D. STRELETSKAYA

The surface dynamics at Se-Yakha River Basin (Yamal Peninsula, Russia) due to periglacial slope processes during the last 45 Years

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Aerial photographs taken in 1949, 1970, 1976, 1985, 1988, and 1990 were analyzed in reference to the changes in topography resulting from the periglacial slope processes (active layer detachments and slumps) in the region with continuous permafrost and widely spread ground ice deposits. Two various sites were analysed.
The area of site 1 is about 50 square km. On the aerial images of 1949 and 1966 no modern slides are found. On the images of 1985 two slides are noted, and during the field survey of 1988 one more slide that didn't exist in 1985 was found, probably formed in 1986. And finally, during the field survey of 1989 and on the images of 1990 more than 300 new detachments were mapped that formed in 1989. They exposed more than 1% of the total slope area.
At site 2 massive ground ice is found at the depths of 1-3 m below the surface (at site 1 - deeper than 7-10 m). This results in the different mechanism of earth mass removal - slumps (repetitive earth flows prevailing). On the aerial images of 1949 and 1970 modern slumps are not found, but on the images of 1976 on the area of 12,6 square km exposed by slumps are 0.4 km (3.2%). On the images of 1988 new slumps exposed the territory of 0.25 square km, and renewed the old thermodenudation cirques that were «sleeping» before 1976.
Slides and slumps affect the processes of river-channel formation, thermoerosion, thermokarst and others. Removed masses often barricade the streams and even small rivers so that dammed lakes are formed. These lakes may exist for several years (one observed on site 1 and formed in 1989 had still the same area in summer 1996). Even rather big rivers may be in part dammed so that the channel is narrowed and the new meander start to form (in summer after the slide dammed 5-7 m of the 30-m wide river channel, the river bank retreated 10 m into the land to form the meander at the former linear portion of the channel).
Almost all the surfaces exposed by the slope processes, are subjected to quick rill formation. During the first year after the slide, branching rills up to 1 m deep, 80 cm wide and tens of meters long form. Lakes also form on slopes above shearing surfaces by concentrating the run-off and damming it by the removed mass. Lakes, sometimes found on gentle slopes nowadays, are remnants of the ancient landslide process.
Analysis of the slope process activity showed that:
1. Both sites are characterized by the different type and cyclicity of the slope process. At site 1 process of slump formation is rather even, with slight peak of activation between 1976 and 1988. At site 2 active layer detachments are catastrophic, with the absolute peak of activity in 1989.

2. The reasons for such difference are in various geological structure: the depth at which the massive ice is found. At site 1 the massive ground ice is not participating in the detachment mechanism, shearing surface is at the active layer base along the interface frozen ice-bonded clay/thawed sand or frozen ice-bonded clay/thawed clay. At site 2 mass waist is due to thawing of the ground ice and flow of the liquefied clayey material down-slope.
3. Slope development is climate-dependent especially in permafrost regions. All the slope processes are known to result from the high water content (high pore pressure) of deposits, but only in permafrost regions there is such a source of water as melting ground ice. Slumps are more or less active depending mainly on the air temperature. The warmer is the summer, the deeper the thaw and the more possible is massive ground ice melting on slopes. Melting of ice gives enough water to provide mass waist. Active layer detachments move due to the immense rise of the active-layer pore pressure that depends on the summarized effect of the high summer temperature (and thus - rate of thaw and water liberation), summer atmospheric precipitation, and high ice content at the active layer base (the last is formed due to the specific conditions of freezing the year before possible activation).
4. Modern slopes of the Central Yamal Peninsular are sculptured by several stages ofactive layer detachment activation that are seen in concave slopes, specifically branched ravines, small thermokarst lakes on slopes, highly meandering streams with series of dammed lakes «threaded» on the narrow channel.

EVGENY P. LELIKOV, & YURY I. MELNICHENKO

Deep structure and Japan sea floor morphology

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A clear reflection of a deep-earth structure is an the Japan sea floor landforms. Large morphostructures with a different types of crust limited by deep-earth faults are defined in the Japan sea. It is a shelf with a continental crust 25-30 km thick, large submarine upland (Jamato rise, Korean plateau) with subcontinental crust 20-24 km thick, deep sea basins with suboceanic crust 11-14 km thick.
Deep-sea basins have a flat bottom surface at a depth (3000-3500 m) and are complicated by volcanic ridges. They are built by cenozoic basaltoides discharged in submarine conditions. The crust structure of large submarine uplands consists of basaltic, intermediate (or second layer) and sedimentary layers. Precambrian metamorfic, paleozoic-mesozoic sedimentary, volkanic-sedimentary and igneous rocks similar in age and composition to surrounding land formations form the intermediate layer. These rocks were generated in the crust structure thickness 30 - 35 km. Marine neogene-quaternary deposits have sedimentary thickness 0-2500 m.
The submarine uplands were broken into separate blocks by the north-easternward (Korean plateau) and sublatitudeward (Yamato rise) faults. The rift valleys also of north-eastern and sublatitude directions take place at the centre of uplands. Gradually they come to deep-sea basins. A step-block structure is typical for the surface of the submarine uplands. At the same time, upland blocks drop down toward deep-sea basins limited by sizable faults. The rocks of an intermediate layer are exposed on the sharp fault slopes. The basaltic volcanoes often are located in region of sizable faults. A gradual decrease of the crust thickness (from 24 to 18 km) the to ward deep-sea basins and rift valleys coincident with upland blocks along deep fault.
The difference between thicknesses of the modern crust and crust formed during formation of precambrian complexes and phanerozoic abbyssal and mesoabbyssal granitoids is a sign of a sial destruction.A magmatic erosion associated with a rise of mantle diapir in the Meso-Cenozoic time might work as the principal mechanism of the destructional phenomena which caused the formation of Japan sea basin. The destruction of the Japan sea area crust leads to the appearance of the special destructional morphostructures. The mentioned above submarine large uplands belong to such kind of morphostructures.

BERTRAND LEMARTINEL

Essai d'évaluation de la dénudation néogène des Monts Ibériques Occidentaux

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L'analyse correcte des taux de dénudation sur le long terme suppose que les produits érodés soient en totalité conservés en un lieu facilement accessible, ce qui est rarement le cas. La chaîne ibérique occidentale présente à cet égard un intérêt majeur: l'accumulation corrélative de son orogenèse néogène s'est faite dans les bassins autrefois endoréiques de l'Ebre et du Duero. Nous pouvons donc évaluer les vitesses de sédimentation, mais aussi, par le biais du calcul de la rapide déformation de la surface d'aplanissement fini-oligocène, la dénudation de cette moyenne montagne qui combine les traits d'une chaîne alpine et d'un massif en roches anciennes. Notre domaine s'avère en cela fort original.
Cette appréciation de la durée est rendue possible par la présence de microfossiles mammaliens dans le matériel qui remblaye les bassins. Loin d'être inscrit dans un *continuum* propre à satisfaire le mobilisme ambiant, le décapage de la montagne obéit au contraire à des rythmes saccadés

scandés par des ruptures brutales d'origine tectonique. Les épisodes bien identifiés et délimités dans le temps de soulèvement des *sierra* sinduisent des moments d'érosion accélérée. Celle-ci s'atténue ensuite rapidement et fait place à des processus beaucoup moins actifs pendant de longues périodes, alors même que de notables variations climatiques sont enregistrées. La commande tectonique, même dans cette modeste montagne, s'est révélée décisive.
L'ensemble des données permet d'ailleurs de comprendre non seulement les vitesses de la morphogenèse, mais également les fonctionnalités du géosystème. La région que nous avons étudiée se prête donc particulièrement bien à «la définition des interactions entre la tectonique et les modèles d'évolution sur large échelle et longue durée».

HARTMUT LESER[1] & UWE RUST[2]

Pleistocene and holocene sediments and palaeosoils of the Northern Namib Margin (Namibia)

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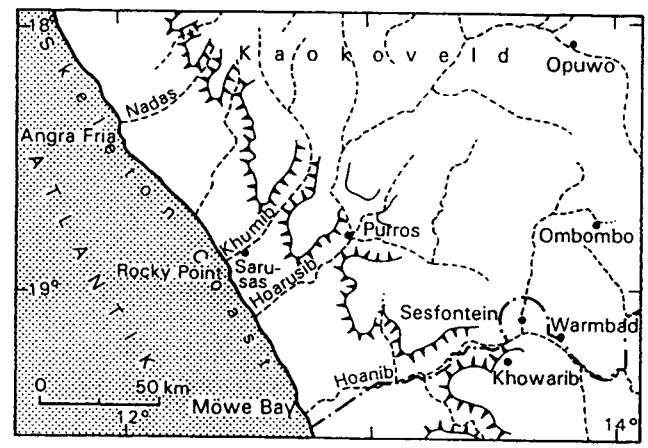
The Northern Namib Desert is part of the Kaokoveld area of Northwestern Namibia. The investigated area is situated between the Atlantic coast («Skeleton coast»; 0-50 mm precipitation p.a.) and the Great Escarpment (50-100 mm). The topographical catchment areas of the dry valleys of the rivers Khumib, Hoarusib and Hoanib extend to the plains of the Northern Nambian Highlands.
All rivers pass basins and mountain areas with transverse valleys. The basins are filled with silt sediments, which are presently being eroded. The age is unknown (presumably Pleistocene). Parts of the transverse valleys, e.g. gorges, bifurcations, valley widenings, are terrace landscapes with interlockings of tributaries and main river terraces. In accordance with Rust & Vogel (1988) three main terraces were identified in the Khumib-, Hoarusib- and Hoanib-catchment: 5-7 m, 10-12 m, 20-25 m. The terrace sediments verified a complicated sedimentary history. Fanglomerate debris, sands, silts and gravels (coarse crushed stones) are assembled. Especially at Hoanib river «White sediments» were found. They show a minimum thickness of 12-15 m with a mixed layer structure of tufaceosm limestone, cemented sands, limestone duricrusts and fanglomerate debris, as part of the Hoanib terrace landscape. Some fossile soils were found, too.
Terraces, fossil soils and sediment types prove:
– The main character of the climatic type did not change from Pleistocene up until today: The Namib and Namib margins consistently show semiarid or arid climates, that means probably for the last some hundred thousand years or more.
– Climatic changes are typical not only for large parts of the Pleistocene, but also for the shorter time of a terrace sedimentation cycle.
– During the terrace sedimentation cycle there were short wet periods with conditions for semiterrestrial to semiaquatic soils. That means short phases of extreme wetness existed.
The dating problem of terrace sediments and fossile soils is yet unsolved. Rust & Vogel (1988) and Rust (1987) estimated Würm age for their «Lower terrace» in accordance with the Homeb Silts (23-18 ka BP; dated by Vogel [1982]). The samples of the field trip in 1996 are currently being examined.



LAURENT LESPEZ

Alluvionnement et dynamique des paysages holocènes sur le cône alluvial de Kalambaki, Macédoine orientale, Grèce

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Le bassin de Drama constitue depuis le début du Néogène un fossé subsident qui fut occupé dans sa partie méridionale, depuis le Pléistocène moyen et jusqu'en 1930, par un marais (Ténaghi-Philippon). Les recherches géomorphologiques, sédimentologiques et géoarchéologiques ont pour objectif de comprendre la dynamique des paysages dans la partie centrale du bassin. Celle-ci est gouvernée par les apports sédimentaires du Xéropotamos qui ont construit le vaste cône de Kalambaki (12 km de l'apex à la partie distale et 16 km de large) et par les variations hydro-climatiques qui ont conditionné les battements du marais.
Les recherches géomorphologiques et la photo-interprétation (images aériennes et image Landsat TM) ont révélé l'instabilité et la forte dégradation de ce géosystème depuis l'Age du Bronze. Depuis cette époque les alluvions du Xéropotamos sont responsables d'une aggradation du cône qui dépasse souvent 3 m et fossilise de nombreux tells

préhistoriques et constructions antiques (Via Egnatia).L'analyse sédimentologique des coupes observées révèle l'alternance de périodes pendant les quelles les écoulements sont divagants(époque byzantine et ottomane) et de périodes pendant lesquelles les écoulements plus concentrés permettent le développement de sols sur de grandes surfaces (Néolithique, Antiquité).
L'alluvionnement sur le cône de Kalambaki dépend essentiellement de trois facteurs: (1) le degré de mise en valeur des sols dans le bassin-versant du Xéropotamos, (2) le contrôle des écoulements et l'intensité de la mise en valeur sur le cône, (3) les variations climatiques qui conditionnent l'importance et la fréquence des écoulements du Xéropotamos et le niveau du marais. Contrairement à ce que l'on observe souvent en Grèce, dans la plaine de Drama, les crises érosives et l'alluvionnement qui en résulte sont récents. En effet dans un espace pourtant mis en valeur depuis longtemps (Néolithique Moyen), la période d'aggradation maximale débute vers le VIIIème siècle ap. J.C et culmine vraisemblablement à la fin de l'époque ottomane (XVIIIème siècle). Cela s'explique par la conjonction de trois facteurs. A la fin de l'époque ottomane, le contrôle des écoulements sur le cône est inexistant car le système économique consacre les parties basses des dépressions à l'élevage extensif alors que l'intensité de la mise en valeur est maximale dans la partie amont du bassin-versant devenue espace-refuge pour de nombreuses populations grecques et que la détérioration climatique du Petit Age Glaciaire fournit des conditions à l'érosion et au transport tout au long du bassin-versant.

PASCALE LETURMY[1], JEAN LOUIS MUGNIER[1], & BERNARD DELCAILLAU[2]

Developmentand morphology of fault propagation folds

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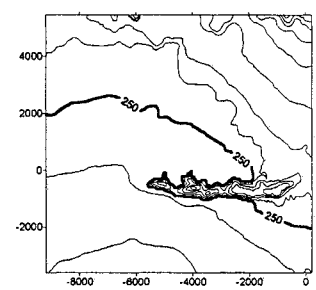
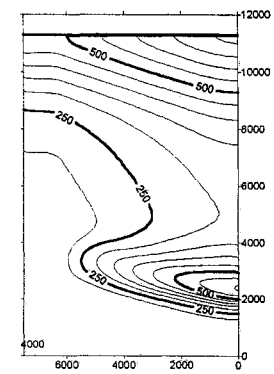
In fold and thrust belts, it is common to encounter asymmetric folds with one steep frontal limb: fault propagation fold is a common folding mechanism, to create that kind of structures. It occurs when a propagating fault loses slip and terminates up section by transferring its shortening to a fold developing at its tip. In some cases those fault propagation folds are developing forward and laterally, therefore cross sections from a part to another reflect time variations in the development of the structure.
Any step of the development of the structure can geometrically be describe with equations (Suppe and Medwedeff, 1984), and it allows us to modelise that kind of structures with a numerical method developed in Grenoble University. This 3D numerical method couples kinematic models with a superficial short range transport method which describe erosion and sedimentation. We compare the morphology of a fault propagation fold and of a fold related fault. It appears that for the same shortening the morphology of the two structures will be different as the high of the anticline and the volume of removed sediments are influenced by the deformation style. The lateral development of fault propagation folds induces an obliquity of the new structure compare to the orientation of the belt, this obliquity is as high as the lateral propagating velocity is low.
Comparisons between results of the model and structures of the Siwaliks of western Nepal have been performed. In this foreland thrust belt, the tectonic front is locally characterised with present fault propagation folds which are developing. They form small relieves which laterally die and disappear under the plain. In the Chitwan National Parc a small hill (400 m high and 10 km wide) is observed, the development of this structure influence the morphology of the piggy-back basin, and the location of the rivers. Numerical models have shown that this fold is developing over a short ramp, with a very thin sedimentary section involved in the thrust and a steep basal decollement. Near the Rapti River a more developed fault propagation fold is also observed, it lateral propagation causes a westward shift of the channel river, and it influences the distribution of the hydrographic system.



Topographic map of the Chitwan structure.



Topographic map of the modelled structure.

ANTONI G. LEWKOWICZ[1] & JAMES HARTSHORN[2]

Debris flow and slushflow activity in a high arctic mountain range, Ellesmere Island, Canada

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Debris flow and slushflow have produced extensive clastic deposits on the eastern side of the Sawtooth Range, Fosheim Peninsula, Ellesmere Island. Flow deposits extend up to 2 km downslope from the mountain front and cover about 10% of the long pediment slope. Small hillslope debris flow deposits (volumes of 10-10^3 m^3) and large channelized debris flow deposits (volumes of 10^3-10^4 m^3) aresimilar to

examples described in the literature for other high latitude and high altitude environments. However, many of the channelized flows are also affected by slushflow activity which has modified the sedimentological and morphological characteristics of parts of their tracks. Between 1991-1996, only one new deposit formed: a hillslope debris flow took place in July 1993 after two days of precipitation totalling 30 mm with a maximum intensity of about 8 mm in 12 hours.These values fall well below the threshold usually required to initiate debris flow, even in a permafrost environment.

Flow deposits were dated using a combination of photo interpretation and lichenometry. Lichen growth curves for the area were produced by correlating the sizes of *Rhizocarpon geographicum* and *Sporastasia testudinea* specimens with enlargement of ice-wedge polygon troughs.Geomorphic work by rapid mass movements was relatively uniform throughout the 20th century with average vertical transport estimated to be 17 x 10^3 Mg·m yr^{-1} km^{-2} (± half an order of magnitude), corresponding to a rock denudation rate of 0.05 mm yr^{-1} for the basins and peaks feeding the east-facing slopes.Channelized debris flow produced more than 70% of this transport. The maximum recurrence interval for large channelized debris flows was 30 years, substantially shorter than that reported from locations in northern Scandinavia and Spitzbergen.This suggests that weathering rates in the Sawtooth Range are relatively high, probably because of frost-susceptible bedrock and frequent freeze-thaw cycling.

To extend the record of rapid mass movement, six sediment cores ranging in length from 1.0-2.2 m were retrieved from a 2.9 km^2 lake (depth 140 m) that bisects the Sawtooth Range adjacent to the terrestrial study area.The sediment in the cores was predominantly non-laminated silt with low organic content and it accumulated at rates of 0.13-0.22 mm yr^{-1} during the Holocene. Distinct coarse-grained facies within this homogeneous material are indicative of rapid mass movements on the surrounding slopes. Unlike results from mountainous areas of Europe and elsewhere, the cores did not reveal simultaneous changes in mass movement activity rates around the lake basin as would be expected if regional climate change was a significant factor. This indicates that rapid mass movements in these cold, arid mountains are governed by processes acting at the local slope scale, and that periods of enhanced activity are controlled by a combination of intrinsic geomorphic thresholds and micro-climate.

FENGHUA LI & FUTAO LIU

On urban landform system structure of Changchun City and its formation, planning and construction

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Urban geomorphology is an independent borderline science between the geomorphology and urban sciences. Urban landform system structure is closely related to the urban formation, planning and distribution, precautions of urban geomorphological disasters and the formation of urban landscape. In this paper, we take Changchun city as an example in order to analysize the basic feature of urban landform system structure. Changchun is located in the transitional zone between the eastern mountains and the Northeastern Plain. According to the differences of landform system structure, Changchun city can be divided into six landform regions: Changchun platform, Xinlongshan platform, Yitonghe River valley, Xinkaihe valley, Jingyuetan hills and Xinlicheng reservoir. The city is properly constructed in the eastern part of the Changchun platform and in the central part of Yitongheriver valley. The surface of the platform is of wave-shaped and the slope is of appropriate. As it is made up of loess, it has a high bearing capacity. On the platform, there are many shallow valleys, which not only make drainage easy but also complicate the urban landscape and make a good condition for the proper construction of city and landscape distribution.

The forming history of Changchun city has passed several stages. Russian and Japanese colonists had fighted for and occupied this place early and later. They always choosed landform parts favorable for themselves, consequently being lack of general distribution, Changchun city has five blocks differently arranged. This brings some difficulties for later construction.

The downtown of Changchun City is on the eastern part of Changchun platform. Industry zone and depository zone were located outside the city according to the request of their land utilization and landform conditions. The valley is used as green land, the platform and valley suburbs are used as the production base of vegetable, side-food and agriculture and husbandry. Jinyuetan hills is a scenery zone in suburbs, it also can be used to develop fruit forestry. Xinlicheng reservoir is a water source of the city and can prevent flood, in the mean time, it can be used to develop fishery and forestry.

Changchun is well known as a forest and garden city, its greenland area rate is the highest in the whole country. We must make full use of the superiority of the landform system structure, keep and develop such a city scenery so that keep it harmony with modern development.

JIANSHENG LI

Major artificial geological calamities in Hainan, China

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Hainan Island is situated N18° 10'-20° 10', E 108° 37'-111° 03'; 180 km from southeast to northwest, 250 km

from northeast to southwest; covering an area of 33920 km^2. It is China's only large island in the tropics and the second largest inland of the country. In Hainan are found various terrains formed by different materials. With long ages of external geological forces and man's interferences diverse geological calamities have been caused. Those mainly artificially brought about are:

1. coastal erosion

The main cause of coastal erosion lies in the plunder of coral and coralreefs, which has resulted in 300 m of coastal retreat.

2. desertization of coastal belts

The cause, besides arid climate, is the depriving of forest vegetation by man. In some places, 26km of coastal shelter forests have been cut bare.

3. seawater invasion

Exhaustive pumping of underground water has been lowering the underground water level year after year. Seawater on theoaverage has invaded 100m.

4. mine cave-in

Cave-in and landslide resulting in casulties are long-standing threats. An example of surface landslide occurred in Changchang coal mining area on 1st May 1989.

Prevention and elimination of these artificial geological calamities is an urgent task calling for immediate action

YOULI LI, JINGCHUN YANG & SHIMIN ZHANG

Volcanoes in Eastern Datong Basin, Shanxi, China

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There are 29 volcanoes with different scales in the east part of Datong basin and they are seperated by a NEE trending fault into two parts.The conical volcanoes,composed of pyroclasts, are mostly located in the north part and the sheild volcanoes, composed of lava and pyroclasts, are in the south.The analysis of the chemical composition of 20 samples from different volcanoes shows that the volcanic rock are alkaline basalts in the north and tholeiites in the south. Stratigraphic evidence shows that basic lava and pyroclasts are embedded in the upper part of the Middle Pleistocene lake sediments or between the Middle and Upper Pleistocene loess. Lava and optalic layers under lava have been dated to be 290-98 kaBP with K-Ar and TL methods. Comparing with the distribution and the activity of active faults in this area, it is concluded that the distribution, eruptional type, lithological landform of the volcanoes have close relations to the active faults.

YOULI LI & JINGCHUN YANG

Tectonic geomorphology in the Heihekou Area, Zhangye, Gansu, China

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On the banks of the Hei River two natural profiles show the Heihekou fault,the boundary of the mountains in the south and the plain in the north. It is an active reverse fault and has a long history of activity.Based on the gravel form and lithologic measurement and statistics, it is found that the late Early Pleistocene gravels (about 880 kaBP) were right laterally offset about 5 km by the fault.The movement on the fault in the Late Pleistocene caused the terraces of the Hei River, T4 (13 ka BP), T3 (10 ka BP) and T2 (5 ka BP), vertically dislocated 9 m, 4 m and 2 m, and the rise between T4 and T3 was right laterally offset about 12 m.Combining all of these data, it is concluded that the Heihekou fault has been an active reverse fault with lateral slipping in the Quaternary; the average slipping rate is 5.78 mm/a since the late Early Pleistocene, and it has moved two times in the Holocene with a rate of 0.4 mm/a in vertical and 1.2 mm/a in right lateral,and the interval of the active events is about 5000 years.This study also shows that geomorphological study on the offset and dislocation of the alluvial systems and alluvial surfaces is an efficacious method to study active faults.

KARNA LIDMAR-BERGSTRÖM

Cratonic relief - a matter of uplift and exposure through Phanerozoic Time. Experiences from the Laurentian and Fennoscandian shields

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Although glaciated the Laurentian and Fennoscandian Shields show a relief differentiation in the basement surface, which cannot be explained by Plio-Pleiostocene glacial erosion except for in certain settings. The landform categories are mainly preglacial in origin. In the Swedish part of the Fennoscandian shield three main groups of landforms exist: extremely flat plains mainly without residual hills, undulating hilly terrain, and plains with residual hills. They have been shown toreflect specific times of exposure of the Precambrian basement during the Phanerozoic. In addition valley incision has occurred following uplifts. These data have earlier been used for conclusions on palaeotectonics in Sweden

Detailed surveys of landform categories, distribution of saprolites in the basement, and the relations of landforms and saprolites to cover rocks of different ages are important sources of information for interpretation of relief evolution. In Fennoscandia the extremely flat plains were formed in the Late Proterozoic-Early Palaeozoic, the undulating hilly relief mainly during the Jurassic and Cretaceous, and the plains with residual hills during the Tertiary. Kao-

linitic deepweathering and subsequent stripping were the main causes for the undulating hilly relief. Differences in bedrock composition and particularly structurally week zones were emphasized in the relief.
About the same landform categories as in Fennoscandia occur within the Laurentian shield. They might be explained in a similar way as the Fennoscandian landforms This conclusion is based on published data on deep weathering residues and remnants of Phanerozoic cover rocks. Thus the distribution of the landform categories could be of importance for reconstruction of Phanerozoic tectonic history also within the Laurentian shield.

DIMITRI A. LILIENBERG

Morphostructure and tectonic-climatic mechanism of the Caspian Sea level fluctuation

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The Caspian phenomenon results from the long-term interaction of the lithosphere, hydrosphere, atmosphere, global and regional factors forming an integral natural system. Any change in each of those components produces a direct impact on the sea level.
During the latest years the principally new data on a morphostructure, recent and contemporary tectonogenic mechanisms have been collected. As revealed, the leading role in deformation of the Caspian Depression belongs to lateral motions parented by a plate collision and stress coming from the Arabian Plate Projection, a pulsatory stress-strain mechanism controlling the Caspian Depression capacity (regardless to the actual water volume), oscillatory-wave vertical motions associated with the Earth's rotation fluctuation, existence of mantle plumes, etc.
The principal stages of the Pliocene-Quaternary evolution of the Caspian, its major transgressions and regressions are associated with the radical reorganization of the depression morphostructure, water balance and level. Characteristically that all transitions from the stable to unstable status were short, impulsive, and disastrous. The transgression stages are correlated (insignificantly leading in time) with the periods of general contraction and rootless folding causing general contraction, reorganization of morphology and basin capacity, new depression slopes development. Growing basins were discordantly superimposed over the older structural pattern. This is known for the Pontus, Akchagyl, Apsheron, Baku, and Khazar sea transgressions. The stages of deep regression (up to few hundreds of meters) correlate with the regional spreading, erosion of slopes, expansion of paleodeltas. The present-day morphology was formed in late Pleistocene-Holocene and does not match with that ofpreceding stages.
Climate changes are in certain correlation with tectonogenic stages. This fact points to an existence of the common tectonic and climatic integral mechanism. So the transgression and regression events in the Caspian can be considered as a regional answer to global changes of the geosystem. An analysis of instrumental data shows an oscillatory-wave nature of contemporary vertical motions in the Caspian region and adjacent areas. They reveal themselves in a quazi-periodic100-120, 50-60, 35-40, 25-30, 10-15, 5-7, 2-3, and 1-year cycles. That correlates with the analogue periodicity of hydrologic and climatic processes and can be traced in different aspects of endodynamics such as vertical and lateral crustal motions, seismicity, mud volcanism, dynamics of underground waters, variations in oil and gas production.
The lateral velocity of the tectonic motions is assessed to be in the range of 4-7 cm/year, the vertical velocity makes up 1-2 cm/year (for the cycles of few tens of years) and 3-6 cm/year (for the shorter cycles), i.e. 10^{-4} - 10^{-5}, same as an order of the Caspian level fluctuation. Tendencies of endo- and exegenous processes coincide in many points. For example, the anomalous drop of the Caspian level in 1929-40 and the rise in 1978-95 were coincident with activation of large-scale processes (seismicity) in the adjacent areas of northern and intermediate orogens (respectively) of the Alpine belt.
In «caspianlogy», the contribution of tectonogenic and climatogenic factors to the Caspian Sea level fluctuations were traditionally considered as independent from each other. Such a unilateral approach shall be changed to the integral concept of the tectonic and climatic mechanism with a different shares belonging to the tectonogenic and climatogenic components in different stages of evolution. To instrumentally monitor the named processes the project of the International Caspian Test Area has been developed.

JUNSHU LIN

Analyses on karst development responses to climate and the problems of Climatic Geomorphology

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Based upon the studies of solution rates with enviroments and the quantitative analyses of landforms in the South and North China, the respons model of seven equations have been set up. The model shows that the precipitation P is an important factor affecting on solution rate X except the lithological quantization value L and the relief quantization value G as follow:

$$In(X)=1/(\frac{4.210}{In(P)}+\frac{0.829}{In(L)}+\frac{0.295}{In(G)}-0.637)$$

However, the temperature as a threshold to bring the precipitation into play in the nature solution process which have been shown by another equation. In combination

with the morphological analyses by using the measurement and statistics in the different systems of climatic geomorphology, the equations suggest that the karst morphologic development is a complex responses process to the climate; which varite with the latitude and longitude; the upper structure layer are more stable and maintain the paleoclimatic morphology, but certainly lowering with the evolutional process.
The results and other geomorphological reasons suggest that the climatic geomorphology still is an important branch of geomorphology, though some geomorphologists no longer believe in simple association of climate and landforms recently.

JIUN-CHUAN LIN

Taiwan geomorphology and global tectonics

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Taiwan is an area of active arc-continent collision lying between the Philippine Sea and Eurasian plates, with the Philippine Plate moving north-west at approximately 70 km/yr. The aim of this paper was to identify and interpret the tectonic movements of Taiwan employing a geomorphological approach. The landforms of Taiwan closely reflect the tectonic history and stratigraphy. From analysis of the tectonic background of Taiwan, the nature of plate tectonics in Taiwan is demonstrated. An uplift-denudation, tectono-climatic interaction model for the Central Range and Coastal Range is also proposed.
Plate collision of Taiwanese domain began in the north of the island approximately 4 Ma ago. The landforms are thus a maximum of 4 Ma old in the north becoming progressively younger to the south, and of present-day origin on the south coast. An uplift rate of about 2-6 mm/yr has been established in several areas of Taiwan using a number of methods and approaches. The geomorphological features have evolved under the influence of tectonic evnironment and a monsoonal sub-tropical climate.

VLADIMIR M. LITVIN

Role of horizontal and vertical tectonic movements in global relief formation

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Tectonic movements play the decisive role in formation and development of Earth structural relief. According the new geomorphologic and geological-geophysical investigations, especially in ocean, the system of its influence, movement amplitudes and direction and observed results are explained the most logical in the plate tectonic conception where the horizontal movements are regarded as primary and the vertical movements - derivative from its. As it established the horizontal movements caused the Earth general morphostructural plan formation including the mutual position of the lihospheric plates, continents and oceans, different planetary and regional relief forms, and the vertical movements determinated the relief forms creation, its sizes, heights and division. Horizontal movements of lithosperic plates having global nature are the most considerable. The plate spreading, deep matter lifting and ocean crust increase take place in the mid-ocean ridge axes. The ocean plate subduction and continental crust formation take place in the island arcs, active continental margins and deep-sea trenches. The pilling up of crust layers, folding and moving over formation in the mountain systems take place at continental plates collision. The horizontal movements rates of the lithosperic plates were changed in Mesozoic and Cenozoic from 1-2 to 8-9 sm/year in different regions and times, and the movement amplitudes reach in present from 1000-2000 to 8000-10000 km. The subduction rates in deep-sea trenches correspond to spreading rates composing from 2-3 to 7-9 sm/year. As result of oceanic plate movements the submergence processes are predominated on the ocean bottom on the both parts of the mid-ocean ridge axes. Its axes are found on the recent depths about 2,6 km that is determinated by isostatic equilibrium between the uplifting mantle matter and load of the forming oceanic crust. These processes lead to formation of the mid-ocean ridges and oceanic basins as the global relief forms. The average rates of submergence in Mesozoic and Cenozoic were 0,02-0,04 mm/year and vertical movement amplitudes reach in present 4-5 km on the outlying oceanic basins. The similar amplitudes and submergence rates to 0,05-0,07 mm/year inducing by submergence of the peripheral oceanic plates are observed on the continental margins and in the sea basins of transition zones. At that time the island arcs made the active uplift caused by subduction processes with average rates 0,1-0,2 mm/year and amplitudes from 2 to 5 km and more from Neogene to Recent. The continental platform plains made the oscillating movements in all time that led the formation of the shields, low and rising plains, plateau and basins etc. The average rates of movements are 0,01-0,05 mm/year, and the amplitudes reach 4-6 km from Mesozoic to Recent. The young folding mountain systems as result of continental plates collision made the uplift to 6-8 km with average rates 0,3 mm/year in Neogene-Quaternary period that is observed on the levelling surfaces. The revive and rejuvenate mountain systems drawing into this process with block movements are characterised the similar rates of vertical movements but some lesser size. Simultaneously the tectonic movements have essential effect on the exogenic processes leading to structural relief modelling. The denudation prevailing on the continents is increased at the uplift, but the accumulation prevailing on the ocean bottom is increased at the submergence.

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Changes of the palaeolake shoreline of the central Qaidam Lacustrine Basin in the arid area of western China

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The Qaidam Basin, located on the northeastern Tibet Plateau in western China, is a great arid lacustrine basin. The lacustrin basin is about 2800 m above sea level and it covers an area of approximately 121,000 km^2, with lot of dispersed salt lakes and vast salt march and salt desert. Detailed basin analysis has proved that the center of subsidence, i.e. palaeolacustrine basin, in the basin was not stationary during its entire history.It was initially in the west of the basin during the Tertiary period, towards the end of this period (Pliocene), this center of subsidence moved to east, and during the Quaternary this center of subsidence moved further eastwards to the Threee-lake area in the middle of the basin where the thickness of materials accumulated during this time is in the range of 2000-3000 m.
According to the results of boundary ages determined palaeomagnetically and deposition rates of the typical facies obtained by sedimentological analysis, the correlation, subdivision and geochronological system of Quaternary deposits with 3000m thick in central Qaidam Basin has been established on basis of the biostratigraphic correlation. The Olduvai event and the M/G boundary are separately at depth of 880-710 m in Se Zhong-6 BH(bore hole) and the depth of 1460m in SeShen-1 BH.The yearly rate of accumulation is obtained for the following typical facies: 1) semi-deep lake facies, 0.45 mm/yr.; 2) shallow lake facies, 1.03mm/yr.; 3) lake shore facies, 1.28mm/yr.; 4) lake basin bog facies, 0.94mm/yr.; and 5) delta facies, 0.90 mm/yr.
The analysis of climatical indicators, including lithology, palynology, Cl^- content, $\delta^{18}O$ and so on indicates that the Qaidam Basin has been generally becoming drier and drier, with climatical fluctuations obviously controlled by the periodic changes of eccentricity of the earth orbit. In glacial, the ancient Qaidam lake tended to expand and climate was relatively humid. In interglacial, however, the lake tended to contract and climate was relatively dry. However tectonics is the critical factor controlling general developing trend of the Qaidam lake basin. On the basis of analysis of vertical facies of long cores, the paleolake's evolution of Qaidam Basin can be divided into three stages as follow: a) In the interval between 3.05 Ma B.P. and 1.95 Ma B.P.,the transgression were developed gradually; b) Transgression of lake happened widely from 1.95 Ma B.P.,especially after 1.35 Ma B.P.,the lake enlarge and deepen in water depth; c) Beginning with 1.00Ma B.P.,the lake contracted remarkably. Both the south shoreline and north shoreline moved a distance of 25 km to center of lake.
Present geomorphy of the lacustrin basin of the central Qaidam Basin has been gradully developed after the regression of the palaeolake shoreline in the central basin. The large lacustrine basin of the central Qaidam Basin has been separated into several salt lakes by the neotectonic movement and the underground deformation of structure during the late Pleistocene and by the climate becoming most drier during the Holocene.

ALEJANDRO LOMOSCHITZ[1] & JORDI COROMINAS[2]

Analysis of the evolution of the landslides using geomorphologic criteria. Applicability to the Barranco de Tirajana basin (Gran Canaria, Spain)

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The Barranco de Tirajana is located SE of Gran Canaria island. The role of the mass movements in shaping this basin has only been acknowledged very recently. Former theories suggested either a volcanic origin or a tectonic one. Since 1968 only the erosive genesis has been found feasible.
Up to 28 large rotational and translational landslides were identified whithin the basin, some of them over 1 km^3 (Lomoschitz & Corominas, 1992). Three different stages have been marked out in the landslide evolution (fig. 1). The most active period triggering landslides corresponds to the interval between 0.6 and 0.125 my ago (Middle Pleistocene) and redates the ages of the landslides that were formerly considered as starting 3.4 my ago (Itge, 1990). Most ofthe landslides are inactive at present. Recent activity is due to reactivation of the foot of a large ancient landslide in the Rosiana area, where four historic events have been recorded in 1879, 1921, 1923 and 1956 (Lomoschitz, 1995).

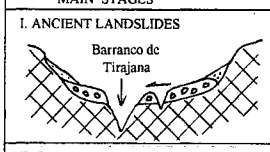
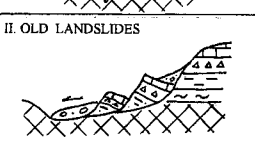
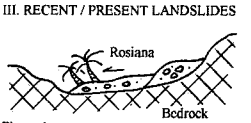
MAIN STAGES	GEOMORPHOLOGIC CRITERIA
I. ANCIENT LANDSLIDES 	- Bedrock appears below. - Hummocky surfaces and very eroded zones. - Large grabens filled with deposits. - High weathered rock masses, clay-silt rich matrix. - Middle Pleistocene (< 0.6 my.).
II. OLD LANDSLIDES 	- Well developed scarpments and tilted bodies quite unweathered. - Grabens partly covered with scree deposits. - Obturation deposits > 51.700 y. BP. - Middle - upper? Pleistocene.
III. RECENT / PRESENT LANDSLIDES 	- Well preserved forms, present drainage network invaded by landslides, clearly defined boundaries. - Small landslides located at the valley bottom. - The increase of bed load causes braided river channels. - Active landslides in Rosiana area, open scars, tilted trees, etc.

Figure 1.

JORGE LÓPEZ-BLANCO[1], LEOPOLDO GALICIA-SARMIENTO[2] & FELIPE GARCIA-OLIVA[2]

Hierarchical analysis of relief features in a small watershed in a tropical deciduous forest ecosystem in Mexico

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This study is part of a long-term ecosystem evaluation project performed in five small watersheds in a tropical deciduous forest in Western Coast of Mexico. The present study corresponds to a hierarchical analysis of slope features in one of such small watersheds (Basin No.1, with a extent of 15 ha).
The analysis considered four spatial scale levels: 1. Total watershed, 2. Facing-slope orientation (North-South), 3. Altitudinal ranks segmented by faults and, 4. Hillslope-Unit. Fourteen hillslopes units were delineated, which were grouped in four types according its geometric properties.
Two main faults divide the study watershed in three altitudinal areas. The upper one has flat and homogeneous hillslope units. The middle sector has steeper and convex hillslope units and the bottom (near basin-mouth area) has both steeper convex and steeper plane hillslopes.
The South-facing slopes are longer than the North-facing ones. Longer hillslopes have more slopes-breaks and South-facing hillslopes units are more different between them than others. The configuration of fluvial network was not explained at the total watershed level. The slope grade and the first-order subcatchment area are not correlated. However, the fluvial network is strongly influenced by the hillslope-unit morphology.
As a result, the analysis suggest that there are three different environments where both processes initiation of channels and water movement take different roles.

NINA VLADIMIROVNA LOUKINA

Le calcul des vitesse des mouvements néotectoniques par l'analyse des terrasses marines et fluviales etdes surfaces d'aplanissement

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L'escalier unique d' étagements du relief: des terrasses marines et leurs correspondres ou indépendences terrasses fluviales et aussi leurs surélévation par des surfaces d'aplanissement, contient l'information sur les mouvements néotectoniques des région concrètes. Pour le calcul des vitesses des mouvements récents les deux paramètres sont necéssaires: l'hypsométrie des étagements du relief et l'âge du chaqun d'entre eux.
Sous l'hypsométrie terrasses on comprend l'altitude relative de leur rebords au-dessus des niveaus de la ou de le lit des rivieres en mètres; sous l'hypsométrie des surfaces d'aplanissement - les altitudes maximales absolues de leurs buttes-témoins.
On définit l'âge des terrasses et surfaces d'aplanissement comme la fin de leur formation. Ce temps s'établit d'après l'âge des dépôts subaériens des couverturs, superposant des sédiments marins ou alluviaux sur les terrasses et des dépôts anciens ou bien des roches cristallins sur les surfaces d'aplanissement. Les dépôts sont datés d'après les données biostratigraphiques, palynologiques, archéologiques, etc., tenant compte des résultats d'analyse d'âge absolu. Ensuite les terrasses stadiaires sont corrélées aux étapes climatostratigraphyques par utilisation l'échelle mondial de chronologie absolut. C'est les fins des étapes climatiques définissent l'âge des terrasses et des surfaces d'aplanissemant. Chaque étape climaticque comprend l'interglaciation (ou la periode plus chaude) et la glatiation (ou la periode plus froid), la regression et transgression des mers et de l'Ocean Mondial, le cycle d'aridification et d'humidification, etc.
Pour calcul les vitesses des mouvements néotectoniques on construit les graphiques de dépendance d'altitude des terrasses et des surfaces d'aplanissement de leur âge absolu. Plus la pente de la courbe obtenue est douce, plus les vitesse de la fragmentation d'erosion sont petites et au contraire la vitesse de la fragmentation d'erosion est indentifiée à celle des mouvements tectoniques positive. Ainsi on établit les vitesses des soulèvments dès le moment du début de la fragmentation du niveau de crêtes.
À l'aide de cette méthode on étudiain des terrasses marines des rivages septentrionaux des Mers Noire et Caspienne, des terrasses fluviales et des surfaces d'aplamissement de la zone montagneuse de l'Eurasie Oriental et du Sud de la Siberie, ainsi comme des régions adjactens des platformes. Il est devenu claire que certaines systèmes montagneux etains des soulèvements 25 mln. a en arrière, à la fine de l'Oligocène (Kopet-Dag , Tien-Shan); l'autres - 10 - 6 mln. En arrière, à la fin du Miocène - au début du Pliocène (Carpates, Crimée, Caucase); quelques-uns ont l'âge pas plus de 5 mln. a (des systèmes du Sud la Sibérie) et il y a encore plus jeune (par example, Kamtchatka). Les extrémités des plateformes s'entraînaient en soulèvement il y a 700-750 milles a en arrière.
Le calcul des vitesses des mouvements néotectoniques etant realisé on a obtenu le résultat sur l'intensification des soulèvements tectoniques des systèmes montagneuses en Pleistocène supérieur (il y a 130 milles a) et pour les extrémité des platformes - à la deuxiéme moitié du Pleistocène supérieur (il y a 55 milles a). On marque les vitesses maximales des soulèvements tectoniques au Holocène. La vitesse moyenne de cette période est plus de 1 mm par an.

XIXI LU & DAVID L. HIGGITT

Recent changes of sediment yield in the Upper Yangtze, China

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Reservoir sedimentation is one of the many environmental problems associated with the Three Gorges Project in China.The rate and characteristics of sedimentation which directly affect the operating life of the reservoir is closely related to soil erosion and sediment transport dynamics in the upstream catchment and to the ability to manage the throughput of sediment-laden waters.Controls on recent temporal changes in sediment yield is one issue of concern to policy-makers engaged in the management of the sedimentation problem.Temporal changes in sediment yield have been examined using gauging data from stations in the Upper Yangtze basin between 1956 and 1987.Whereas many previous studies have concentrated on the trends in the main channel of the Yangtze the distributed pattern of temporal change across the whole catchment is complex. Time series analysis indicates ten stations with increasing trajectories of sediment yield and six with decreasing trajectories. The relationship between observed changes and patterns of runoff, land-use change and the construction of water conservancy projects is analysed and the implications of the changes discussed. It is suggested that human activities of deforestation and the expansion of agricultural land have had the most significant impact on sediment yield but that the importance of fluctuating rainfall and hence runoff cannot be excluded.

YANCHOU LU, AIGUO LIU, GONGMIN YIN & JIE CHEN

Infrared stimulated luminescence (IRSL) dating on river terraces

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In this paper we describe our effort to determine the age of some river terraces with infrared stimulated luminescence (Irsl) method. Our Irsl measurements on the zero-age samples collected from the surface of river terraces and alluvial flats reveal that the majority of equivalent doses of them are less than 1 Gy. This indicates river terraces can be dated by Irsl dating of certain sediments on them. As an example, three terraces in Gansu province were dated. Irsl measurement on three samples collected from these terraces has been conducted. The age of them is 27±2 ka, 53±1 ka, and 10,5±0.9 ka respectively, which represent the age of these river terraces. These data can be used to determine rates and patterns of local neotectonic movement.

JOSÉ LUGO, M. TERESA GARCÍA & OSCAR SALAS

Anthropic modifications in the south part of Mexico's Basin

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The topography of the endorheic basin of Mexico was shaped during the Pleistocene by intense volanic and exogenous processes which still continue nowadys. Human activities started a new transformation stage of such a topography in the 14th Century with the foundation of Tenochtitlan on islets of a lake, which later became Mexico City, actually one of the most populated zones in the world. The constant transformation of the topography was increased in the second half of the 20th Century. This has led to the presence of dangerous processes such as cracks now extending some tens of kilometers on the lacustrine plain of Mexico's basin, as well as landslides induced by human activities which result in increasing damages.

In the middle of this Century, the sinking phenomenon of Mexico City by water extraction from the subsoil was established. From the 70's, a cracking phenomenon was recognized on the borders of the City. At present, such cracks represent, as a whole, some tens of kilometers, and damage familiy housings and communication routes, mainly on the lacustrine plain. A transformation is occuring on the topography which changes the horizontal surface into an inclined, corrugated or unevenly surface to the center of the lake, with scarps even 60-80 cm high.

The cause of this phenomenon can be explained by natural factors such as the clayish and volcanic constitution of the subsoil, and the arrangement of strata with horizontal and vertical directions. Human influence is related to the drying of lakes, plains urbanization and water extraction from the subsoil. At the end of the 20th Century, we find ourselves in a situation of uncontrolled growth of the City, which means that we daily contribute to the transformation of the environment and to the increase of risks.

S.A. LUKYANOVA & GALINA D. SOLOVIEVA

Coastal erosion of Russia

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Erosion of sea coasts is a very actual problem under conditions of present-day sea level-rise and will be more important in future if a prognosis of the sea-level rise acceleration can become a real fact. The danger of coastal erosion is now known all over the world. In our days more than 45% the world shoreline experience wave erosion. This

problem is very important in Russia also. Mapping (scale 1:5,000,000) of genetic types of the Russian sea coasts shows that the erosional processes take place on all the sea coasts of Russia. Here there are many types of erosional coasts, including erosion of depositional features. These latter destructive coasts form 1.2% of the Russian shoreline. Thermo-erosional coasts have the most wide development due to climatic peculiarities of this country. They constitute more than 13.6% of the whole shoreline of continental Russia (about 70 000 km). Erosional-accumulative coasts, where erosional sectors alternate with depositional ones, are very representative in Russia and form 10.6%. The same part of the Russian shoreline belongs to the erosional type proper (10.6%), where wave erosion deals with various rocks. Average rate of erosion variates from 0.2-0.3 m/y to 15-20 m/y according to local factors. The most wave destructive coastal regions are within Arkhangelsk area, Kamchatka Peninsula and Azov-Black Sea region. In the whole, erosional coasts reach 41% of the Russian shoreline and this value will encrease under future acceleration of the world ocean level rise. Above mentioned quantitative data can be useful for management of coastal zone.

LAURA LUNA, ANGEL SERAFÍN & JOSÉ JUAN ZAMORANO

Detailed geomorphological cartography of «La Palma» cavern, Veracruz, Mexico

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This poster presents a topographical surveying and a detailed geomorphological cartography (scale 1:400) of «La Palma» cavern, located at the northestern slope of the Sierra de Atoyac in Tepatlaxco, State of Veracruz in México. Field work permitted the survey of the local topography using compass, clisimeter and tape. A preliminary geomorphological map was prepared for the semiactive level of the cavern after the topographical surveying phase and was later verified during field work. This cartographical representation allowed to locate and describe the erosive and accumulative karstic processes and derived features, and the factors which are controlling them (lithological, structural and hydrological).

The Sierra de Atoyac is an assimetrical anticline whose major axis has a NW-SE orientation. This mountain range is made up of rocks from the Upper Cretaceous (belonging to the Guzmantla Formation), whose limestones can be divided into different facies (platform, reef and pre-reef units). The stratum thickness varies between 0.3 and 3.0 meters and has thin layers of marlstone (from 1 to 5 centimeters). This structure is highly fractured and is affected by strong dissolution processes that give place to several karstic features.

The cavern development direction corresponds, in general, to the major axis orientation of the anticline. The cavern is divided into two gallery levels, which have a practically horizontal development. The upper level is 1,295 meters long, semiactive and has been explored and surveyed all along, whereas the lower level is still active. The karstic features and processes of the upper level are mapped and described on this poster. Features in the semiactive level are large fallen blocks, high water marks, mud deposits, pebbles and calcium carbonate precipitates. The associated processes with these features are: fallen blocks by gravity, fluvial erosion, dissolution and chemical precipitation. Along the cave through the karstic features and processes, litohological, structural and hydrological controls can be observed. The cave development is controlled by the limestone stratum orientation (NW 37°) and by the almost perpendicular fractures to this direction (27° to 50° NE-SW). The hydrological factor is revealed by some mud deposits and calcium carbonate precipitates located along the gallery. On the other hand, high water marks are visible over the cave walls which indicate a variable hydrological regime.

IOAN MAC & IOAN IRIMUS

The evolution of the riverbeds in conditions of tectonic basin situated on a platform morphostructure: the Transylvanian Depression

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The fluvial riverbeds are subjected to a complex controll, with both variables dependent on the fluvial system and independent of this one.
The Transylvanian Depression, situated in the middle of the Carpathian orogene, but on a structure of platform, covered by a thick sedimentary layer, presents a totally specific situation, of morphohidrodynamic controll. First of all the tectono-structural variable is expressed by two tendencies which affect both the phragmented basement and the layer, which is distarted by epirogenetic movements and diapir folds: the raising of territorial compartments which affect segments of valleys and subsident movements, which impose other relations between the erosional processes and the accumulation ones. In such circumstances the riverbeds present contrastant behaviours on neighbouring spaces: strongly alluviated segments in alternation with segments in which the main rock comes directly at the surface; portions in which appear floodplains, but also portions where these ones are lacking; portions with highly developed meanders, in which the corridors of meandration are well distinguished and portions in which the riverbeds follow an evolution with a relative uniform profile. Consequently, the tectonic reflex of both the basement and the layer, is expressed in the present physiognomy, structure and dynamic of the fluvial riverbeds, in differentiated shapes, from place to place.

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Aspects of weathering and landforms evolution on gypsum slopes and ridges of Sicily

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Most of the papers dealing with the geomorphological evolution of surfaces in gypsum rocks develop the analysis of the erosional forms originated by mass wasting, by fluvial and by karstic processes. In particular it is possible to find information about landslides, fluvial valleys, blind valleys and dolines.
Aim of this paper is to discuss relatively neglected aspects related with the weathering latu sensu of the outer layer of the gypsum rock, especially in correspondence of the denuded slopes and ridges.
In western Sicily we have found ideal conditions for the study of these aspects. In fact there are large rocky surfaces without a soil cover as a consequence of the soil erosion induced by forest clearing, fires, sheep and goat grazing. Macro-crystalline, alabstrine gypsum, laminated balatine and arenitic gypsum outcrops widely. Between the most interesting areas we remember the large slope of Serra Balate, south of Palma di Montechiaro and some reliefs in the neighbouring of Sant'Angelo Muxaro (f.i. Monte Mpiso).
On most of the surfaces it is possible to recognise a «weathering crust» characterised by a polygonal fissuring and other small forms indicating phenomena of increase of volume of the outer rock mass for a thickness between some decimetres and some metres. The development of this crust is not controlled by the bedding or other structural features, even if sometimes one or more sides of certain polygons correspond to previous fracture lines.
Inside the crust there is a clear evidence of the tendency to the sealing both of the previous and of the new formed fissures.
The morphological types recognised on the rocky surfaces are: a) the rocky polygons, often with bended fringes, b) the gypsum bubbles, c) the pressure ridges, d) the pressure humps, e) the pancakes, f) the pressure pans and the pressure half pans, g) the steps.
The size of these forms is between some decimetres and some tens of meters. The largest bubbles are more than 10 meters in diameters and 50 cm in high.
In some areas it is possible to recognise «mega - bubbles» in form of small domelike hills with diameters of some tens of meters and highs of some meters. On some of these forms a well developed polygonal crust is also recognisable. A spectacular group of mega-bubbles constitutes a small ridge near to the houses «Salamona» not far from Muxariello on the road to Sant'Angelo Muxaro.
The summits of many hills in gypsum may appear similar to the mega-bubbles. These domelike forms show different sizes, from some tens to some hundreds of meters in diameters. The domelike forms are not controlled by the dip of the gypsum beds; in fact those have been found also on blocks with steeply deeping or vertical beds. On most of the dome summits a polygonal fissuring with pressure structures underline that the outer layer is evolving as a «weathering crust» characterised by processes of increase of volume.
However, it is not possible to explain the evolution of these domelike summits only with the bulging phenomena of the outer layer. The genesis of this type of form is surely the expression of a homogeneous behaviour of the rock in comparison with the erosional processes. These forms may remember some domelike summits in granite rocks. Probably, it is just the formation of the «weathering gypsum crust» which favours the development of the domelike forms trough the creation of isotropic field of stresses, with reference to the central part of the relief. The weathering crust minimise, in this way, the influence of the pre-existing structural elements, like the bedding planes and the fractures.

In relation with the existence of this weathering crust, the epikarst in gypsum is not well developed. However local situations exist with absorbing cavities both inside bubbles and pressure ridges. An interesting aspect of this epikarst is that while most of the pre-existing discontinuities are sealed near to the surface they tend to be open at the depth of a few meters. This aspect is in accordance with the model of volume increasing of the outer layer.
The causes of this changing of the characters of the outer rock layers are not jet well explained. The explanation of most of the Authors that they are the result of the transformation of anhydrite in gypsum are probably simplicistic. The mineralogical analyses carried on in some of the studied areas reveal that the anhydrite is present only in a very small amount.
Between the other processes that could explain the increase in volume we list: the transformation gypsum - bassanite, the recrystallization of gypsum (perhaps also in connection with the annual cycle of the porosity water), an increase of porosity in consequence of the tensional relaxation, the phenomena of thermal dilatation, a plastic deformation linked with a rearrangement of crystal's location, a combination of more different processes.
We are planning specific research works to clarify the more effective processes involved in this peculiar morphological evolution.

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Erosion processes and land degradation episodes during the last 3,000 yr at the Axum Region (Tigray, Northern Ethiopia)

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The region of Axum, in the province of Tigray, Northern Ethiopia, is characterized by a long established agricultural background, considered to be one of the oldest in the African Continent (over 2,000 years). The effects of such human disturbance in combination with other external environmental stressors, such as climatic variability, can be found in slope deposits and in particular at tributary infilled valleys, where sequences of coarse materials are interbedded with buried soils.
The study of land degradation processes and its causes involved reconstructing the human and natural environment during the late Holocene, using mainly geomorphological and geoarcheological techniques.
Stratigraphical analysis of several infill valleys enabled the identification and characterization of three main land degradation episodes, the oldest one dating 2250±190 yr BP, corresponding to the first large scale human intervention in the area: introduction of new technologies such as the iron-tipped plow, and new plants such as barley and wheat. Regarding the other two episodes, the first one can be attributed to the declining period of the Axumite Kingdom (ninth to eleven centuries), whereas the second one was particularly active during the eighteen-nineteen centuries.
During the last five to six decades, geomorphological evidences reveal a sudden increase on erosional activity, affecting mostly slopes, and in the last 30 years shifting towards the valley floors, producing deep incisions at the infill valley deposits and channel metamorphosis. During this period two important events can be distinguished: the first, large-scale deforestation of 1936-39 and the changes on land tenure and property size, produced after the 1975 rural reform.

MARY ANN MADEJ

The development of longitudinal channel bed patterns

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Following large floods and large inputs of sediment in 1975, the channel bed of Redwood Creek became almost flat and featureless. The river thalweg was surveyed in three reaches in 1977, 1983, 1986, and 1995. One reach degraded from 1977 to 1995, one aggraded, and one remained about the same. In 1977, variation in bed elevations was low and channel bed elevations showed little periodicity. During the subsequent 20 years, channel bed elevations show increased variance and the channel bed has developed patterns of distinct periodicity, with shorter wavelengths through time. The development of these bed patterns in a gravel bed river contributes to channel roughness. Roughness in gravel bed rivers is generally defined only in terms of a characteristic grain size, but larger scale roughness factors (bed clusters, gravel sheets, bars, pools and riffles) also contribute to flow resistance.
This study used a statistical analysis of series of bed elevations as a method to quantify changes in bed roughness and bed pattern over time. The hypothesis tested was that a series of bed elevations is random after large sediment inputs and becomes both more variable and more systematic through time. However, longitudinal patterns in Redwood Creek are neither perfectly random nor perfectly regular because of the interaction of random processes (i.e., tree falls causing pools) with processes producing periodic patterns (such as alternate bar formation).
Channel widths in the study reaches vary from 60 to 110 m, median particle size D_{50} ranges from 15 to 32 mm. The river has low sinuosity (1.03 to 1.10), with an alternate bar planform. Typical bar lengths are 500 to 650 m.

Variability in bed elevations was evaluated using the standard deviations of detrended thalweg elevations for each study reach. Logarithms of the thalweg elevations were used to obtain a normal distribution. The length of each survey transect was about 3000 m. Standard deviations increased steadily after 1977, and then, in the degrading reach, leveled off after 1986. Pool depths were significantly deeper and pool spacing was significantly closer in the degrading reach than in the aggrading reach of river. Average pool spacing was three times the channel width. Not only did pools become more frequent and deepen, and riffles become more prominent, but finer scale undulations in the bed also developed. Such heterogeneity is important for providing habitat complexity for aquatic organisms.
Pattern development was analyzed by the use of semi-variograms and correlograms to test for spatial autocorrelation. Such an analysis of channel pattern needs to be designed at a scale capable of discerning critical phenomena. In this case, pools and riffles form critical aquatic habitats, and so a minimal discernible length of 10 m was chosen, as it is less than the length of pools and riffles in this particular system.
Bed surface elevations were first linearly interpolated to obtain similar spacings of about 10 m. The spatial autocorrelation function was calculated for distance classes (lags) of 10 m to a maximum lag of 1000 m. Initial results based on semi-variograms and the spatial autocorrelation coefficient Moran's I showed the development of both fine scale and broader scale spatial autocorrelation in the channel bed through time. Fine scale (< 50 m) correlation appeared first, probably due to localized processes such as scour around woody debris and bedrock outcrops forming pools. Later larger features at the scale of alternate bars became better defined. Still later, in the degrading reach, spatial correlations at an intermediate scale (200 to 350 m) emerged.
In conclusion, both variation in bed elevations and their spatial characteristics can be used to characterize the development of channel bed pattern on a reach scale after large inputs of sediment. The scale and degree of pattern development differed in aggrading and degrading reaches of the river channel.

ABDEL-MONEIM A. MAHMOUD

Paleodrainage and prehistory settlement, Farafra Depression, Western Desert, Egypt

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The Farafra Depression is located between Lat. 26° 40' to 27° 30' North and Long. 27° 30' to 28° 40' East at the western Desert, Egypt. It is chosen to illustrate the dependence and response of prehistoric human settlement to the occurrence of surface water durng the humid episods. The first phase in the eaerly Holocene, ended at about 8000 bp, while the two others correspond to mid-Holocene moist intervals (5900-5000 and 4800-4600/4500 BP). The onset of an arid trend in the central Sahara not later than 4500 BP, may have led people to move from the inner Sahara towards the Nile Valley.
The major trends of the paleodrainages in the Farafra depression are directed mainly towards NE, NW and SW directions. These drainages played an important role not only for making a permanent playa lakes but also for sculpturing the depression itself promoting the Karstic activities. Also the geomorphology played a role for protecting some of these playa in the depression. Most Neolitic settlements found out around these playas.

GIVI M. MAISURADZE

The role of young volcanism in the formation of the relief in Georgia

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In the formation of the present morphologic features of the territory of Georgia considerable role had tectonic movements and volcanism which revealed at the lete-orogenic stage of the Alpine geotectonic cycle. Volcanism took place in subaerial conditions, had specific areal type of eruption, and manifested itself, with some interruptions, in all geotectonic zones in Georgia during the Neogene and Quaternary. Sublatidudinal interzonal and submeridional tranversal deep faults controlled magmatic cycles of the Mio-Pliocene and Late Pliocene-Pleistocene. Especially distinctly the role of volcanism in morphogenesis revealed within the Transcaucasian tanversal uplift, particularly in the central segment of the Greater Caucasus and in the South-Georgian upland (the Lesser Caucasus). Accumulation of pyroclastic and effusive material of great thickness led to the relative leveling and inversion of relief. At the places of the intensely dissected erosional-denudational relief on the Paleogene-Neogene substratum were formed volcanic uplands (Keli, Erusheti, Javakheti), lava plateaus (Akhalkalaki, Gomareti etc.) and flows infilling paleo-valleys of the rivers Khrami, Mashaveri etc.
Some Alpine morphostructeres of the Greater and Lesser Caucasus controlling the pattern of ancient hydrographic network were buried under lava and pyroclastic formations. The inversion of relief resulted in rebuilding of hydrographic network of such large rivers as the Mtkvari (Kura), Khrami, Aragvi etc. There appeared new volcano-accumulative watershed astructural ridges of meridional

trend (the Arsiani, Samsari, Javakheti). A specific type of volcanic relief with monogenic and polygenic volcanoes of central type was formed with which a great amount of piroclastic material, lava sheets and lava flows are connected.
The age of volcanic relief is Mio-Pliocene (Sarmatian, Meotian, Pontian) and Eopleistocene-Pleistocene) in the South Georgian upland, and Antropogene in the central part of the Greater Caucasus. The last volcanic eruption in Georgia took place 6000 years ago in the Kazbek massif.

STANISLAV A. MAKAROV

Soil avalanchings in the Baikal Region

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Soil avalanchings from slopes that occur in the mountain ridge of Lake Baikal, refer to major natural catastrophes, causing destructions of engineer constructions. Depending on the geological structure of the slope sediments in the Baikal Region, three types of soil avalanching are distinguished:
Type 1. Soil avalanchings forming in gently sloping narrow gullies of the run-off in eluvial-deluvial sediments, having a foliated structure (fig. a). Section of the sediments (from top to bottom):
– the first layer: gruss-detrital sediments, filler - sand loam, content 30-40%, sand loam filtration coefficient 0.06-0.45 m/day, and layer thickness up to 0.6 m;
– the second layer: sand with inclusions of gruss and detritus, sand filtration coefficient 2-4 m/day, and layer thickness from 0.5 to 5.0 m;
– the third layer: ledge rocks greatly decayed and seamy.
The filtration rate in the second layer is several times higher than in the first; therefore, long-lasting and intense rains give rise to ground slope run-off in the second layer which produces a hydrodynamic upthrust of the first layer in the lower part of the slope, as a consequence of which water-saturated slope sediments go unstable, and soil avalanching sets in.
Type 2. Soil avalanchings that form in glacial sediments above their contact with solid rocks. Downward the slope they transform to mudflows, with well-defined courses in eluvial-deluvial sediments (fig. b).
Type 3. Soil avalanchings that form in valleys of temporary water currents, with the thickness of loose sediments ranging from 5 to 10 m (fig. c)
Because of the complicated and diverse character of the natural conditions of the Baikal Region, as part of further investigation the types of avalanchings identified here will incorporate not only intermediate forms of soil avalanchings but also, possibly, new ones.

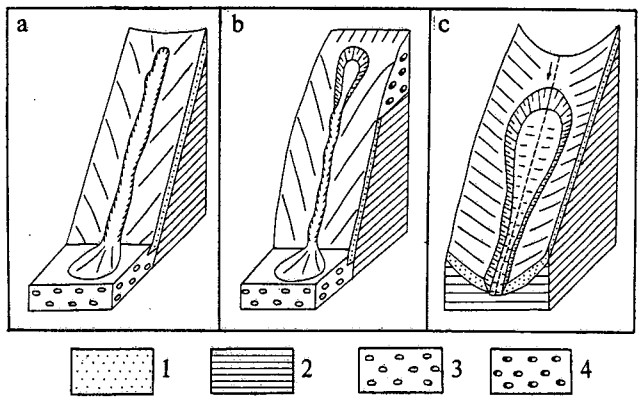

FIG. Types of soil avalanching in the Baikal Region.
1 - eluvial-deluvial sediments (block-detrital with gruss-sand loam filler; 2 - ledge rocks; 3 - alluvial sediments (gravel-pebbles with sand filler); 4 - glacial sediments (boulders, blocks, pebbles, and detritus in the loam-sand filler).

JONI MÄKINEN

Sedimentation in a complex subglacial environment in Säkylä, SW-Finland

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The lithofacies and depositional history of three stratigraphic sections excavated in late Pleistocene glacigenic relieftype in SW-Finland is described. Sediments in the excavation appeared to be very variable and immediately invoked detailed study. The study site is located in the community of Säkylä near the fracture line which cuts the bedrock threshold between Jothnian sandstone depression and higher rising Svecofennidic metamorphic and igneous rocks.
The study site in association with hummocky moraines represents sedimentation within meltwater catchment area of 10 km long tributary esker joining the 200 km long esker chain in SW-Finland. Sedimentation has taken place in the warm-based ice margin which terminated in glaciomarine conditions with frozen bed zone near the grounding-line.
Deposits consist of complex subglacial tunnel deposits associated with sliding bed conditions, deposits from hyperconcentrated flow with very local rock material, quarrying and deformation of glaciofluvially transported material by closure of tunnel walls. These processes were followed by sedimentation of sandy deposits during the phase of rapid melting and flow in open-tunnel conditions, where large blocks of local rock dropped from the tunnel roof. Later deposits were influenced by sliding ice bed near the ice margin, change in flow conditions leading to sedimentation of subglacial lacustrine deposits, deposition of subaquatic subglacial melt-out till and deformation due to oscillation of grounding-line zone and finally partial erosion by seashore processes after continuous land uplift.

This kind of very complex coexistence of subglacial processes and related deposits is rarely described in the literature. The interpretation of the evolution of the depositional environments is based on detailed lithofacies descriptions and classification, consideration of depositional and erosional processes, and building of a framework to explain vertical and lateral changes in the sections.
The conclusions made here do not include any model, because this study is made within single formation and can therefore act only as a local summary. The study can, however, be helpful in ongoing sedimentological field work which ultimately requires that models are established, verified in the field and finally rejected or accepted as a useful tool for further study.

OLIVIER MAQUAIRE

Les glissements de Villerville-Cricqueboeuf (Calvados, France). Douze années de surveillanc: fréquence et magnitude

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Les versants littoraux du Pays d'Auge sont soumis à une importante activité de mouvements de terrain. En janvier 1982, un glissement majeur a occasionné de nombreux dégâts et un recul de la couronne des deux cirques qui enserrent le bourg de Villerville: le cirque des Graves, à l'ouest et les Fosses du Macre, à l'est sur la commune de Cricqueboeuf. A partir de fin 1984, l'installation d'un réseau de surveillance permet de suivre, selon des pas de temps plus ou moins rapprochés, les déplacements en surface et en profondeur et les battements piézomètriques en relation avec les conditions climatiques. Le dispositif de surveillance allégé sur Villerville depuis 1990 a été complété fin 1991 par un nouveau réseau de mesures topométriques à Cricqueboeuf.
Depuis une douzaine d'années, les enregistrements discontinus des différents paramètres permettent de mettre en évidence une activité quasi-permanente avec de courtes périodes de forts déplacements liés à des excès pluviométriques pendant les semaines ou les mois précédents l'événement, entraînant une forte élévation du toit de la nappe phréatique telles que février 1988, l'hiver 1992-1993 et janvier 1994, et de plus longues périodes de faibles à très faibles déplacements pendant des périodes de déficits pluviométriques où l'on assiste à un tarissement et à un abaissement saisonnier ou pluriannuel de la nappe, en particulier entre 1988 et 1992. Parallèlement, on observe un recul de la couronne de glissement, en particulier aux Fosses du Macre avec un recul de près de 8 m en quelques dix années.
Une étude dendrochronologique et dendrogéomorphologique a également été entreprise. L'observation de la forme et de la dimension des arbres ainsi que de la forme et de la largeur des anneaux de croissance du tronc et des branches a permis de mettre en évidence des périodes et des secteurs particuliers d'activité en relation avec les données climatiques disponibles depuis le début du siècle.

HAMPIK MAROUKIAN[1], DIMITRIS PAPANASTASSIOU[2] & KALLIOPI GAKI-PAPANASTASSIOU[1]

Palaeogeographic evolution and seismotectonic implications of the broader area of Eurotas river (Greece) during the Quaternary

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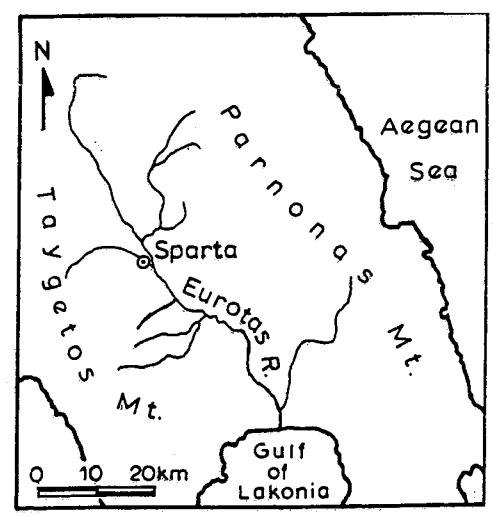
The valley of Eurotas, located in southeastern Peloponnesus, is bounded by the mountain masses of Taygetos (2407 m) in the west and Parnonas (1935 m) in the east which are composed mainly of limestones and to a lesser degree by phyllites and flysh.
Mount Parnonas exhibits a relatively gentle karstified palaeorelief, crossed by a well developed drainage network which is controlled to a significant degree by the prevailing fault tectonism of the area. On the contrary mount Taygetos has a more rugged topography, a more limited parallel drainage system where the main channels are intensively downcutting today due to recent uplift.



In the Late Pleistocene - Early Pleistocene, the morphology of the area was completely different than that of today. During this period, Parnonas was much higher than Taygetos and due to the intensive erosion extensive alluvial fans were formed west of it blocking the natural southerly course of Eurotas and forming a lake.

In the Middle - Late Pleistocene, the tectonic activity of the area shifts to Taygetos. The ensuing intense erosion results in the development of alluvial fans towards the east covering the older fans of Parnonas.
The tectonic activity of Taygetos is still going on until today. Its central part in the east exhibits triangular and trapezoidal facets separated by wine glass canyons. At the base of the eastem face of Taygetos and for a distance of about 20 km a fault scarp is observed whose height reaches at some points 10m. Correspondingly, the torrents just before their exit from the mountain present a series of knickpoints.
All of the above features support the supposition of recent seismic activity although the last destructive earthquakes are known to have occurred in the 5th and 4th B.C. centuries.

ALAIN MARRE[1] MICHEL LAURAIN[2]
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Les mouvements de terrain: un processus efficace qui explique le faconnement des grandes vallees des regions temperees: l'exemple de la Vallee de la Marne en Aval d'Epernay, France

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En aval d'Epernay, la Marne creuse sa vallée dans le revers de la Côte de l'Ile de France. Ce plateau est constitué par les sédiments (calcaires, argiles, etc.) de l'auréole tertiaire du centre du Bassin parisien. Ils reposent sur la craie de Champagne d'age crétacé. La surface du revers est à une altitude de 240 à 245 m. La Marne coule à 70 m. Large de 4 à 5 km au sommet des versants et de 1 km dans la plaine alluviale, c'est là une très grande vallée dans laquelle, chaque section de un kilomètre, correspond à un volume de 340.000.000 à 510.000.000 m^3 de matériaux qui ont été évacués pendant le Quaternaire. Il s'agit là, de volumes considérables que le seul ecoulement des eaux ne semble pas pouvoir réaliser, meme pendant les périodes froides du Pleistocène.
La cartographie géomorphologique de cette vallée a permis de montrer qu'il existe, sur ces versants, une alternance spatiale de formes «lisses» (terrasses et versants régularisés) et de formes «rugueuses» (glissements de terrain et coulées). De plus, on constate que les glissements et leurs coulées associées occupent une large part de ces versants. Enfin, toutes ces formes naissent à partir des formations meubles et plastiques d'âge tertiaire et descendent souvent, grâce à des vallons taillées dans la craie, jusqu'au niveau de la plaine alluviale. Une chronologie relative des formes dues aux mouvements de terrain par rapport à celles dues a d'autres processus (les terrasses et les versants regularisés) a permis de montrer que les glissements de terrain et les coulées ont fonctionné à plusieurs reprises pendant le Quaternaire.
On peut ainsi constater que, grâce au creusement linéaire réalisé par la Marne, un déséquilibre s'est maintenu sur les pentes de cette vallée. Aidé par une lithologie favorable, cette instabilité a permis le déclenchement de mouvements de terrain successifs qui ont amené jusque dans le lit de la rivière de grandes masses de matériaux. C'est ainsi que de très gros volumes de sédiments déstructurés ont pu être ensuite exportés vers l'aval. Il y a là un enchaînement de processus, où les mouvements de terrain jouent un rôle essentiel. C'est ainsi que de très gros volumes de matériaux ont pu descendre le long des versants, être évacués et contribuer à façonner la très large vallée qu'occupe la Marne.
Actuellement, on constate que cet enchaînement de processus n'est pas éteint: les années pluvieuses (1988, 1994) connaissent toujours des mouvements qui peuvent se traduire par des dégats dans le vignoble, sur les routes et mêmes sur les habitations. Ainsi un processus efficace qui est responsable du façonnement des versants depuis le début du Quaternaire, est devenu, aujourd'hui un aléa à l'origine de risques majeurs.

SIDYA MARY

Morphology and dynamics of beaches along the Black Sea shores

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Beaches as a constituent element of the coastal zone are widely spread along the shores of the non-tidal Black Sea. Sandy beaches are most frequent within Ukraine and here they are least of all studied. Sediment deficit and high wave energetic potential are the most important conditions for their development. These conditions were formed during Holocene history of the Sea basin. Natural deficit of beach-forming fractions conditioned significant spreading of abrasive processes which cause great damage to industrial, transport and agricultural units. That is why many shores of the Black Sea require protection and stabilization. And beaches are an obligatory detail of any effective shore-protective structures. In this connection modern morphology and dynamics of sandy beaches is considered from the point of their shore-protective importance.
The following methods were used as main for the investigations: long-term natural morphodynamical and lithodynamical monitoring, topographycal surveys with the basic scale 1:250 and geomorphological profilling, nevelling, sampling of sediments and their laboratory processing, laboratory analysing, processing and its computer interpretation.

Large amount of information about morphology and dynamics of sandy beaches in the coastal zone of the non-tidal Black Sea mainly on the example of Ukrainian shores has been accumulated and processed. Two main types of beaches were considered: with lean-to (foreshore) profile and two-sloping (gable) profile (with foreshore and backshore sides). Beaches containing in themselves from 10 to 40 m^3/m of sand prevail. Numerical correlations between linear and volumetric parameters of the beaches were obtained. It was found out that the parameters are relatively stable during long-term period. Under the impact of wave regime during storms and some seasons beach undergo short-term deformation values fluctuate around certain average value are different in correspondence with concrete local conditions. This conclusion was elaborated for coast-protective constructions of different types, which gives opportunity to optimize planning, management and operation of coast-protective structures.

In the paper in succession are given: conditions of development and definition of sandy beaches, morphodynamical types and development in duration of time, the results of the study of correlation between same parameters of natural beaches sizes. Then we consider the problem of creating and dynamics of artificial beaches from the position of correlation of beach dimensions and wave energy regulation. Such approach has practical importance for projection, management and operation of the beaches as a means of abrasive and erosive shore protection against wave destruction. In natural conditions of the Northern Black Sea coastal zone sandy beaches are subjected to the action of storm waves from 0.5 to 5.1 m high. The most effective waves higher than 1.25 m, act during 470-850 hours a year in the average for a long-term period (5.4-9.7% a year) in different sectors of the coastal zone. The average reoccurence of wave height more than 3 m is 0.04-0.07% (or 35-62 hours) a year. The strongest sandy beach deformations take place during the action of the waves higher than 1.25 m. As a rule stormy waves are steep, usually 0.03-0.08. The main conclusions are:

– As a result of long-term instrumental measurements sandy beaches in the coastal zone of the non-tidal Black Sea were studied.

– The amount of drifts contained within the beach is its universal dimension, numerical values being different within various alongshores lithodynamical cells within a coastal zone.

– The parameters of sandy beach are closely interconnected with rather high coefficient of correlation, which indicates of close connection with the full complex of forming factors and processes.

– Relative stability, constancy of long-term dimensions of sandy beaches preserve against the background of essential short-term variations around the average value within strictly definite limits.

– Regularities of natural development of beaches must be used in the processes of planning, management and exploitation of shore-protective structures. In this connection three main scenarioes taking into account the correlation of dimensions (volume) of artificially created beaches, and ammount of wave energy acting on beaches: artificial increase of protecting beach sizes by means of artificial filling with preservation of non-changed wave energy flow; artificial reduction of wave energy amount with preservation of previous natural supply of drifts on protecting beach; artificial reduction of wave energy amount and increase of protecting beach dimensions by artificial filling of drifts.

– Numerical values of lithodynamical cubic content and limits of short-term deformations of beach parameters are different in various alongshore lithodynamical cells and sites of the coastal zone.

REMO MASSARI & P.M. ATKINSON

Modelling susceptibility to landslide: an approach based on individual landslide type

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Landslide hazard mapping amounts to map the probability of landsliding within a given region (that is, where landslides might occur in the future) in a given time scale (Hansen, 1984). This may be achieved using both direct and indirect approaches. A landslide map may be used to some extent as a landslide hazard map because slopes that have already failed are likely to be composed of weaker material that may be subject to further movements. However, a landslide map fails to assess the landslide hazard for slopes that have not yet failed, and generally overestimates the hazard for areas that have already failed. Therefore, it is generally necessary to attempt to map the landslide hazard.

A landslide hazard map should include an indication of the time scale within which a particular landslide is likely to occur. In practice, data on the temporal dimension of the landslide hazard are difficult to obtain, since landslide triggering is usually due to external causes (rainfall or earthquakes). For this reason landslide hazard maps are usually simple landslide susceptibility maps (Carrara & *alii*, 1996). When attempting to map landslide susceptibility, one never has data on future landslides. The statistical model is constructed between data on past landslides and a set of selected independent variables. As a consequence, the estimated susceptibility is likely to be similar to a landslide map. The assumption is that, for those slopes that have not already failed, the relative differences in the estimated values may point to relative differences in susceptibility to landsliding.

The selection and definition of independent variables is a key point in modelling landslide susceptibility. For example, old landslide areas are sometimes reforested partly as a result of a slope stabilisation program. In a statistical model, landslides will be positively correlated with reforestation. However, reforestation is a post-landslide condition and, clearly, does not imply an increase in susceptibility to

future landsliding. If reforested areas were included as an independent variable the tendency to map landslides rather than susceptibility to landsliding would be increased. Therefore, when building the statistical model, it is important to select and define variables in such a way that they reflect conditions before rather then after landslide occurrence. Then, the model is applied to present conditions since we are interested in future landslide susceptibility. Particularly in the case of dormant landslides, properties surveyed at the present time are more likely to reflect conditions post-failure and are, therefore, redundant. Too often, the indiscriminate inclusion of such variables in the analysis has resulted in simple indirect landslide mapping (i.e., recognition of geologic and geomorphologic features of area already failed) rather than real landslide susceptibility mapping.

Generalised linear modelling was used to model the relation between landslides and several independent variables for a small area of the central Apennines in Italy. Raster maps of landslides and independent variables were produced from air photographs, topographic and geological maps, and field survey. Logistic regression relations were obtained between landslides and the independent variables surveyed, chosen to reflect conditions prior to landsliding (Atkinson & Massari, 1996). Nine variables were used in the case of all landslides and dormant only, and 17 in the case of active landslides. Geology and slope angle were found to be always highly significant factors in the models. Slope aspect and strike were also significant, particularly for dormant landslides. In the case of active landslides, vegetation cover and concavity/convexity of the slope were more significant than geology and slope angle.

However, the extreme variability of causing factors, and the diverse influence of each factor in each type of landslides made the single model, while useful in the understanding of the overall processes occurring in the area, imprecise. Moreover, since more than 50% of landslides in the area are of the Slump & Flow type, the model was heavily weighted by this group.

In this paper, different models were constructed for different types of landslides, again subdivided into dormant and active. Landslides were classified following Varnes (1978) and Wieczorek (1984). Several types of landslides were detected (slump & flows, rock-falls, debris-flows, rock-slides, earth-flows, etc.). For the present analysis, landslides were separated into five groups and each group into active and dormant. Within each landslide body, rupture and deposit areas were identified, since only the features of the former are relevant when modelling landslide susceptibility.

The resulting statistical models are very interesting. Each independent factor has a different influence in each group of landslides. Some factors, such as the density of lineaments, dip and strike of the strata, are influential only in a few types of landslide. Others, such as slope angle, have a different behaviour in each group. From each model it is clearly possible to produce a map of the relative landslide susceptibility for each landslide type. These form the output that is generally needed by the end user, even if assessing the accuracy of the predictions is difficult since one would require data on future landslide occurrence.

The present study highlighted the high potential of the multivariate statistical approach in a geographical information system for understanding the geomorphic processes connected to the presence of landslides.

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Regional controls on bedrock and alluvial channels

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Field data from five drainage basins in Washington and Oregon, USA, (Willapa River Basin, Finney Creek Basin, Boulder Creek Basin, Satsop River Basin, WA, and Deton Creek, OR) show that bedrock channels generally have a higher slope given a similar drainage area, but that the threshold values are lithology dependent. Data were collected during the summers of 1992, 1995 and 1996. The most comprehensive data set (Willapa River Basin, WA) contains a total of eighty-three sample sites with reach average slopes of 0.002 to 0.300 and drainage areas of 10^4 to 10^8 m^2. Channels were classified as either alluvial, bedrock or mixed; the latter are reaches with alternating sub-reaches of bedrock and alluvium-floored channel that extend over at least one channel width in length. The study basins host a variety of land management practices including agricultural, timber harvest, and recreation (national parks). Lithology in the study areas range from basalt and siltstone in the Willapa River Basin to more competent low-grade metamorphic rocks in Boulder Creek and Finney Creek Basins. For each lithology, data from bedrock and alluvial reaches define distinct fields on area-slope graphs. Data from the Willapa River Basin show that the threshold slope for bedrock channels in a basalt lithology is higher than the threshold slope in the sedimentary lithology, indicating that a larger drainage area for a given channel slope is required to form a bedrock channel in a marine basalt rather than in a more friable siltstone. Bedrock channels in Boulder Creek Basin require larger drainage areas for a given channel slope than bedrock channels in the Willapa Basin. Deton Creek Basin (underlain by sandstone) has a similar threshold to the sedimentary portion of the Willapa River Basin. Several reaches surveyed in the Willapa River Basin, however, did not conform to a simple area-slope threshold. These exceptions that lie outside the general field for their channel type appear to be controlled by differences in sediment supply, scour, or in-stream stuctures. A local low sediment supply, due to upstream sediment impoundments (i.e., local low-gradient valley floors, beaver dams, and log jams), appeared to characterize the few mixed or bedrock channels that plotted within the field defined by data from alluvial reaches. Also, several steep channels

with large amounts of large woody debris plotted within the general field defined by data from bedrock reaches, but were cobble/gravel bedded streams in the local low-gradient areas between the debris structures, a finding similar to that reported by Montgomery & *alii* (1996) in the Satsop River basin. Our findings show that (i) an area-slope threshold generally defines bedrock and alluvial channel morphology in Pacific Northwest channels, but that (ii) regional differences in the threshold value appear to depend on lithology, and (iii) variations in sediment supply and the influence of large woody debris can locally overwhelm these general trends.

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Coastal cliff erosion in southern Italy and southeast England: environmental controls and management problems

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The erosion of coastal cliff is a process of fundamental importance in a number of contexts including threats posed to cliff top properties, the maintenance of sites of geological, scientific and archaeological interest and the provision of sediment to neighbouring beaches and other depositional environments. This subject is currently being jointly investigated by English and Italian research teams with the financial support of Crui and the British Council.
In southeastern Apulia, three contrasting examples of soft cliff erosion are provided at Cerano, Otranto and Porto Miggiano. The coastal area surrounding Cerano is characterized by a high cliff cut in clayey sands with a narrow sand beach at its foot. Cliff evolution is dominated by mass movements triggered by tension cracks and subsequent weathering; wave action is responsible for the removal of failed cliff material. Groynes and other defences works have recntly been constructed to create a wide beach in front of part of the cliff which is backed by a power plant under construction. The coast north of Otranto is characterized by cliffs up to 15 m high developed in weak, layered calcarenites which in several place are rapidly retreating due to rock falls. Two main group of processes are responsible: (1) weathering induce by seepage along strata planes combined with wave action, and (2) cave formation and widening with subsequent roof collapse. In the area surrounding Porto Miggiano, south of Otranto, an indented cliff up to 30 m high is developed in weak calcarenites. Cliff retreat here is mainly by rock falls induced by wave impact which loosens metre-scale rock block along major joints.
In several parts of eastern and southern England, soft cliff composed of a variety of Tertiary and Quaternary lithologies are eroding at rates of up to 2 m/yr. Actively eroding cliffs were formerly much more extensive, but large sections of coast have been protected by defence works since the middle of the last century. Some section of coast, e.g. between Weybourne and Happisburgh in northeast Norfolk, now display an indented plan form due to differential erosion between adjacent unprotected and protected sections of cliff. In the softest lithologies, composed of complex sequences of glacial till, sands and silts, cliff retreat occurs due to a combination of land drainage and wave undercutting of the toe slope during storms, leading to large scale rotational slides and mudflows. Average rates of recession over the past century have been 1-2 m/yr. On harder lithologies, such as Chalk near Hunstanton in northwest Norfolk, retreat occurs mainly by wave undercutting and rock falls. Average rate of recession here have been <0.5 m/yr during the past century. The highest rates of erosion (>6 m/yr) occur on cliffs composed of uncosolidated and weakly consolidated sandy sediments as for example at Covelithe in Suffolk. Currently, there is active debate concerning whether such cliffs should be left undefended, and, indeed, whether existing defences should be removed in some areas. Work currently in hand aims to model the likely pattern of cliff evolution in different lithology and wave energy settings which may follow removal of defences.

NIKOLAJ MASYUK, NIKOLAJ KHARITONOV & VALENTIN PASHOVA

The assessment of major and trace elements' migration in conditions of steppe landscape

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Investigation of typical for centre of Ukraine steppe the landscape has been done.Slopes with steepness 1,5 degree had weak-expressed erosion soils. Slopes with steepness 1,5-7 degree had washed off upper horizon of humus more than 2 time.
It was established that nitrogen and phosphorus contents in the slope soils were 1,5-2 times lower that in plain.Erosion of soils leads to reduction of heavy metal concentration too.The content its elements was Ni 5,2-9,7, Cr 1,4-5,0 and Pb 8,6-11,1 mg/kg. We have showed that number of ammonificated microorganizms on the sunlit slopes was 1,5-2 times bigger than on the shady slopes.
The investigations of effectiveness of new fertilizers' forms were conducted in the conditions of greenhouse and field experiments. Results of field experiments have showed that increasing of barley yield from polymer-based fertilizer use was 0,5 ton/ha on the plain and 1,0 ton/ha on the slope.

NORIKAZU MATSUOKA

Rates and processes of periglacial mass movements in the Japanese Alps

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A comprehensive field monitoring was undertaken on geomorphic processes operative on high mountain slopes. Monitoring included year-round recording of soil temperature, moisture, snow depth, frost heave and near-surface soil movement by using data loggers, as well as a manual, interval measurement of surface soil movement. These parameters have been observed, at most, for six years. Typical data are shown in figs. 1 and 2.

A large part of the high mountain slopes in the Japanese Alps is supported by thin debris cover usually 50 cm thick or less. Despite the seasonal frost penetration in excess of 1 m deep, the thin frost-susceptible layer screened the effect of the seasonal freeze-thaw activity on soil movement. Soil heave during seasonal freezing was indeed only comparable with the amount accompanying diurnal cycles. Soil movement mainly reflected the repetition of diurnal frost heave and settlement in both autumn and spring, indicating the predominance of frost creep. The diurnal frost action was favored by the periodic precipitation that prevented soil desiccation, as well as by the lack of snow cover in autumn and early winter. Snow cover increased in late winter, permitting the high soil moisture content during the thawing period. The high moisture availability was responsible for both small-scale debris flows at the onset of thaw and diurnal frost action after seasonal thawing.

Most of the velocity profiles showed downslope concavity. The base of movement lay between 20 and 40 cm deep. The mean annual surface movement varied from 0 to 50 cm yr^{-1}, depending mainly on the slope gradient and the thickness of fine debris layer. Where fine soil composes the uppermost layer, needle-ice activity enhanced the movement of surface grains, producing discontinuity in velocity profiles.

In summary, the high diurnal freeze-thaw frequency, intensified by the high moisture availability and the paucity of snow cover, facilitates near-surface frost creep and seems to culminate in miniature periglacial features, such as sorted stripes with a spacing of 20 to 30 cm and stone-banked lobes with a riser of 30 cm high or less.

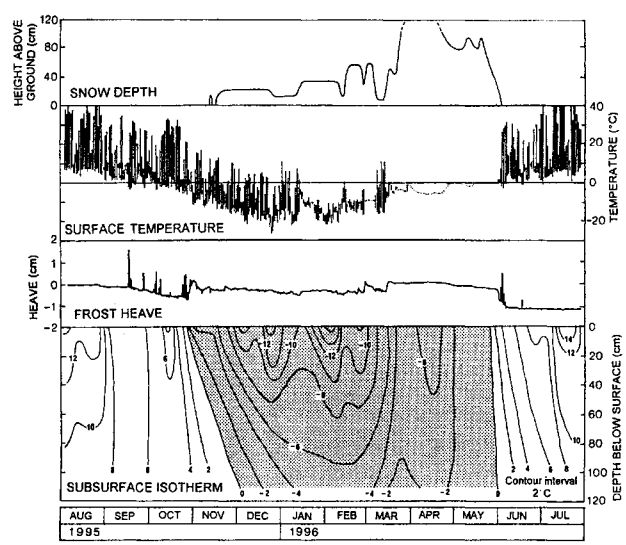

FIG. 1. Annual variations in snow depth, ground temperature and frost heave activity on a 14 debris slope with small-scale stone-banked lobes.

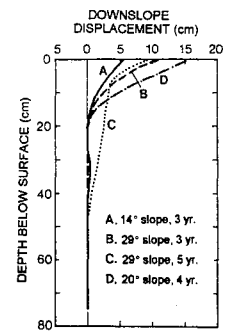

FIG. 2. Cumulative deformation of strain probes. Slope gradient and measurement period are indicated.

ALEXEY V. MATVEYEV

Tectonic factor evidences in the glacial relief structure of the Russian Plain

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Tectonic factor makes itself evident in the relief structure of the territory where old ice sheets were widespread in two ways: immediately, by creating tectonic landforms, or transforming some parts of landforms of other genesis, or indirrectly, through the sedimentation character, or exogenic land sculpturing processes. Proper tectonic landforms are rather few in nature. They look like flattened elevations and depressions with an amplitude of first few metres. Some tectonic motions created shallow lake basins (Lakes of Sporovskoye, Vygonovskoye, Chervonoye, etc.), resulted in 2 to 5 times increase of the stream gradients in uplifting zones, in formation of tectonic terraces.

Landforms that creation is indirectly due to tectonic movements are more common in nature. The reason is that physical properties of rocks are changed above the active tectonic structure zones, anomalies of geophysical (gravity, thermal) fields are created, glacier fissuring is developed and contributed to the better entrainment of the glacier bed material and consequently, increased the thickness of glacial deposits and showed itself in the morphology of the Earth's surface. Glacial uplifts (those of Grodno, Minsk, Novogrudok, etc.) are sometimes classed with big positive structures, and lowlands (like those of Polotsk, Polessie,

etc.) - with depressions, saddles or troughs. These structures exert also control over the location of all the big river systems.
The most diverse data on the tectonic peculiarities evidenced in the relief have been obtained from local structures, that show themselves in the river siting, parameters of river valleys (width, depth of incision), coefficients of channel meander, occurrence of logs, eolian relief, geomorphological anomalies. Rupture dislocations are also well seen in the land morphology and are responsible for the formation of straighten river valley sections, knee–like river bendings, linear eolian ridges and hills, end moraines, active karst processes. A typical feature of end moraines confined to tectonicly active zones is a widespread occurrence of glacial tectonics. In several cases, the recent tectonic movements predetermined the glacial relief morphology, in particular, the height of some landforms, banded and arched arrangement of ridges and hills.
The influence of deep structures upon the relief of glacial plains is substantiated by statistically significant mutual correlation of maps showing the crystalline basement, bedrock roof and land surfaces. The coefficient r=cos a was used as a conjugation measure and determined and a cocine of an angle formed by isolines in their intersection point when maps are superposed. This coefficient value is often as high as 0.6-0.8.

ROLAND MÄUSBACHER & MONIKA IGL

The influence of climat change and human impact on the sediment flux in the Werra-catchment, Germany

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The river Werra, with a catchment area of about 3.000 km^2 is located in the center of Germany. Most of the water and sediments are derived from two middle mountain regions, the Thuringian Forest and the Rhön with altitudes up to 1000 m. asl. Due to subsidence on the flood plain of the Werra, the Late Glacial and Holocene deposits are up to 17 m thick, providing the possibilty of high temporal resolution, especially for periods of aggradation. In addition several small sub-catchments were examined in order to study the sediment transfer from the catchments to the flood plain of the Werra in more detail. The sedimentologial, palynological and chemical records, derived mainly from core samples, provide the following results:
The flood plain stratigraphy of the Werra shows that during the Late Glacial sand and gravel were deposited, without any change in composition or facies. During the Holocene, up to the Roman Period, in most of the cores fine grained overbank sediments with organic matter are dominant, suggesting a stable period with limited sediment transport. Only during a period of about 500 years at the end of the Holocene warm period (6.000-5.500 BP), coarse sands were deposited. The grain size content of these sediments are comparable to the results of granulometric analysis of young flood plain sediments collected after a ten years flood of the Werra in 1978. Sediments with similar properties were deposited on the flood plain of the Werra during the last 2.000 years .
In the sub-catchments a repeated change from minerogenic to organogenic sediments is visible during the Late Glacial. These sequences of organic and minerogenic deposits starts in the early Bölling and ends with the Younger Dryas. During the Holocene mainly organic sediments were deposited. Only during the last 500 years coarser material, derived from soil erosion on the slopes was deposited. The results show that the response to climat change and human impact differs according to the size of the catchment. The results from the flood plain of the Werra suggest that the changes of the fluvial dynamics induced by climate change in the Late Glacial were too short to establish a new sedimentological regime. Alternatively, the lack of organic deposits might be explained by severe erosion in the main channel of the Werra during the Younger Dryas. The earlier signal of human impact in the main valley suggests, that deforestion in the catchment was restricted to some areas, but large enough to establish a new regime in the main channel.

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Topographic signatures and implications resulting from segmentation of the Baja Rift Margin

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Long continental rifts commonly have segmented margins whose main extensional structures alternate between vergence of the main extensional structures in one direction and vergence in the opposite direction. The alternating vergence has important implications on the tectonic, topographic, and sedimentary evolution of rifted margins. Of particular interest is the rate of escarpment development and the longevity of structural accomodation zones. This model of rifting was applied (Axen, 1995) to the Gulf Extensional Province along the Main Gulf Escarpment (Mge). The Mge, which has kilometer scale relief and runs the length of the eastern margin of the Baja peninsula is believed to reflect the interplay between erosional and tectonic processes, including vergence reversals. The Mge could thus represent a the topographic expression of a segmented rift margin characterised by east-vergent footwall segments separated by accomodation zones from west-vergent hangwall segments. The accomodation zones are themselves active structures during various times in the rift history

and impact sediment transport systems in the evolving basins. In the vicinity of Loreto, we find surprisingly, that the accomodation zone may either remain active or become reactivated, and effect both topography and the sediment source areas for rapidly subsiding Pliocene basins.

RAM K. MAZARI & T.N. BAGATI

Geomorphology of soft rock sediments of the Northwestern Trans Himalaya

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The northwestern Trans Himalaya includes the regions of Ladakh, Lahul and Spiti and lies in the cold and dry climatic belt of the Himalayan mountain ranges. Great many valleys in this belt are infested with a variety of Quaternary deposits which have been shaped to attractive configurations by a variety of processes over a period of time. In essence the morphological features that have developed on these sediments are reminiscent of environmental changes that have occurred primarily on account of uplift related climatic alteration.

The morphological features developed on the soft rock sediments of the valley bottoms may be classified into two types i.e. riverine and lacustrine. A third and contrasting type may be added from the slope deposits. Riverine sediments are mainly the product of glaciofluvial outwash, whereas discrete lacustrine deposits represent the impounded stretches of the valleys developed by tectonically dislodged slope material and/or climate sensitive process change. The morphological features produced on indurated riverine sediments include mono block cathedrals, nested cathedrals, story in story cathedrals, earth pillars, combs, murals, caves and amphitheaters. In dry lacustrine sediments the predominant morphological features are railing posts, flutes and grooves, funnels, tunnels and arches. Among the slope deposits channel chutes and levees represent a significant set of features.

Sediment composition, facies variation and matrix have played an important role in the development of various features in the soft sediments. Riverine sediments principally belonging to limestone catchment show marked degree of induration compared to non-calc catchments. Induration itself has provided a strong grain in the development of tall and extensive morphological features in these sediments. In the case of lacustrine deposits variation in the morphological features is time dependent being determined by the occurrence of the event and subsequent sediment accumulation. Major lacustrine deposits date back to more than 45,000 yr B.P. (Bagati & *alii*, 1996) Thus, old and thick lacustrine sequences exhibit variety in the morphological build up, whereas young and relatively thin sequences show subdued geomorphic architecture. Features on slope deposits on the other hand are determined by the bed rock angle and catchment characteristics and their response to the climate.

From the build up of the morphological features it is evident that moist regime was once a predominant geomorphic agency in the Trans Himalayan belt but as uplift of the Higher Himalaya progressed from Middle Pleistocene onwards, moisture gradient tilted sharply southward rendering the region cold and dry and the eventual development of the micro landforms. Seasonal snow thawing and aeolian activity is a dominant external energy in the Trans Himalaya for the development of various micro geomorphic features. The mode of origin of the various micro landforms has been discussed.

MALGORZATA MAZUREK

Variations in fluvial transport as a response of the catchment system in a young glacial area, West Pomerania, Poland

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In the contemporary denudation system of the temperate zone, fluvial transport plays a fundamental role in carrying away material from erosion and denudation in a catchment. A detailed analysis of fluvial transport allows it to be recognised as an indicator of relief evolution, including soil leaching and erosion.

The object of investigation was the Kluda catchment, which is a part of the upper Parseta hydrographic system and which is considered representative of the young-glacial zone of West Pomerania and the Polish Plain. The study is based on the data from four hydrological years 1990-1993. Water sampling was carried out once a month in 31 sites that were located on small tributary streams in order to reflect the range of geological, land use and topographical conditions.

The solute load predominates over the suspended and bed loads in the structure of materials transported in the Kluda gauging profile. This structure remains unchanged even during large floods. The ratio of dissolved to suspended load is influenced by weathering processes, the amount and nature of solutes available in the drainage basin, and the character of water cycle (water residence times).

Substances dissolved in river water may come from the atmosphere, the biological cycle, and primarily from the processes of chemical weathering taking place in the soil and deeper down in the substratum. The transformation of precipitation into runoff is associated with the constant change in the physical-chemical parameters of water involved in the water cycle. Variations in the concentration of Ca^{+2}, K^{+}, SO_4^{-2}, HCO^{3} and SiO_2 ions can be useful as natural indica-

tors when studying the mechanism through which precipitation is transformed into river runoff. On the basis of the analysis of lithological and hydrogeological conditions and chemical contents of surface water, it was possible to distinguish components of the runoff in the Kluda and describe the hydrological system of the catchment.
The stream water of the Kluda catchment belongs to the calcium-bicarbonate type. It is characteristic of young-glacial lakeland areas built of tills rich in calcium carbonate. Worth noting are the waters of basins without outlets that can be found throughout the catchment, which are largely of the calcium sulphate type. The range of variation in physical-chemical parameters of those waters reveals considerable differences in the properties of surface water in the catchment. A grouping procedure and principal components analysis, carried out on the basis of 10 physical-chemical parameters characterising the measurement sites, produced four (A, B, C, D) hydrochemical groups. The groups mainly reflect the influence of the lithology, pattern and character of soil processes and water pathways in the catchment.
The established routes of water circulation in the slope system and their importance for the supply of solutes to the channel system provided a basis for distingnishing four morphodynamic zones in the catchment (a divide, a hillslope, a plateau escarpment, and a valley). These zones make different contributions of water and solutes to the river channel from the watershed area. Their spatial distribution is an indicator of feature of present tendencies in the relief development of young-glacial areas.

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Geographic Information System (GIS) reliability in earthquake-induced landslides simulation, a case studied: Irozaki area, Izu Peninsula, Japan

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In the last decades a growing number of spatial landslide hazard models has been developed. These modelling approaches aim at the identification of areas with specific probability for future landslide events, which means to evaluate spatial probability of future slope instability. The Gis techniques have demonstrated, in such kind of studies, to be a useful tool for their capabilities in treating a huge amount of multidisciplinary data pertaining to large areas.
The present work demonstrates and discusses the results achieved from the application of Gis in earthquake-induced landslide prevision.
The main purpose of the suggested methodology is to determine the reliability of hazard scenarios obtained by a computer modelling technique, coupled with a Gis and properly tailored, for determining the instability proneness of slopes due to earthquake shaking.
The algorithm of the programme for the stability analysis is based on the known equation for the calculation of the critical acceleration in pseudo-static conditions, for an infinite slope model, proposed by Wilson & Keefer (1985). The algorithm considers the following parameter: slope angle, soil/rock specific weight, depth of the slipping surface, friction angle and cohesion mobilised along the slip surface and the seismic acceleration. As concerning the epicentre of the seism, it has been possible to test the applicability of the model using a two dimensional scaling function for the ground seismic acceleration.
The application of this algorithm resulted in hypothetical or theoretical distribution maps of landslides induced by the project earthquakes. These maps have been compared to the ones obtained directly from the interpretation of aerial photographs, and showing the actual landslides distribution. The application was carried out over the Izu Peninsula, located few dozens of kilometres southern of Tokyo area, where the intersection of the three lithospheric plates that are involved in the tectonic evolution of the Japanese arc-trench system is found. This area is widely known for its seismicity; in fact, in the recent past, it has been the theatre of many earthquake sequences as well as spectacular volcanic eruptions. These natural hazards have had a very strong impact both on the people and on the morphological evolution of the territory. Of particular interest, two earthquakes set off in 1974 and 1978, known as «Izu-Hanto-Oki» and «Izu Oshimae-Kinkai» respectively, were studied thoroughly and it was possible to relate a great number of mass movements directly to the main earthquake shocks. The availability of good aerial photograph coverage, conducted over the area immediately after the occurrence of the earthquakes, has allowed the construction of maps showing the distribution of seismically-triggered landslides.
The effectiveness of the scenarios obtained from the performed simulations has been judged by the superimposition of both simulation and actual distribution maps. In this way, a reliability index was developed. This index is based on the percentage and position of landslide areas that are exposed in both the simulation and distribution maps.
Achieved results seems to be realistic and confirm a good level of reliability of the simulation model herein presented. The calibration of the model consents to apply it in the evaluation of the landslide hazard due to earthquakes in other parts of Izu Peninsula. However, the authors propose that such a model should be used as a starting point for the development of more complex simulation models that could consider the contemporary influence of severe rainfall events.
Finally, a number of conclusions have been formulated concerning landslide movement direction in relation to the orientation of both seismic source areas and slopes.

NASIP MECAJ

Physical environment and geomorphology of the Durres-Vlora Region in Albania

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Albania's 429 km long coast is dominated by a narrow flood plain opening into the Adriatic sea in the North Coastal Region and steep mountains coming down to the Jonian sea in the South Coastal Region. This diverse and dynamic land-sea interface has been a corridor of intense interaction between natural systems and human activities for centuries. The rich diversity of coastal habitats and geomorphologic features, including beaches,wetlands and lagoons barrier islands and dunes, large bays and harbours, rocky cliffs, caves and grottos, have provided an irreplaceable natural resource base for people since Illiric tribes first settled here over 3000 years ago. The flood plains and wetlands areas of the northern coast have been considerably altered to support human settlements,while the rugged character of Albania's southern coast has to date prevented intense urbanization.
The Adriatic coastal zone, which is characterized by the alluvial coastal plan stretching along low-lying sandy shores, is similar in the North and in the Central (Durresi-Vlora) Coastal Regions of Albania.
The South Coastal Region is characterized by the prevailing steep sloping mountain range of karstic origin and the rocky shores.

IAN MEIKLEJOHN

Weathering of Southern African rock art: a geomorphological perspective

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The disappearance of rock art in southern Africa through natural rock weathering processes has been a cause for concern for a considerable period of time. Unfortunately, research has until recently failed to adequately identify specific mechanisms that are responsible for the deterioration of this valuable heritage. However, recent investigations have made it possible to determine some of the weathering process that may be responsible for the weathering of some of the rock paintings in southern Africa. Data from micro-climatic monitoring, chemical analyses and rock properties are presented together with a discussion of the weathering of the Clarens Formation sandstones.
Investigations have shown that rock moisture regimes, and to a lesser extent rock temperature changes, at or near the rock surface are potentially the most important controls on the deterioration of rock art in the study region. While moisture has previously been acknowledged as been damaging to rock art, specific mechanisms were poorly understood. The wider implications of this research for southern African rock art and its preservation are discussed.

RITA T. MELIS

Paleosols and eolianites in the west coast of Sardinia (Italy)

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Paleosols and caliches intercalated in eolianites overlying and underlying tyrrhenian marine deposits (Isotopic stage 5e) have been studied with a view to gaining a deeper insight into the main geomorphic processes that affected the Sardinian coasts during the Quaternary. Several stratigraphical sections occurring in a variety of morphological contexts (bays, promontories, sea cliffs and paleosea cliffs) have been examined along the west coast which is swept by violent NW winds (Mistral).
Chemico-physical and sedimentological analyses of the different soil horizons together with examination of thin sections indicated that the majority of rubefied buried soils, intercalated in eolianites, formed in the interstadial periods on slope deposits in climatic conditions characterized by alternating wet and arid phases. The pedorelicts occasionally found in these horizons indicate that the parent material is composed of material that has already undergone pedogenesis, derived from the erosion of soils in neighbouring areas.
The occurrence of several calcic and petrocalcic horizons in the eolianites indicates alternating semi-arid periods of intense pedogenesis with more arid ones during which eolian processes prevailed. The petrocalcic horizons have preserved the underlying sediments from erosion and in some places have formed extensive sub-horizontal surfaces.
The palaesols allowed to recognize unconformities, estimate the duration of time represented by an unconformity, and estimate the paleoenvironment at the time of the unconformity.

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Some peculiarities of evolution of the Philippine Sea Basin

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The Philippine Basin presents some problems in understanding the history of the western Pacific Ocean. The Kyushu-Palau area has been visited by research vessels *Professor Bogorov* cruise 30/31 (1989), cruise 33 (1990), *Akademik A. Vinogradov* cruise 16 (1990). Bathymetric and dradge data has been collected during an investigation of the sea floor. According to the data of deep-sea drilling (59 Leg. of *Gl. Challinger,* Sites 447, 448 and 126 Leg. of *J. Resolution,* Sites 787, 792) the zonal scalle of Oligocene was created on the basis of quantitative and qualitative analyses. The sections occur allong two transectes: northern (Aoga Canyon) and southern (Kyushu-Palau). The main criterion of identifying radiolarian zones is dominanting of representatives of one or two genera.

Volcanic, block-tectonic and gravity-accumulative landforms have formed a relief of the area. Submarine shield and stratified central-type volcans stands out against a background of a sea-bottom. Basalts similar to oceanic islands tholeiites and sodium trachytes compose volcanic structures of the west part of the Ridge. Volcanic (basalts - rhyodacites) and pyroclastic rocks similar to island-arc type compose composite volcanoes. Volcano-tectonic depressions accompany volcanoes of two types.

Two tectonomagmatic epochs have composed the morphogenesis process of the Kyushu-Palau.Probably amagmatic tectonic crustal movements had finished morphogenesis at Lower Oligocene.

The oldest sediments of Early Oligocene were discovered at the Kyushu-Palau Ridges.They cover the volcanic breccia. The Early Oligocene zone Tristylospyrs triceros contains 18.83 %of species-index and 10.87 % of representatives of related genus Gerathocyrtis (Nanno-zone NP 23). Higher up the section a layer of volcanic glass devoid of radiolarians divides the Early and Late Oligocene. The Late Oligocene zone is Haliomma Lirianthus-Cerathospyris strasburgeri (Nanno-zone NP 24). It contains 13.8 % of the former species-index.

The Late Oligocene radiolarian association is characterised by a cyclic development. Predominance of major groups Dercadospyris and Calocycloma is recorded.

It is to be noted that isochronous associations of the Pacific Ocean and the (Ontong Java, Site 289), the Late Oligocene radiolarian associations are characterized by predominance of multi-chamber Nassellaria. The correlative analysis of isochronous associations of Oligocene and Early Miocene radiolarians unable us to suggest the geographical barrier which existed at that time between the Philippine Basin and the Pacific Ocean. This barrier was represented by the Mariana arc.

LJUBOMIR MENKOVIĆ[1] & MIROSLAV MARKOVIĆ[2]

Glacial morphology of Serbia (Yugoslavia)

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The first data on glacial morphology of Balkan were submitted by Cvijić at the end of last and beginning of this century. He has reported the existence of traces of glacial forms on the Serbian highest mountains Prokletije, Šara and Koritnik. The newest, present day investigations were carried out by remote sensing applications, accomplished with the field observations. By such approach in these localities discovered are numerous cirques, glacial troughs, moraines and other characteristic forms produced by work of the Pleistocene glaciers.

The Prokletije Mountain makes Serbian border with Albania. The cirques here are located just below the highest peaks and mountain ridges. Their elevation ranges from 2000 to 2200 meters. The cirques are continuing into short glacial valleys, with lengths of some 4000-4500 meters. The moraines are well preserved only in the cirques. At the lower altitudes they are mostly eroded. The lowest registered elevation of moraines is approximately 1500 meters. The Pleistocene glacial forms are inherited by the fluvial ones. In the most of the cirques springs of the numerous small rivers are settled.

The Koritnik Mountain is situated in the extreme southern part of Serbia. Only one cirque, altitude of 2000-2200 meters, is developed here. Located just below the mountain top, with width reaching 1200 meters, it is deeply incised in limestone rocks. The cirque narrows towards northeast and continues into glacial trough with length of one kilometre. Bottoms of both, cirque and glacial trough, are covered with moraines composed of limestone exclusively. Moraines can be traced to the altitude of 1400 meters.

The Šara Mountain, located on the Macedonian border, displays abundance of glacial forms. On its northern side, belonging to Serbia, thirty cirques varying in diameter from 100 to 1500 meters are registered. All of them are located immediately below the main mountain ridge oriented northeast-southwest. The cirques have elevation from 1900 to 2400 meters. The glacial valleys that follow the cirques, have lengths of 2-3 kilometres. They end, as a rule, with terminal moraines.The lowest of them are found at altitudes of 1200 meters.

Positions and mutual relationships between investigated glacial forms enabled determination of the snow line altitude. During the Pleistocene it was at 1900 meters on the northern sides, and at 2200 meters on the southern sides of the mountains. That indicates development of the Pleistocene, precisely Würm glaciation, only on the highest altitudes of the investigated mountains. The type of glacier was depending on the snow line position, i.e. on topographic surface above it. The most of glaciers were developed as

cirque (hanging glacier) and valley type. On the [ara Mountain, where the vast plain at 2200-2400 meters altitude exists, a glacier of plateau type was developed.

BRIAN MENOUNOS

Holocene, debris-flow activity within the Colorado Front Range

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Debris flows are an effective sediment transfer mechanism within many alpine areas of the world. This statement was recently tested within a mountain range of Colorado by specifically: a) addressing their presence and geomorphic significance within contemporary times; b) evaluating their effectiveness through the Holocene Epoch.

Within this environment, debris flows occur preferentially on southwest-facing slopes, west of the Continental Divide in basins with relatively high ruggedness numbers. Magnitude of the flows range from 100 to as large as 8000 m^3 with a mean volume of 900 m^3. Recurrence intervals for individual basins vary, but are generally less than 100 years. An estimate for geomorphic work produced by annual debris flow activity (1.69×10^6 Joules $km^{-2}yr^{-1}$) was calculated as a means to quantify the effectiveness of debris flows in surface denudation. When evaluated within the context of other Front Range hillslope process rates, debris flows are significant in alpine, landform development. Comparison of this effectiveness with data from other mountain environments, however, indicates that Front Range debris flow activity is low and may be explained by lithologic and climatic controls.

Given the evidence of Front Range, climate change within the Holocene, past rates may show no relationship to contemporary activity. A Holocene chronology of debris flow activity for the Front Range Mountains was developed as a means of comparing past and present effectiveness. Incorporation of lichenometric, pedologic, and accelerator mass spectrometry (Ams ^{14}C dating of terrestrial deposits indicate that debris flow activity coincides with recognized Neoglacial activity during the late Holocene. A larger than expected number of deposits date to the Audubon Glacial Advance (1850-950 yr BP) and supports the contention that hillslope instability is enhanced during times of climatic deterioration.

A longer and more robust record of debris flow activity exists within lacustrine sediments obtained from a Front Range, alpine lake (Sky Pond). Fifteen Ams ^{14}C ages provide absolute ages for several debris-flow units and allows estimates to be made on others through extrapolation. In contrast to the terrestrial record, the largest and most numerous lacustrine debris-flow laminae were deposited durirlg a period of regional climatic amelioration (8000-4500 yr BP). Minimum sediment yield estimates for the catchment, inferred from the accumulation of minerogenic matter within the lake, was also greater than during late Holocene time. This evidence, combined with re-interpretations of previous sedimentary records from other depositional environments in the Front Range, suggests that mid-Holocene episodic sedimentation exhibited regional synchroneity. Changes in debris flow activity and other forms of episodic sedimentation were most likely driven by the onset and availability of monsoonal inclusions into Colorado during the Holocene and not due to the exceedence of geomorphic thresholds. Unlike many alpine environments, however, a correspondence between enhanced debris flow activity and climatic amelioration exists for the Front Range. Differences in precipitation regimes are the most likely sources of this discrepancy and implies that alpine environments will respond to future climate change differently.

GÁBOR MEZŐSI & JÓZSEF SZATMÁRI

Assessment of the wind erosion activity on the Southern Part of the Great Hungarian Plain

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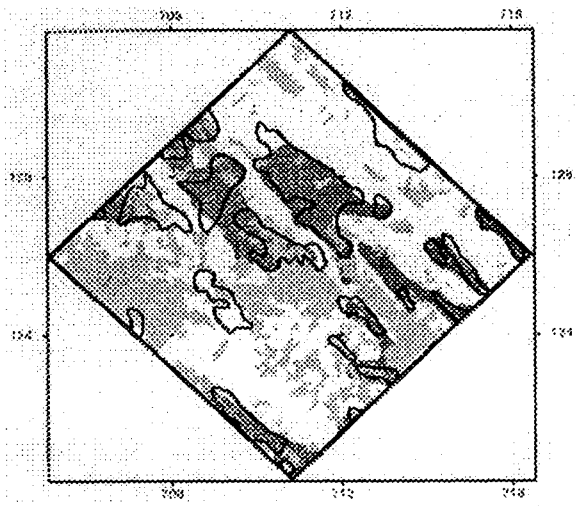
Wind erosion processes endanger nearly 23 % of the total surface of the Danube- Tisza Interfluve region. Thus it is apprent that conservation of light sand soils against wind erosion is vital, so much as privatization started in the first years of this decade brought fundamental changes in facilities of soil protection. In 80's a county-wide soil protection network directed the resaech to reduce the damages. After the privatization (1988-89) the landuse (type and structure) was changed. The results of this process were overlapped with the natural aridification tendency of the South Hungarian Region. Both changes indicated us to launch a research project with the following aims:

– to build up stations for measurements of deflation and accumulation of sandy soils,
– to provide suitable information and advice for the private landowners
– to asssess the risk of wind erosion in the Danube-Tisza Interfuve region for the regional dvelopment plan..

In this study we would like to summerize last problem, to border the territories endangered by wind erosion and also to define the size of these areas. We marked out 64 km^2 large area around the stations. The monitoring methods of the test area were elaborated. After collecting and meausring of the geomorphological, soil and landuse characteristics these data were transported to a database. The idea of the analysis based on Gis and remote sensing methods. We selected the surfaces covered by sandy soils, the surface was used as cultivated area and posited not in the deprression between sand dunes. There are the where the wind

erosion might be active due to the ecological parameters (ecologically critical areas Eca). Taking the Landsat and SPOT images the soil wetness index (Swi) were calculated. On the Swi relates to canopy and soil moisture. We supposed that the driest areas (Swi < 6 %) exposed to wind erosion a greater extent. Overlapping the maps of physical parametes by the SWI map and the landuse map good correlations were found between the landuse and Swi indexes.



Grey - SWI < 6% , black - alkali soils , encircled - depressions between sand dunes?

KATERINA MICHAELIDES & JOHN WAINWRIGHT

Slope-channel coupling: effects on slope evolution and channel response

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There is a strong interaction between catchment form and its flood and erosion response. Over geological timescales, the catchment form is influenced by the flood and erosion response, and vice versa. Slope-channel coupling is an important factor in this interaction. First, it gives the boundary conditions for the base of the slope, and hence its evolution through time. Secondly, it determines the amount and timing of sediment and water inputs into the channel system. Previous studies have demonstrated that the presence of floodplains separating hillslopes from channels strongly affect discharge downstream and alters the amounts of sediments entering the channel. Floodplains act as a storage or buffer zone for water and sediments coming off the hillslope and also from overbank flows. For these reasons, an in-depth understanding of slope-channel coupling is fundamental to our understanding of both the short-term response of catchments, and their long-term evolution.

Several Mediterranean catchments have been investigated in terms of their coupling characteristics. A number of differences have been noted between these channels. First, the angle of dip of the floodplain is not always horizontal as most studies have assumed. Certain floodplains dip towards the channel, with varying angles, whilst others dip away from the channel and towards the hillslope. These patterns appear to be related to differing channel flow régimes and land uses. Secondly, roughness of the floodplains varies both downstream and across the channel. Thirdly, vegetation characteristics vary in response to the coupling characteristics. Vegetation on floodplains is more developed than the more frequently disturbed main channel vegetation, and enhances the buffering capability of the floodplain. Fourthly, sediment size varies in relation to the coupling characteristics, and this has further feedbacks to the floodplain roughness and infiltration. Fifthly, the distribution of floodplains follows the oscillations of the channel plan, but is also controlled by the location of tributaries.

A simple model has been developed to investigate the interactions between slope evolution and catchment response for a variety of scenarios of coupling. The results from this investigation further illustrate the importance of the interaction. More detailed studies of this relationship in the field are already underway.

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Utilisation de nouvelles techniques de localisation et de traitement des données géographiques appliquée à l'étude de la pédogénèse en milieu volcanique complexe: l'exemple de l'estive expérimentale de Ternant (Massif Central français)

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A proximité immédiate des édifices volcaniques de la chaîne des Puys (Massif central français), le plateau granitique ou gneissique s'est trouvé plus ou moins recouvert de saupoudrages variés dans leur composition (trachytique, trachyandésitique, basaltique) et dans leur taille (cendres fines de taille millimétrique à centimétrique) durant tout le tardiglaciaire et le début de l'holocène. La dynamique des versants et la pédogénèse ont ainsi été profondément perturbées et l'activité humaine (déforestation, mise en culture, pâturage) puissante et continue depuis l'âge du bronze a encore amplifié ce phénomène.

Sur le site expérimental de Ternant (60 ha, 10 km à l'ouest de Clermont-Ferrand, 1000 m alt.), une carte des sols au 1/4500 ème a été réalisée par quadrillage systématique

(maille de 80 m) puis échantillonnage stratifié. 80 profils tarière avec mesure du pH eau de l'horizon A, 5 fosses pédologiques avec analyses complètes des différents horizons (granulométrie, pH, M.O., C/N, CEC, P, K, Ca, Mg) ont été effectués en faisant appel aux nouvelles techniques de localisation et de gestion des données (tachéomètre électronique et balise Gps différentielle pour les levés de terrain, logiciels Pc Arc-info et Idrisi pour l'analyse spatiale des données et Vistapro pour les visualisations 3D à partir d'un modèle numérique de terrain au pas de 2,5 m élaboré à cette occasion). Les résultats de l'étude pédologique ont ensuite été confrontés aux données de la végétation (38 relevés de végétation, mesure de la biomasse produite et offerte au pâturage, analyse de la valeur nutritive (cellulose brute, N, P, K, Ca, Mg) sur deux années (1995,1996) afin de mieux comprendre le comportement des animaux au pâturage, dans un contexte de sous chargement.
Cette nouvelle approche a permis d'étudier la dynamique des sols à plusieurs échelles de temps (le quaternaire pour la répartition des saupoudrages et leur incorporation dans le sol, les décennies passées pour décrire la situation actuelle, les évolutions récentes à court terme en fonction de la pression de pâturage) et de réaliser des visualisations 3D explicatives des modèles proposés. Elle facilite en outre la confrontation avec les données écologiques et du comportement animal dans une approche globale destinée à simuler les évolutions probables de la végétation en fonction du type de pâturage.

PIOTR MIGON

Weathering mantles and their bearing on the long-term landform evolution of the Sudetes, SW Poland

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Two types of weathering mantles have been for long recognised in the Sudetes Mountains and their foreland, SW Poland. These are kaolinic mantles, regarded as indicative of advanced alteration in hot humid climatic conditions, and 'immature' grus weathering mantles, developed largely but not exclusively on granite. Their distribution reflects the gross morphological division of SW Poland as the former occur in tectonically downthrown areas subject to net accummulation since the beginning of the Neogene whilst the latter are typical for higher grounds of net denudation. The age of kaolinic mantles is constrained by the age of overlying sediments and is Palaeogene-early Miocene, although the onset of kaolinisation is likely to be at least Cretaceous in age. The gruses are believed to be younger, Pliocene-Pleistocene in age.
Products of kaolinic alteration cover the landscape that represents a mantled and partly stripped etchsurface. As such, it gives an insight as to how the early Tertiary topography may have looked like. Highly varied relief with strong lithostructural control had already formed in the Palaeogene and, consequently, the widely held concept of the 'Palaeogene planation surface' finds little support. It seems that the hilly landscape of the Sudetes may be to a large extent a stripped etchsurface rather than a product of erosional dissection subsequent to the late Neogene tectonic movements. Moreover, the widespread occurrence of the kaolinic mantles in the Sudetic Foreland shows that the topography is primarily inherited and little overall change has taken place in the last ca. 10 ma.
Controversy surrounds the grus weathering, its age and palaeoenvironmental significance. Overlying sediments suggest that the grus profiles may vary in age, the oldest being at least Pliocene and the youngest late Pleistocene-Holocene. Their close adjustment to the present-day topography indicates that the grus profiles are unlikely to be roots of former weathering mantles of enormous thicknesses which have been eroded away. Several features suggest that the grus weathering profiles vary as to the way they have behaved during the Quaternary. Some have been truncated and/or buried which may have caused fossilization, whilst the other have been progressively deepened or renewed in response to discrete episodes of uplift and/or climatically driven changes in the course of surficial geomorphic processes. In particular, deep grusification is characteristic for footslope settings where water availability and protection of permeable slope sediments provide optimal conditions for deep weathering to proceed. Therefore, they by no means may be regarded as relict. Thus, it is possible to use the weathering profiles as indicators of the current dynamics of the landscape.

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Man- relief relation among middle mountain spaces: a comparative case study

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The Romanian Carpathians are mountains with an important fragmentation degree, having a big population and settlement density and a great variety of human landscapes. Human being has actively adapted to the carpathian environment for centuries (since Neolithic).
This case study is a comparative approach of two areas with similar morphologic conditions but extremely different human landscapes: the Bran- Rucar Corridor and the Upper Prahova Corridor.
The Upper Prahova Corridor is a transversal axis with an accelerate dynamics after 1850 because of the opening of

the most direct connection betweenTransylvania and Bucharest. Forest landscape transformed in a short period turning into a complex industrial and urban landscape with concentrated towns alongside the valley inside small depression basins, covering a great part of the glacis-terraced slopes and of the high riverbed. This landscape is also dynamic today.
On the opposite, the Bran - Rucar Corridor preserve a typical rural landscape, with scattered villages on the karstic plateaus and lenghthened settlements alongside the main road (an old road that became not very important after the Prahova Valley opening). Here, man-relief relation is specific by the permanent settlement access in the altitude, but also by the increased human pressure by temporary inhabited settlement (meadow houses).
Different regional planning problems are characteristic for these two types of landscapes.

ANDREJ MIHEVC

Dolinas, their morphology and origin, the case of dolinas from Kras, Slovenia

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Dolinas, defined as a closed centric depressions, between Skocjanske jame caves and Divaca on SE part of Kras plateau are described.
The surface of this karst area is levelled between 450 in 400 m, but on small scale broken with numerous dolinas, which are elementary and characteristic morphological element of the surface. Vadose zone of the karst is thick, as the free surface of the main underground river is about 250 m under the surface.
On the surface of about 30 km^2 on the map in scale 1:5000 closed depressions, dolinas were analysed. They vary from 10 til - 300 m in diameter and depths from few to over 100 m. Density of dolinas is up to 240 per km^2, but the densities vary depending on different factors.
Morphologically and genetically we can distinguish at least four types of dolinas in the study area, such as collapsed dolinas, solution dolinas which develop from underground karst features and dolinas developed along distinctive tectonic zones

MARIA MIKHAILOVA

Morphodynamics of river mouth bars

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A river mouth bar is a complex accumulative object, which develops at a river mouth as a result of the river and partially sea sediment deposition under the river-sea interaction. The main causes of the river mouth bar formation are the decrease of the velocity of the river flow at the nearshore and the abstraction of the river flow from the bottom. The river mouth bars are typical practically for all river mouths. The river mouth bars are shallow and dynamic barriers between the river and the sea. So they present significant obstacles to navigation and require artificial deepening.
Morphology and morphometry of the river mouth bars depend on water flow and sediment yield of the river or the delta channel, wave energy, depth and slope of the nearshore, tides, storm surges, ice regime, artificial measures, etc.
The development of the river mouth bar under relatively steady condition usually includes the following stages: 1) pioneer mouth bar formation; 2) lunate bar formation; 3) mouth bar widening; 4) central shallow bank formation and flow bifurcation; 5) scour of the central shallow bank and flow strengthening. Further these stages are repeated and a new bar forms seaward. An initial two-channel delta can be formed after bifurcation if the central shallow bank is very large or it is consolidated by pioneer vegetation.
Under the natural conditions the stages of the river mouth bar formation are subjected to the long-term and seasonal fluctuations of river water flow, sediment yield and wave energy. During the period with a high water flow the bar actively protrudes into the sea, its area and height increase. Over the period with a low water flow the bar is subjected to wave action and erosion. The spits are the products of the wave destruction of the bar. The sediments of the longshore drift can take part in the formation of these spits.
The paper deals with the quantitative analysis of the results of the field investigations of the river mouth bar morphology, morphometry and morphodynamics in nontidal deltas of the Sulak and Terek Rivers (the Caspian Sea) and the Danube River (the Black Sea). Besides these investigations carried by the author, data on the river mouth bars in the deltas of the Yana and Indigirka (Russia, Siberia), the Daugava (Latvia), the Vistula (Poland), the Huanghe (China) and the Mississippi (USA) Rivers are also used.

DAVID MILAN

Fine sediment interaction with the pool-riffle system

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Current thinking considering transport of fine-grained bedload sediments (<2 mm) through pool-riffle systems that experience velocity reversal, suggest that deposition initially occurs upon riffles during a spate. During waning

flows, where flow competence increases on riffles and decreases in pools, fines are winnowed laterally into downstream pools where they are deposited and stored until the rising limb of the next high flow. At this stage according to theory pools become more «competent» and previously deposited material is re-entrained. Field experiments conducted on the River Rede an upland gravel-bed river in Northumberland, UK, suggest however that fine sediments interact with the pool-riffle sequence in a very different manner. The natural flux of fines and the transport of an artificially-introduced magnetic tracer were monitored through the reach using an array of basket traps in conjunction with freeze coring. Coupled with hydraulic information, this enabled the production of a three-dimensional picture of fine sediment development over time. Freeze-core data did not pick up higher concentrations of tracer in pools as may have been expected; instead it appears that deposition occurs upon riffles, particularly on the channel peripheries and over point bar surfaces on the falling limb of high flow events. Fines are principally stored between the interstitial spaces in the topmost layer of the sub-surface sediments (as revealed from freeze-core evidence), and also as lenses on the lee-side of armour layer particles. There was no evidence to suggest that fines were winnowed from riffles into pools during waning flows. A conceptual model describing behaviour of fine sediment transport in upland pool-riffle systems is put forward.

JOHN D. MILLIMAN

Fluvial sedinment discharge to the sea and the importance of regional tectonics

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The geomorphic/tectonic character of the drainage basin and the actual basin area have first-order controls on the sediment discharge of most rivers. Topographic control (which in fact serves as a Surrogate for tectonic character of the basin), however is strongly dependent on the erodability of the substrate - younger sedimentary rocks being more erodable than older crystalline rocks. Climate (particularly precipitation) and human impact can play important roles, often explaining deviations from the load predicted on the basis of topography and basin area alone.

Suspended sediment (SS) yield of mountainous rivers increases 5 - to 9 - fold for every order of magnitude decrease in basin area, the result of decreased storage capacity, steeper gradients, and greater susceptibility to episodic events such as floods and landslides. As a result, a large percentage of the SS discharged to the ocean comes from small mountainous rivers, which generally discharge onto active margins. In contrast, a substantial part of the fluvial sediment load of large rivers, which mostly discharge to passive margins, may be deposited on subsiding lowlands or deltas; as a result, the actual sediment discharge to the ocean may be considerably less for some large rivers than cited in the literature. We therefore have probably overestimated the sediment discharge of large rivers to the ocean at the same time we have underestimated the discharge of smaller rivers.

Dissolved sediment (DS) yield of mountainous rivers with moderate to high runoff also increases with decreasing basin area, out at a lesser rate than for SS. DS yield is demonstrably lower for river basins with low runoff. While DS yield increases with decreasing basin area, its increase is less than that for SS. The resulting high SS/DS ratio in smaller mountainous rivers presumably reflects the decreased effect of chemical weathering due to the shorter period of sediment storage between erosion and discharge to the ocean.

Evolution of the river basin also can cause changes in fluvial sediment discharge. For instance, as a river progrades and (eventually) merges with other rivers. the SS yield should decrease and DS should increase, a situation not unlike that expected for rivers draining denuded mountains.

HUGH H. MILLS

Abandoned bedrock meanders used for the study of hillslope evolution

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Evolution of hillslopes on resistant bedrock takes place so slowly that direct observation of change in most cases is impossible. Instead, it is necessary to order modern-day hillslope profiles according to their relative age, and then consider their forms to represent stages in a developmental sequence. In the unglaciated Appalachians and Interior Plateaus of southeastern North America, landscapes are poorly dated, and finding a chronosequence of hillslope profiles is difficult. One opportunity to do this is provided by incised meandering streams near the western margin of the Eastern Highland Rim, Tennessee, U.S.A. Incision below the surface of the plateau is about 100 m, and valley walls are underlain mainly by the chert-dominated Ft. Payne Formation. These streams show «ingrown» meanders, characterized by gentle slip-off slopes on the inside of the meanders and steep undercut slopes on the outside. Some of these meanders have been abandoned when stream erosion cut through the narrow neck of the meanders. The floors of these cutoff meanders range in height from 2 m to as much as 43 m above the modern stream level (henceforth abbreviated «Asl»). Based on regional denudation data and one measurement elsewhere of stream incision rate, streams are incising somewhere between 10 and 60 mm/ka, so that the age

of the 43-m-high meander could range from 0.7 to 4.3 my. Hillslope profiles were surveyed on both active and abandoned undercut slopes. Active slopes were assumed to represent the initial form of the evolving slopes. The form and steepness of abandoned slopes were then related to the height of the meander floor above the modern stream. The assumption was made that over the long term, streams have been cutting down at a constant rate and that the rate varies little within the study area.

Actively undercut slopes show an upper convex segment, then a free face (cliff), a straight (debris slope) segment, and a concave basal segment. The free face can approach verticality, and may even be overhanging. The most rapid change in this initial form occurs soon after the meander is cut off. Abandoned undercut slopes, even those associated with meanders only 2 m Asl lack a free face, and show somewhat gentler overall slopes. Slopes on meanders situated 2 to about 20 m Asl maintain straight segments with angles showing only a slight decline from the 36°-38° angle associated with the youngest slopes; overall slopes decline, however, as the straight segment becomes shorter. The straight segments are not talus slopes, for bedrock ledges occur at the surface. The oldest slopes, those on cutoffs 30 m or greater Asl, have developed into convex-concave slope profiles with only a suggestion of a straight segment; steepest slopes may be as low as 14°-15°. An effort to model hillslopes from their initial forms (i.e., those of present-day undercut slopes) to their «final» forms (i.e., those of the highest abandoned meanders) was made using a model that incorporates rates of creep and other diffusive processes, wash, and landslides. Based upon typical values of creep, wash, landslide threshold angle, and other parameters, the results indicate that the age of the oldest hillslope is unlikely to be much older than 1 my, suggesting that the stream incision rate has been closer to 60 than 10 mm/ka.

NATALIA N. MITINA

Geomorpholodic peculiarities of shores as indicators of bottom natural complexes of shoals

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Complex studies of the bottom natural complexes (Bnc) in the Sea of Japan coastal zone (the Far Eastern coast) are carried out at the depths from 0 to 40 m. The Bnc are differentiated from landscapes to complex areas during the analysis of the graph-correlation relationships of landscape profiles, because the named morphological units covers in vertical the whole coastal zone of wave transformation. Natural communities with equal graph-relations are of the same morphological name in the structure of the landscape under study. It is determined by quantitative methods that the factors of land ecosystem are the main landscape-forming ones of submerged Bnc in the sea coastal zone, which are part of the sea landscape structure. Geologic - geomorphological coast type (the landscapes of abrasion-accumulative bay coasts, those of rias coasts, etc.) is the main factor of submerged landscape separation. The separation of the areas is bound with the geological and local tectonic structures of the coast and, consequently, with the coast line configuration. The following areas are distinguished: the bays with accumulative coasts, the abrasion coasts formed by the mountain ranges with an active cliff, and the abrasion-accumulative coasts with an atrophied cliff. The system of complex areas at the sea shoal are recognized by the mesoforms in the coastal relief (capes, kekurs, straightened coasts, etc.). The complex areas are confined to the elements of the bottom relief mesoforms and to the character of water masses, which are formed with the assistance of the river flow (for instance, the benches of the semi-isolated bays with freshened water masses).

Bnc, which cover part of a shallow-water profile and are the constituents of compound stows, - simple stows, substows, series of facies and facies - were distinguished by traditional methods. Simple stows were distinguished by the mesoforms of bottom topography, substows were separated out by the elements of mesoforms. The series of facies were isolated with gradual change in any factor, for example, in hydrodynamical activity; the facies were distinguished by biocenotic varieties.

Compound stows of bays include three simple stows of terraces of different age and hights: modern sea abrasion terrace located at a depth from 0 to 5 m, the first and the second relic sea abrasion terraces located at depths of 5-12 and 13-17 m, respectively. Simple stows of abrasion terraces are composed of substows of abrasion slope and abrasion terrace. The simple stow of the second sea relic abrasion terrace of bays is composed of substows of abrasion scarp, abrasion ringes, and slightly inclined surface. The abrasion scarp of modern sea abrasion terrace locates above a zero depth and is excluded out of considerations. The substow of the slope of modern abrasion terrace is divided into two series of facies, located in the zones of a surf current and a wave destruction. The called substows and the series of facies are divided by a biocenotic indication.

The compound stow of sea accumulative bay planes includes two simple stows of terraces of different age and height: modern and ancient accumulative terraces. The simple stow of modern accumulative terrace located at depths from 0 to 5 m is composed of two substows: the slightly undulating slope and the avandelta of an inflowing river. Within the limits of the substow of slope of modern accumulative sea terrace, we distinguished two facies: the facies of modern swells with a height of no more than 1-2 m and that of interswell subsidings. The substow of avandelta includes two facies: the facies of mouth pocket and that of mouth bar. In this case, the facial division is carried out on the basis of differences between the elements of relief mesoforms due to clearly defined mesoform elements, on the one hand, and because of absence of sessile benthos forms occupying the specific Bnc, on the other hand. The simple stow of a relic sea accumulative terrace is located at depths

of 5-20 m in the zone of wave transformation, and it is divided into substows of ancient bar (with a height of 3.5 m, and a length of 200 m), bedplate - an ancient bed of inflowing river, flattened, slightly inclined, terrace side and fragments of abrasion ridges. The facies of substows of ancient accumulative terrace are also divided on the basis of biogeocenotic varieties.
Complete sets of Bnc are encountered only in bays; and they are composed of three, for benches, and of two, for accumulative plains, terraces of different height and age. The called units of a morphological division are either partially absent or are undefined in a topography in other coastal forms. A depths, where a bench is overlain with a mantle of accumulative sediments, is different for each of compound stows depending on a coastal topography, proximity of a river delta and a volume of a river flow, and a type of water body and a direction of along-coast constituent of drift-gradient currents. It is established that the individual set of BNC of lower rank is typical of each of 15 compound stows modificated with the help of a correlation analysis.

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Geomorphological evolution and tectonic reactivation in a tropical plateau (Campos do Jordão, SE Brasil)

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The distribution and nature of landforms in southeastern Brasil clearly show the heritage of the Cenozoic tectonic processes that followed the opening of the south Atlantic ocean basin. During the Palaeogene (Eocene-Miocene) normal reactivation of old Brasiliano/Pan-African shear zones brought about a striking tectonic feature: the Continental Rift of Southeastern Brasil. In eastern São Paulo this structure is topographically expressed by the Serra do Mar and Serra da Mantiqueira, as elevated geomorphic units, and the Taubaté Basin, as the downthrown unit. Further uplift of probable Miocene/Pre-Pleistocene age would have accentuated differences in altitude between compartments.
At the southwestern end of the main block of the Serra da Mantiqueira, the Campos do Jordão Plateau is individualized by morphostructural and climatic characteristics. During the Quaternary its elevation above 2000 m resulted in a typical tropical montane landscape system, the «altos campos». On the summits of the plateau (1900-2007 m), this landscape is characterized by local relief of 40-50 m, generalized hillslope convexities, shallow slope depressions and relatively broad floodplains filled with peaty sediments. In this area, along the northeast-trending lineaments of the Precambrian Jundiuvira Fault, the Galvão valley presents three geomorphological compartments separated by breaks in the longitudinal profile. Knickpoints occur where the Jundiuvira fault cuts lineaments in zones with evidence of reactivation that seem to have been preferential sites for the stream piracy phenomena observed along the Mantiqueira divide. These facts plus morphological evidence such as assymetric valleys with straight scarps, triangular and trapezoidal facets, hanging valleys, countercurrent confluence, etc., are indicative of the reactivation of ancient regional structures.
Morphostructural analysis of part of the Campos do Jordão Plateau, including characterization of Quaternary deposits and brittle tectonic structures, has led to the identification of three superposed neotectonic regimes of Holocene age: an initial E-W right-lateral transcurrent binary with left-lateral movement of NNW transcurrent faults, followed by E-W extension that affected stone-line deposits, and a final E-W compression that generated shear joints in colluvium, organic-rich soils and peat deposits.
Quaternary evolution of the landscape of the main tropical montane system of southeast Brasil thus reflects a combination of climatic influences and recurrent neotectonic activity.

SALVATORE MONTELEONE, GIUSEPPE PIPITONE & MARIA SABATINO

Geological and environmental characteristics of the new towns built after the 1968 earthquake in the Belice Valley (Western Sicily)

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In January 1968 an earthquake of magnitude Richter 6.0 shook western Sicily causing over 400 deaths. The epicentre was in the valley of the River Belice. The earthquake caused considerable damage in ten
towns in the provinces of Agrigento, Palermo, Trapani and totally destroyed the towns of Gibellina, Poggioreale and Salaparuta in the province of Trapani, and Montevago in the province of Agrigento. These towns were rebuilt in new locations some kilometres from the original sites. The choices regarding the new sites and their urbanization were in the responsibility of the State.
This study on the new sites of Gibellina, Poggioreale and Salaparuta shows that missknowledge of the geological, geomorphological and geoenvironmental characteristics led to mistaken choices of territorial planning when reconstruction began. It has been found that the modifications to morphoevolutionary processes caused by human intervention have triggered considerable alterations in the evolution of the territory, creating a situation of hydrogeologi-

cal hazard. The geomorphology of the area before and after urbanization has been established by a comparison of maps on scales of 1:25.000, 1:10.000 and 1:5.000 and of aerial photographs on a scale of 1:18.000 and 1:10.000.
Gibellina was rebuilt on a low-lying area composed of clay marl lithologies (Upper Miocene) cut across by a watershed collecting the waters of a catch basin, which after the urbanization work was diverted and canalized. The result is that after critical meteorological events (the most serious case was in November 1992) the town centre is flooded and buildings are damaged.
The new sites of Poggioreale and Salaparuta stand on pelitic-arenaceous terrains (Middle Upper Pliocene) which even before the urbanization process were subject to widespread quiescent landslide phenomena of various type (slips, debris flows) and extent. Many buildings now present evident lesions due to the reactivation of some landslides.
This situation has negatively affected the physical environment (altered equilibrium of waterways and slopes) as a result of acts of territorial planning not prepared for by appropriate geological and geomorphological studies.
This study identifies the factors of geomorphological instability and suggests methodologies for interventions in areas at risk, in the context of a more rational planning of the territory.

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Erosional and tectonic controls on the elevation of mountain peaks: Olympic Mountains, Washington, USA

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Isostatic adjustment to valley deepening and increased local relief can result in the uplift of mountain peaks. A method for examining the influence of relief development on the elevation of mountain peaks from topographic profiles (Montgomery, 1994) was extended to the three-dimensional case of an entire mountain range in the Olympic mountains, Washington. The Olympic mountains present an opportunity to study erosional and tectonic controls on the elevation of mountain peaks: subduction-related tectonic convergence drives asymetric uplift of the range and Quaternary glaciations scoured deep valleys into the heart of the range. The amount of material eroded from below mountain peaks was contrained by constructing a 30 m grid size digital elevation model (Dem) of the range and then fitting a surface to the collection of highest elevation points within a search radius that varied from 1 km to 8 km. The volume of material between the present land surface defined by the 30 m Dem and the surface interpolated between mountain peaks was averaged over 100 km^2 (10 km by 10 km) grid cells. Maps of the mean elevation, maximum elevation, present relief, and the equivalent thickness of the volume of eroded material reveal several intriguing patterns that allow separation of erosional and tectonic influences on the elevation of mountain peaks in the Olympics. Areas of highest present elevation separate into two primary areas: one centered on Mt. Olympus in the core of the range and the other to at the eastern end of the range. The area with the greatest volume of eroded material centers around Mt. Olympus, whereas the highest mean elevations concentrate in the eastern end of the range. Hence, it appears that the location of the highest peak in the range is controlled by local erosional unloading due to scour of deep valleys by Quaternary glaciation, whereas the general area of high elevations at the eastern end of the range arises from tectonic controls. Plots of the volume of eroded material versus elevation indicate erosion is not a simple function of elevation, as the greatest apparent removal of material occurs at intermediate elevations. This approach holds the promise of addressing the relative importance of isostatically compensated valley deepening and other mechanisms contributing to the elevation of mountain peaks.

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Experimental weathering of a clay-rich sandstone by saline solutions

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A clay-rich sandstone of Carboniferous age, Forest of Dean stone, has been shown to weather rapidly in a coastal saline environment (Mottershead 1994, Pye and Mottershead 1996). The present study investigates in the laboratory the influence on sample cubes of this rock of various saline solutions under controlled conditions over periods of 100 and 200 days.
X-ray diffraction, backscattered scanning electron microscopy, and microprobe analysis were used to characterise the rock cubes before and after the experimental runs. The sandstone consists largely of quartz, feldspar, mica, illite, chlorite and kaolinite, with trace amounts of iron oxides, carbonates and heavy minerals. Clay minerals and micas comprise 10-15% of the rock, representing both detrital matrix material and authigenic cement. The fresh rock has a relatively high compressive strength, of the order of $85MNm^{-2}$.
Solutions of NaCl, $MgSO_4$, $MgCl_2$, and $CaSO_4$ at various concentrations were employed, with artificial seawater as a comparison and deionised water as a control. The mass and linear dimensions of the samples were measured before immersion in the saline fluids, and afterwards in the wet and subsequently oven-dried condition.

Bulk density is shown to be a very significant control on fluid uptake. The final dry mass (including absorbed salts) is shown to be positively correlated with both wet dimensions and final dry dimension. The various solutions were shown to have differential effects on the mass and linear dimensions of the samples, as demonstrated by significant variation in final dry mass of the samples, and both wet and final dry dimensions of the sample blocks.
Tests have been carried out to determine the effects of the different saline solutions on the compressive strength of the test cubes after varying periods of immersion. Results indicate that there is a small but significant differential effect which is likely to increase with increasing immersion time.
Chemical analysis of the experimental saline solutions has also been carried out using inductively coupled plasma spectrometry and ion chromatography, to determine the uptake of anions by the rock and to establish whether any significant loss of particular cations occurs from the rock during immersion. Initial results suggest the latter effect is relatively small but that it may also increase with duration of immersion.

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Soil genesis and landscape evolution in São Sebastião da Vitória, Minas Gerais, Brazil

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The geomorphic evolution of the south-east Brazilian landscape, is considered to be a sequence of dissections and planations due to climatic changes, superposed on differences in lithology. The evolution comprises a number of unstable (truncation of soils; accumulation of slope material), and stable (undisturbed soil formation) phases, which, combined with the overall stability of the landscape, resulted in deep soils of a polygenetic nature. In addition to climatic changes, it is likely that tectonic activity during the Tertiary and Quaternary contributed to the landscape disruption and rebuilding. This implies that the dominating Oxisols will have been more or less affected by erosional reprises that resulted in cycles of soil formation in a landscape rejuvenation scenery.
In order to unravel the link between gemorphic history and phases of soil formation, an area located in São Sebastião da Vitória, centre south part of the state of Minas Gerais, was selected for investigation. The main lithologies are fine textured metamorphic rocks (phyllites and fine schists), and the climate is a Tropical Highland climate, with an average annual temperature of 19-20 °C, and average annual precipitation of 1,400 mm with 4 to 6 dry months. Topographic and weathering soil sequences were sampled, and the soils were studied by means of chemical, mineralogical and micromorphological analyses in order to draw conclusions on their development stages. A set of soil profiles sampled in an catena that cuts through the Oxisol deep into the saprolite, has deeper and redder soils at the top, and yellow and shallower soils downslope.Their macromorphology suggests at least two phases of soil formation. But the redder soils at the summit level, which are remnants of the last stable landscape surface, show relicts of homogenised soil materials that already represent more than one soil formation phase.Vertical sequences sampled in a recent gully nearby the catena show a more complex soil development. They show that the former landscape was affected by gully formation and filling, which was interrupted by at least a short phase of soil formation, witnessed by the presence of buried root layers. As a consequence, the present-day Oxisols have developed on both metapelites and younger sediments. Former gullies have been filled up by sediments in which (various phases of) paleosols had developed. Now they are virtually invisible because of the Oxisol overprint. It suggests that gullies formed by erosion and/or tectonic activity in a planated landscape were filled up in more than one sedimentary and soil formation phases, and eventually overprinted by a phase of Oxisol development. The last landscape incision removed most of the Oxisol cover and was followed by the present soil formation resulting in yellower soils in the slopes. So, climatic changes causing dissections and planations together with tectonic reactivation giving origin to small sedimentary basins are likely the main geomorphic processes intervening in the formation and evolution of the soils in the studied area.

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Morphology and geodynamics of the outer thrust belt of Western Nepal

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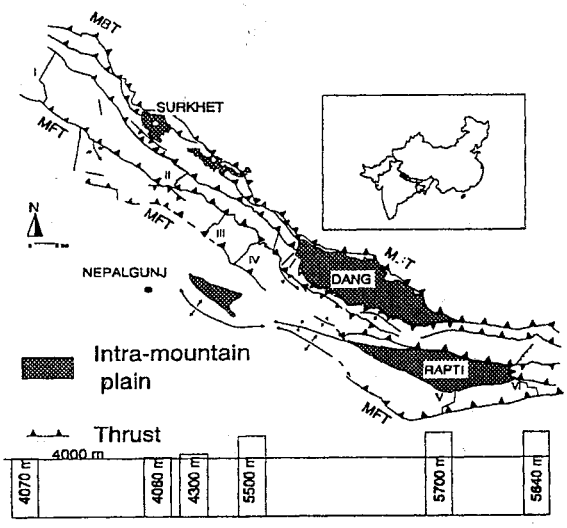
Comparisons between digital elevation data, structural field data and predictions of a numerical model («Wedge») are used to improve the understanding of the landscape and geodynamics of the Outer thrust belt of Western Nepal. The «Wedge» model is based on incorporation of discontinuities in the critical wedge model, a cinematic forward model of serial cross sections and a linear diffusion algorithm that simulates superficial transport. «Wedge» predicts , from a set of mechanical, geometrical and

superficial parameters, the deformation of a thrust pile and the topography above the active thrusts.

The elevation of the first hill that looks down upon the Ganga plain is regular and close to 900 to 1100 meters. This hill is related to the hanging-wall structure of the Main Frontal Thrust (Mft), and it regular elevation results from a steady-state that involves a balance between erosion and uplift-thrust-related. More than 10 km displacement occurs along the Main Frontal Trust, whereas more than 30 km^3 (for a 1km along strike portion) of sediment are eroded in the order of 1 million years.

The large intramountain plains (Duns) of Western Nepal are piggy-back basins above thick thrust sheets that involve more than 5500 m of Siwalik series. The extension of plains is restrained above thinner (nearly 4000 m thick) thrust sheets. The results of the «Wedge» model suggest that the dependence between thrust sheet thickness and extension of the intra-mountain plains is linked to an increase of the dip of the basal décollement beneath the Duns.

Close to the Karnali river, out-off-sequence reactivations of intra-Siwalik thrusts are clearly evidenced above thin (nearly 4000 m) thrust sheets. The application of the «Wedge» model links this peculiar situation to a greater influence of erosion for thrust wedges developed above a gentler basal dip and characterised by steeper mean topographic slope. The steeper mean slope enhances erosion, restrains the frontal migration of the thrust belt and induces out-off sequence reactivations.



Thickness of the thrust sheets above the decollement.

SUBHASH CHANDRA MUKHOPADHYAY

Tectonics and landscape patterns of the North Eastern Indian Subcontinent (Parts of S-Asia, E-Asia & SE Asia)

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Present author has made an attempt to investigate on the occurrences of tectonics and evolution of typical polycyclic landscape patterns inclusive of the complex-compound-composite drainage peculiarities (Ganga-Brahmaputra-Irrawaddy Basin) set in seismo-tectonically active terrain of North Eastern Indian Subcontinent (Mukhopadhyay 1995). This part of South (India & Bangladesh) - East (Tibet - China) - South East (Mayanmar)Asia is of - critical geomorphological significance since it includes the nexus of a large number of major tectonic zones controlling greatly the devolopment of distinct landscape elements like a series of ridges and vales, multi-tier river terraces and floodplains, heavily dissected 1andslide-hillsidevalley-sideslopes, incised meanders, composite scarps, wide gently undulaing plains etc. primarily under fluvial - glacial - flvioglacial environments (very humid). The morphotectonic lineaments have been drawn on some details and analyzed statistically domain-wise rose diagrams etc. Such major tectonic zones are-(i) The Naga - Arakan, Yoma fold belts, (ii) Indo - Sinian fold belt, (iii) Nyenchan Tangku' la fold belt, (iv) Himalayan fold belt, (v) Tethyan basin, (vi) Tibetan platform, (vii) Cathaysian platform, (viii) Corner of the Indian Shield, (ix) Sedimentary basins of Assam, Surma & Burma etc.

The imagery used in the study comprised photoformat Mss imagery in bands 5 and 7 from Landsat 1 and 2, generated by Nasa, USA and available through Eros Data Centre, Usgs. Visual interpretation was carried out on prints on a scale of 1:10,00,000 and enlargements on 1:250,000 scale, The interpreted results were compiled on a mozaic on 1:10,00,000 which reduced to about 1: 40,00,000 forms Maps. The analysis of tectonic fabric was based on recognition elements such as tone, texture, size, resistance to erosion, structural and topographic expression, landforms, drainage density and pattern which have brought out spectral characteristics of different terrain features. All morphotectonically lineaments have been drawn, and their significance have been evaluated latter. The results of the preliminary analytical phase with tectonic domains and landforms are also presented.

Shillong Plateau and Mikir Hills: This is an oblong, raised platform etched with close spaced linear, cris-cross drainage pattern on a generally smooth, light toned surface. Two dominant sets of closely spaced fractures are seen trending NW-SE and NE-SW. The most important one delimits the western boundary of the outcrop of the Shillong group and cuts across the Mikir hill. The NE-SE trending Kopili lineament passing in between the Shillong Plateau and Mikir Hill is significant. The Plateau with Archaean gneissic complex and Proterozoic Shillong Group of rocks is bounded to the south by the E-W trending Dauki Fault, to the north by Brahmaputra depression, to the west by the Jamuna lineament and to the east it is covered by the Tertiary sediments of Upper Assam (Belt of Schuppen). Surma Basin: This zone of folded sediments is characterized by arcuate and sinuous ridges and valleys of low relief. NE-SW and SW-SE trending fractures are common which recklessly spaced towards the eastern margin. This is a Neogene basin which widens towards south west; to the

north it is limited by the Dauki fault and to the east by the marginal faults of the Barail ranges. Naga-Lushai-Arakan-Yoma Folded Belts: This is an elongate crescent-shaped belt extending from the Bay of Bengal to the Mishmi block in a N-S, NNE-SSW ot NE-SW direction. It is characterised by parallel ridges and valleys, rugged and intensely dissected topography and parallel and dendritic drainage. Likwise, the Bengal - (Brahmaputra) basin is characterised by flat lying, even and mottled textured terrain with low relief and anastomosing drainage pattern. The NW-SE trending lineaments are very prominent running almost parallel to the stream courses viz. Padma lineament, Jamuna lineament, Tista lineament etc. Used in conjunction with discontinuous data in terrains of poor access, this synoptic medium provides a powerful tool for tectonic analysis. Boundaries of such tectonic zones, thus identified, are marked by pronounced lineaments, either straight or curved. Lineaments of significance include the Dauki fault, Jamuna lineament, Tista and Padma lineaments, Main boundary fault of the Himalaya, Siang fracture, Tsangpo suture, Mishmi and Lohit thrusts, Naga and Disang thrusts, Axial zone, Volcanic line of Burma, Red river faults, etc. Lineaments passing from GangaBrahmaputra delta across the Himalaya to Tibet must be the expression of deep-seated and fundamental crustal fractures, but are possibly of geologically recent origin as evidenced from their manifestation through the recent river deposits of the Bengal basin. The entire area is representative of a conspicuous polycylic landscape with diversified soil - landform - drainage types. The seismo-tectonic activities which are belived to have become very active, due to plate tectonics (Mayanmar Plate & East Indian Plate) have exerted much influence in this evolution.

TIM J. MUNDAY, LISA WORRALL & ANDY A. GREEN

Airborne Electromagnetics - Providing new perspectives on geomorphic process and landscape development in regolith dominated terrains

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Airborne electromagnetic (Aem) methods have a considerable, largely untested, potential for mapping regolith materials in three dimensions and improving our understanding of those processes involved in their development. Other, more common, methods used in regolith and geomorphological mapping have limited skin depths and only return information on the nature and disposition of regolith materials at surface (see table 1). This paper examines the promise of Aem data by reference to examples drawn from the Lawlers area located in the Archaean Yilgarn Craton, Western Australia.

TABLE 1: AEM Data - Content

Technique	*Radiation*	*Skin-depth in typical regolith materials*
Remote Sensing	Visible/Infrared light	< 1 micron
Radiometrics	Gamma Rays	< 1 metre
Radar (Ground (GPR); Microwaves Air & Space)	1-20 metres	
AEM	VLF and below	10-100 metres
Magnetics	Magnetic field	not applicable

Air photos, remote sensing imagery and radiometrics data provide useful, though shallow information, whilst magnetics responds variably to regolith, largely because of the dispersed character of magnetite relative to fresh rock (Table 1). In more resistive terrains, ground penetrating radar may provide information on the disposition of regolith materials at depth. However, the conductivities exhibited by regolith materials typical of Australia, suggest this technology would have limited application, with skin-depths being generally less than 10 m.

Aem surveying methods make use of the response of the ground to the propagation of electromagnetic fields. A primary electromagnetic field is generated by a transmitter in the aircraft. The ground generates secondary electromagnetic fields in response, which are usually measured in a receiver towed behind the aircraft. The difference between the transmitted and received fields reveal the presence of conductors and provide information on their geometry and electrical properties. Regolith materials are variably conductive, depending on their nature and characteristics (physical and chemical). Their lateral variations can produce spatially coherent responses in electromagnetic (Em) data.

We describe a new approach to the processing, display and interpretation of multichannel, multicomponent Aem data which draws on statistically-based methods developed and refined for the analysis of multispectral remote sensing data. The application of the principal components method as a technique for addressing data redundancy and for the display of Aem data for regolith mapping purposes is examined in this context.

A comparison of existing regolith maps (compiled through conventional mapping methods, including the use of air photos and remote sensing data) and Aem data for the Lawlers area, suggests that the surface distribution of regolith materials is likely to be a poor indicator of materials at depth. A significant amount of unmapped, unexplained, detail is also observed in the latter, notably in areas of transported cover, comprising alluvium and colluvium. The application of Aem to regolith mapping and the reconstruction of landscape history is discussed with reference to this information. Comment is also made on the role of Aem in providing information on groundwater hydrology. Aem data for the Lawlers area indicates the importance of structural and lithological control on through-flow.

MUSEYIB AGABABA MUSEYIBOV

The influence of neotectonic movements on the formation of relief of Azerbaijan

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The absolute majority of geologist and geomorphologist, engaging by the study of relief and tectonics of Caucasus and other mountain regions the begining of the neotectonic epoch relates to sole (botton) of the upper sarmation time.
The basis for this is served the discovery in the mountain areas of Azerbaijan of Sarmatian sea deposities on absolute height about 2000-3500 meters (above sea level) on the Major Caucasus mountains and 1100-200 meters (and higher) on the Minor Caucasus.
The considerable activization of neotectonic movements during neogen pleistocen time is confirmed by paleogeographic, paleogeomorphological , paleolandscape, palinological, paleotectonical and other researches.
In the major Caucasus mountains the neotectonic movements showed himself as archblock and folding movements (in the remote sides and in the region of periclinal submergence). But on the Minor Caucasus these movements showhed himself only as a archblock movements.
The mentioned features of display of neotectonic movements as a whole brought to conditioning the morphostructures of different ranks an different types (direct, inverted and so on). The absolute heights of mountain regions and their hypsometric stepness are conditional by characteristic intensity of emergenes.
The intensity of upliftings becomes decreased from axial high mountain zones to sides of mountain systems and further to the side of depression the uplifting is involved by sagging.
According to the character of display and spatial differentation of neotectonic movements the Minor Caucasus is significantly distinguished from the Major Caucasus.
In the Minor Caucasus and further to southt the neotectonic movements and magmatism conditioned to the formation of a whole series of anticlinal horst-anticlinal mountain system, basins-grabens, volcano-tectonic highlands.
The regions of absolute saggings and sedimentations and zone of inverted folding are distinguished in depressed regions of Azerbaijan acoording to tbe character of displaying the neotectonic movements. According to relief, first, it is presented the lowlands and weak sloped plains, but second, fold low-mountains. Within the zones of absolute sag the growth of separate structures feel behind from the speed of sagging and accumulation. At the result of this the separate structures became the nongeomorphogenic. The zones of inverted fold at the beginning and middle of neotectonic stage experienced the intensive sagging , but at the end of the stage the intensive inverted folding. Therefore, in these zones have been formed a whole series of anticlinal, monoclinal low-mountain ranges and ridges and synclinal walleys and basins.
The analysis of features the display of neotectonic movements and relief of Azerbaijan showes that the main carcas of the present relief of Azerbaijan has been formed under prevailing influence of neotectonic movements.

EVGENIY A. MYASNIKOV

Volcanic structures of Upper-Amur Region using evidence of morphostructural (structure-geomorphological) studies

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Studies of volcanic structures of the Upper-Amur region are of great significance inasmuch as their formation is Mesozoic tectonic and magmatic activation being the main and well-expressed epoch of endogenic structural and ore formation within the region (Geological map of Baikal-Amur railway region, 1977; Metallogenic map of Baikal-Amur railway region, 1981 and others).
The conducted morphostructural studies, based on satellite images and available geomorphological, geological and geophysical evidence, provided an opportunity to specify existing ideas concerning the tectonic pattern ant metallogenic specialization of the West-Stanovoi, Central-Stanovoi and Umlekano-Ogodzinsk volcano-plutonic belts.
In regional morphostructural plan data on the belt appear to be components of the «Amur» and «Aldan» mega-morphostructures of the Central type (mega-Mct) about 2.500 km in diameter that have been established by Zolotov (1976), Solovyov (1978), Kulakov (1980). Besides considerable mega-Mct overlapping in the Upper-Amur region allows us to assume fragmentary manifestation of specific rocks and mineralization of the West-Stanovoi belt within the Central-Stanovoi belt and particularly within deep-seated faults of the north-eastem strike and etc.
Each of the volcano-plutonic belts under consideration appeared to be the linearly elongated Mct «row» of the third (60-250 km in diameter) and fourth (20-50 km in diameter) orders, controlling by dislocations with a break in continuity of regional morphostructures (mega-Mct and large linear fault zones). Low order Mct are mainly grouped in linear («circuit») and isometric («satellite») systems, but in any case they are confined to the zones or intersection nodes of fault elements of high rank morphostructures.
Joint analysis of geological and geomorphological conformal complex of distinguished morphostructures revealed that Mct of the third and fourth orders mainly appeared to be complex volcanic and plutonic domal-circular structures, whereas lower- order Mct - paleovolcanoes and local intrusive domes Mct of any ranks are characterized by radial-concentric situation of proportionate relief elements, conformable geological complexes and ore mineralization.

VLADIMIR I. MYSLIVETS

The problems of the structure of the global morphogenesis

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The global morphogenesis is a complicated process, any aspects of which are poorly investigated. Analysis of its structure arises some problems. The first problem is a functional structure. The development of global relief of the Earth is the result of the complex contradictory interaction between geomorphological processes, forces and factors of different - cosmic, planetary, endogenic, exogenic and anthropogenic origin, from one side, and landforms of different orders - from other side. According to modern level of our knowledges, origin of the Pacific Ocean and ancient cratonic nuclears of continents are the result of cosmic and planetary scale events at early stage of Earth evolution (origin of the Moon and impact action of large meteorites and asteroides). Peripheral parts of continents and Atlantic-type oceans are forming under influence of the actualistic endo-exogenous processes, including plate tectonic. These processes are divided into two large groups. Internal processes are organized in the totality of endogeodynamic regimes (V.V. Beloussov), which are changing in time and space and are controlling the character of elementary endogenous processes - tectonical movements, magmatism and methamorphism. External processes are organized in the totality of exogeodynamic regimes - geographical zones, which control elementary exogenous processes - erosion and accumulation of various types. So, the geographical zone is not only the definite territory, but it is also the type of exogeodynamic regime, changing in time and space. The combination of endogeodynamic and exogeodynamic regimes determines the main types of natural environments. The landforms of each type include relict, inherited and newly-formed ones, which developed by different ways.

The second problem is a spatial structure of the global morphogenesis and its origin. The main lithospheric features of this structure - the existence of oceanic, Pacific, and continental hemispheres of the Earth; regular disposition of continents, Atlantic-type oceans; the main orogenic continental and oceanic belts; the orthogonal - diagonal lineament set. These features combine with spatial, zonal-sectoral structure of atmo-, hydrospheric and biotic processes. Their interaction defines spatial regularity of the main agents of the global denudation and accumulation (ice sheets, large rivers, arid regions,provinces of predominance of accumulation in the oceans and so on).

The third problem is an energetical structure of global morphogenesis. It is in a strong connection with aspects , mentioned above, and includes such questions, as sources of energy of morphogenesis, their quantitative parameters and distribution, character of manifestadion and its results. Existing of the energetically active zone on the Earth surface palys an important role in the estimation of natural environments.

At last but not at least there is the problem of temporal structure of global morphogenesis. There are two aspects of that problem. The first ones characterises the evolution of global morphogenesis. So, analysis of global mechanical denudation and accumulation for Phanerozoic time show, firstly, an alteration of relatively quiet and active epochs, and secondly, an increasing of intensity of those processes from each geotectonical cycle to consequent ones. The second aspect concernes modern temporal structure of morphogenesis: the regions of rapid change of relief neighbouring with territories of slow surface development. Each of them has their own «geomorphological» time.

ALIPASHA ALIBEK NABIYEB

Program providing and data base for investigation influence high of relief' on the elements of geosystem by means of mathematical-cartographical modelling on computer

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At present the parametrization of the spatial-temporal structure of geosystem are mainly conducted by their cartographical materials, cartographical-statistical modelling on computer an so on. Therefore this research on first stage needs composing the program providing and data base on computer. For this aims we have composing complex program «Geomor.Base» and data base «Geomor.Data» on base Ibm Pc At at the Calculation Centre Baku State University.

The structure of complex program «Geomor.Base» has a following view:

– morphometrical and kinematic modelling of the relief as a pole of hights and approximation methods of mathematical-statistical and integral calculations; classification of the elements of the relief with the methods of functional analysis; 2D and 3D modellin of the relief with aim of developing geomorphological processes; modelling of the hights of relief for investigation influence on the distribution numerical characteristics of elements of geosystem by the geomorphological levels and characters its contrasts by means of factoral-regressional modelling on computer and so on.

The structure of geomorphological data base «Geomor. Data»:

– morphometric data of various forms of the relief, dynamic and geomorphological processes; cartographical data for images and linear characteristics (geometrical characteristics of the relief: -maximal and minimal and average of hights of relief, numerical data of morphostructures and morphosculptures; quantitative data of elements of geosystem (complex data of geosystems on macro, mezo and micro levels and its elements: soil-plant covers, rivers, and others), and so on.

Results of example. On the basis of the received results one may come to the following results: with encrease of the hight of the place the average amount of the square of the individual groups of geosystems; the change of the general entropy according to the relief is similar to the change of the q square of the hypsometrical level as the both data in the middle mountain of the Minor Caucasus receive maximal amount. The amount of the middle square declination gradually decreases with the increase of the hight of the place and so on.

JEROEN NACHTERGAELE[1] & JEAN W.A. POESEN[1,2]

Gully erosion: after event field survey

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Gully erosion is one of the key processes for understanding links between uplands and permanent streams. But as in the past most studies concentrated on the field scale (e.g. Wischmeier plots) many erosion specialists overlooked ephemeral gully erosion and bank gully erosion (Poesen & *alii*, 1996). Consequently gully erosion is also not included in most of today's erosion models.

There is a need for accurate field data. The best way is to obtain these field data during intensive monitoring campaigns, but this requires several years of detailed fieldwork. Therefore, we used data from some after event field surveys. First of all these data can be used to prove the importance of (ephemeral) gully erosion by calculating absolute and relative erosion volumes due to gully erosion. Besides this, the field data provide also some general field characteristics which make it possible to look for gully initiating threshold conditions. In the most basical way, we try to set out a critical relation between slope (S) and runoff contributing area (A). However, results show that it is worthwhile to try taking into account some other field characteristics such as land use and soil properties.

As our data are directly related to one intense rainfall event, the relations based on these data are site and time (i.e. event) specific. By combining the data sets it is possible to look for more general relations.

Another possibility to overcome the restrictions of space and time, is using a sequential series of aerial photographs of different places. This method of course, has again its own limitations and results in a rather conservative estimation of soil losses due to ephemeral gully erosion (Vandaele & *alii*, 1995). Looking for gully initiating threshold conditions via aerial photographs is far more difficult because of difficulties in delimiting runoff contributing areas (A) and calculating local slopes (S).

Finally the results of the event based field surveys are also very useful to evaluate the few existing models that take gully erosion into account.

RACHIDA NAFAA

Passage de l'érosion aréolaire à l'érosion concentrée dans une région forestière défrichée du Maroc Septentrional

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Les versants de la Mamora vivent actuellement dans un cadre écologique instable, vu le degrès d'anthropisation dans

un espace connu par sa fragilité où les sols sont exposés au défrichement et à l'érosion. La forme initiale des versants est entrain de changer, à cause de la disparition progressive de la forêt naturelle, des practiques culturales inadéquates, des installations introduites (carrières, routes, clôtures, canaux de rassemblement des eaux, etc). Tout cela crée des points de faiblesses sur la surface des versants, qui diminuent la capacité d'infiltration, destructure le sol et bouleverse les profils. Ces versants en désequilibre deviennent sujets à deux actions différentes: la première, se passe lors de chaque événement pluvieux quel que soit sa quantité et son intensité, qui réduit progressivement et d'une façon inaperçue les horizons supérficiels du sol, mais que l'on peut évaluer son importance par la quantification, c'est l'érosion aréolaire. Elle diffère selon les caractéristiques du sol, le type de cultures et les techniques de travail; la deuxième, se passe exeptionnellement en relation avec les événements pluvieux exceptionnels qui dépassent 20 mm/heure, rendant l'érosion plus dangeureuse car les formes d'érosion deviennenent irrévérsibles. Une campagne de mesure (1990 à 1996), nous a permis de bien determiner les conditions de la dégradation des sols dans cette région.

DAICHI NAKAYAMA[1] & MICHIO NOGAMI[2]

The effects of valley intensity parameter as thresholds of stream heads definition for Dem-based stream network properties

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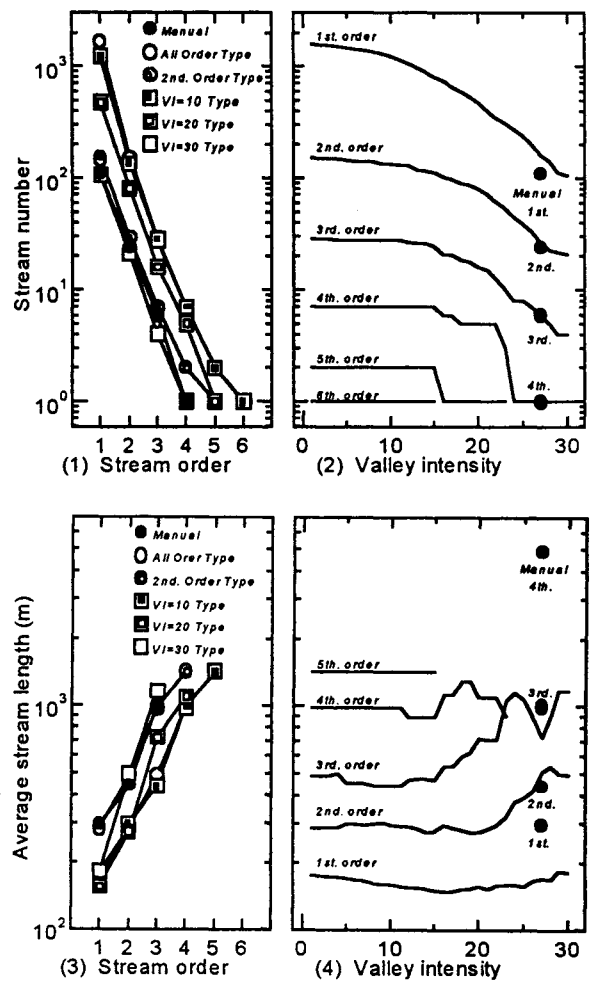
Topographical properties of drainage basin depend on many variables regarding stream orders. Several definition of stream heads used in past researches: the points of bends in contour lines, the points where valley width are larger than valley length, and the end points of «blue lines» drawn on topographical maps. However, personal differences and subjective results might cause when these manual methods are used. Instead the simulating stream networks from Dems with computer can avoid these problems. Of course, the definition of stream heads and threshold effects of Dem-based calculation is also very important to consider Horton parameters and watershed geomorphology. Keith (1993) adopted basin area, and Snell (1994) adopted magnitude of exterior links as threshold definition. The purposes of this study are (1) to define a new threshold criterion of Dem-based stream networks and (2) to consider the effects on Horton parameters by using this threshold.

The Southern Alps region, Central Japan, is the study area here and 50 m quadratic mesh Dems provided by Geographical Survey Institute of Japan (Gsi) are used as basic dataset. First, stream networks are simulated by flow-down algorithm (e.g., Nogami, 1991), then five drainage basins with approximately 20km2 area are selected from Dem-based stream networks. To compare these Dem-based basins with manual ones, both basins are plotted on the same topographical maps (1:50,000 in scale, 20 m contour intervals). Horton-Strahler ordering system is applied to all stream networks in this study. For the case of manual method, uppermost points of bends in contour lines to upstream are used as a criteria of stream heads. For the DEM-based stream networks, three different criteria are tested to define stream heads; (1) use all order of streams (All Order Type), (2) use second or higher order streams of All Order Type (2nd. Type), (3) use Valley Intensity parameter (VI Type) which is defined here as min(H_0-H_1, H_0-H_2); H_0 is relative height between observed point h(x, y) and flow down point h_0(x, y), and is projected to the orthogonal surface against flow direction. H_1 and H_2 are relative height between h(x, y) and h_i(x, y) which is located left and right side of flow line between h(x, y) and h_0(x, y), respectively. VI Type networks are simulated by the three VI cases (10<, 20< and 30<). Where, VI parameters become large, contour lines of topographical map bend to up-



FIGS. 1-4 - Relationship between stream order, average stream length and valley intensity at drainage 1, selected from one of the five basins.

per streams. In DEM-based networks, more than two streams confluent simultaneously. Therefore, the streams which have maximum stream order are joining on same time, stream order of after joining is increased.
R_b = 4.27 and R_l = 1.89 is obtained for average bifurcation ratio (R_b) and average stream length ratio (R_l) of manual-extracted drainage 1, respectively. These results agree with results of other studies treating Japanese rivers (for example, Tokunaga, 1966). On the contrary, Rb is bigger and Rl is smaller than that of manual-extracted networks, respectively, for All Order Type, (R_b = 5.93 and R_l = 1.69), VI = 10 Type (R_b = 5.35 and R_l = 1.76) (figs. 1 and 3). This is caused by All Order Type and VI = 10 Type simulate too many 1st. order streams than manual-extracted networks. This means All Order Type and the threshold value VI = 10 cannot eliminate the valleys or gullies which are not represent on the topographical maps. About stream numbers, the number of VI = 27 show the best agreement with manual-extracted networks (fig. 2). However, the stream length of VI = 27 agree only that of 2nd. and 3rd. order streams (fig. 3). These differences may be caused by locations where stream starts. The uppermost points of these are regarded as stream heads in this study, but not always the case in real. The length of 1st. order streams, therefore, are estimated irregularly. The further study will take this problem into account.

VLADIMIR N. NEVSKY

Do isostasy and rotational regime control relief evolution of continental margins?

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Can Earth's surface processes influence geotectonics? The common answer has been done in hypothesis of denudation-accumulative and glacio isostasy. Its main principles have to be corrected according to recent geophysics and paleogeography data.
As is known surface mass movement both and water-ice transformation causes asthenosphere compensation in sublateral directions. All these inner and outer processes are connected dynamically by means of Earth's rotational regime such as polar wandering and Earth's flattering. There is the interesting fact: R-polarity geomagnetic excursions during Brunhes epoch correlate chronologically with fluctuations of north continental ice volume much better, than with some another processes. In other words north ice coves and rotational parameters change due to glacioisostasy are very probable causes of short-term geomagnetic events. Secondly, locality of some island arcs is assumed to correspond to ancient sedimentary basins of the most large rivers. For instance the L. Antilles arc corresponds to Paleogene accumulation basin of South America rivers of north direction. Pacific arc Ryukyu has been formed near abyssal fans of Paleogene -Neogene Great China streams. These processes are supposed to be caused by extremely high gradients of mass balance on continent-ocean boundary near abyssal sedimentary basins of large rivers. As is postulated lithosphere is of mainly compression and fracturing conditions, so the most probable result of denudation-accumulative isostasy at the boundaries is a subduction. Rifting has a passive role. Subduction of west Pacific type develops under superposition of compensative and global east (according to Nelson and Temple) asthenosphere flows together with opposite vertical movement of interacted blocks. Subsequently the relief of continental margins is reformed. Island arc and margin seas must be regarded as obligatory effect, whereas continental relief has different variants of evolution. In the first case ancient river network is quite reoriented as it was in North-East Asia. In another case network can save its structure, but accumulation basins remove upwards as in Central East China.

ANDREI A. NIKONOV & A.P. SERGEEV

Identification and quantification of seismogravitational relief disturbances: the caucasian mountain area as an exsample

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In contrast to seismotectonic ruptures, seismogravitational relief disturbances (slope movements due to earthquakes) have so far received quite insufficient attention. There are some unresolved problems. The following ones are considered in this paper:
Discrimination seismogravitational disturbances proper as distingnished from pure gravitational ones. Six features of seismogravitational slope disturbances are identified.

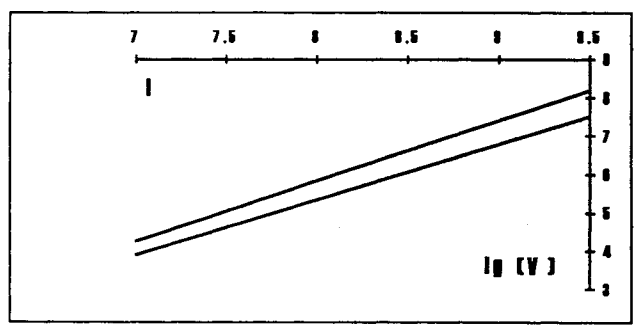

FIG. 1 - Quantitative correlations between recent big bedrock seismodeformations on slopes (V – volume in m^3) and parametres of related earthquakes (I – intensity) of the Caucasus have been derived (see Fig.). This was used to make an attempt to resolve the inverse problem, namely, to assess the intensity and magnitudes of past strong earthquakes from dimensions of relevant deformations.

Classification of seismogravitational features. It is proposed all seismodeformations to subdivide into the following types: seismotectonic, seismogravitational, shaking-inducted, seismohydrodynamic, seismodynamic and ejection ones. Seismogravitational deformations are subdivided into 7 kinds.
Relation between different types of slope seismodeformations and the intensity of responsible earthquakes. Slight surface deformations in the soil are found due to shaking of intensity IV-V or higher, considerable deformations in the rocks due to intensity VI-VII or higher, and heavy relief changes caused by intensity IX or higher.
The present study is based on field observations and published data on earthquakes of the last about 100 years for such mountain regions as Tien Shan, Pamirs, Kopet-Dag, the Caucasus and the Crimea. For the Caucasus catalogues of recorded seismogravitational disturbances for the historical time period (late XIX-XX centuries) and for the older past were compiled.

JAVAD NIKZAD FARROKHI

Hydrogeology and hydrogeochemistry of the Phlegrean Fields, Italy

Hydrogeologist, Tehran, Iran

The Phlegrean Fields geologically consists mainly of heterogeneous pyroclastic products derived from the high explosive volcanic activity which occurred in this area from the Upper Pleistocene to historical times. The complex stratigraphy permits, locally, the presence of layered water tables; on large scale, however, they act as an only water table because of little wideness of impermeable layer. As it appears by piezometric morphology reconstruction the Phlegrean Fields water table presents the following chief features:
– it has a radial downward flow from central part onwards where it reaches the top (26 m a.s.l.);
– it presents a drainage zone northward of Quarto, because of the presence of high permeability lavas;
– it presents an anomalous high piezometric gradient in the southern part.
In the same area, where occurs the piezometric gradient increase, anomalous hydrogeochemical and piezometric phenomena also occur: the Cl and Tds well water values are relatively high and in the period 12/1985 - 11/1986 the well water levels rose up.
All this should be caused by an upward water feed related to an hydrothermal circuit which should make possible the lift of the rich Cl and Tds deep waters. The results of hydrologic balance confirm this hypothesis.

CHIAKI T. OGUCHI[1] & YUKINORI MATSUKURA[2]

Why rock strength reduces most rapidly with weathering?: Based on a study in the changes in rock properties of porous rhyolite

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In an attempt to examine the mechanism of rock-strength reduction due to weathering, temporal changes in microstructure of porous rhyolite were investigated selecting Kozu-shima, a small island of Japan in the Pacific, as the study site. In this island four lava domes formed successively with eruption of rhyolite at the time of 1.1 ka, 2.6 ka, 20 ka and 40 ka. All four domes are composed of biotite rhyolite, with (1) a porosity of about 30%; (2) a chemical composition of 74-77% SiO_2 and 12-13% Al_2O_3 content; and (3) a mineral composition of 5-10% plagioclase, 2-4% quartz, 0.5-0.7% biotite and 85-90% glassy groundmass with flow structure called here as «glass columns». These findings suggest that the four rocks had similar properties when the lava domes formed. No common weathering profile has developed on each outcrop of these rocks. The rocks show little change in lithofacies with increasing depth from the ground surface even on quarries having a height of 10-20 m. Schmidt hammer rebound values do not vary with depth on the quarries. These observations suggest that the porous rhyolite has characteristics of so-called «deep weathering». This high susceptibility to weathering seems to be due to rapid extension of water-rock interaction to deeper zone, which is facilitated by the presence of (1) a large number of cooling joints with the vertical and horizontal surfaces in a rock mass and (2) a high porosity in a rock block, both yielding high permeability in rhyolite. Deep and uniform weathering in each lava dome indicates that the present-day rock properties can be assumed to represent the degree of weathering in the time elapsed from each eruption. Rock block samples taken from the outcrop in each dome are analyzed in detail in the laboratory. Mineralogical characteristics of the four rocks were investigated: (1) X-ray diffraction analyses (Xrd) show that clay minerals such as kaolinite and mica clay minerals are formed in older rocks such as the 20ka- and 40 ka-rocks and (2) Sem photographs show that flow structure in the glassy groundmass is clear in younger rocks such as the 1.1 ka-and 2.6 ka-rocks, while unclear in the older rocks. Chemical composition obtained by X-ray fluorescence analysis (Xrf) and thermogravimetry (TG) indicates that the amounts of SiO_2, Na_2O and K_2O decrease slightly in the younger rocks and decrease rapidly in the older rocks, whereas those of H_2O and $FeO+Fe_2O_3$ increase slightly in the younger rocks and rapidly in the older rocks. Physical properties were investigated by some methods including the measurement of pore size distribution (Psd) which gave the size distribution of interconnected pores that called here as «open pores»: (1) the decreasing of bulk density and the increasing of porosity are large in the younger rocks and small in the older rocks, (2) rapid increase in volume of large pores (about 10(m in diameter) and a little increase in volume of medium pores (about 1(m in diameter) occurred for the first 20,000 years, whereas the rate of the increase accelerated in 20,000-40,000 years, and (3) from the Sem observation, microcracks with a width of 1(m correspond to medium pores in Psd began to form on the surface of the glass columns in the initial stage of weathering such as 0-20,000 years, which leads to the increase in volume of large pores. The results of measurements for mechanical properties show that both uniaxial compressive strength and tensile strength reduced rapidly for the first 20,000 years, whereas they reduced slowly in 20,000-40,000 years. From these analyses it is cleared that the rate of change in rock properties differs through time: the change in chemical properties is slow for the first 20,000 years and is accelerated in the 20,000-40,000 years, while the change in physical properties and the reduction of mechanical strength are rapid in the initial stage and slow in the later stage. The increase in volume of large pores is explained to be caused by the combination of contiguous closed pores with open pores due to «dissolution» of the glass columns. The formation of the microcracks on the surface of the glass columns is explained to be caused by swelling pressure generated in «hydration» process. The above discussion leads to the conclusion that the changes in microstructure due to chemical weathering strongly influenced the reduction of rock strength.

TAKASHI OGUCHI[1]

Broad occurrence of extrazonal periglacial landforms in the Lowlands of Western Japan and Korea

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Previous research revealed active formation of periglacial landforms during the Last Glacial age in western Japan and Korea. Traces of past freeze-thaw action can be found even in coastal lowlands. In contrast, the altitude of the Last Glacial forest limit of western Japan, reconstructed from temperature depression, exceeds 1,000 m. This marked discrepancy in altitude has not been explained. To address this issue, the present paper examines the relation between the distribution of the periglacial landforms and physical factors such as climate, vegetation, and geology.
Even under the present temperate climate, periglacial earth hammocks and stone banked steps occur in the treeless mountains of western Japan. Soil creep by freeze-thaw action is also reported from coastal lowlands with sparse vegetation cover. Under the Last Glacial colder climate, more favorable conditions for periglacial processes undoubtedly prevailed as long as lands were free from thick vegetation. Thus, attention here is directed toward the La-

st Glacial vegetation rather than the degree of temperature depression.

Reconstruction of the vegetation map of Japan at the Last Glacial Maximum has been attempted by several researchers. They yielded different results, since data and criteria for map compilation were not identical. One of the maps was compiled based on the distribution of existing life, as some kinds of life closely related to vegetation types have scarcely widened their territories since the Last Glacial Maximum. The map demonstrates that treeless and/or sparse forest areas broadly occurred in the lowlands of western Japan and south Korea. These areas agree well with distribution of fossil periglacial landforms. In addition, these areas are thought to have low potential for tree growth because of two reasons. First, half of the areas correspond to the distribution of recent tree less mountains (*Hageyama* in Japanese) which were human-triggered but have been maintained owing to an unfavorable physical settings such as slope form, geology, and climate. Second, the other half of the areas are in the proximity of active volcanoes, and thus were subjected to frequent fall of tephras during the Last Glacial. These correlations validate the applicability of the vegetation map. Moreover, most of the treeless and/or sparse forest areas have small amounts of snow in winter, giving weak protection against freeze-thaw action. The condition of little snow also applied to the Last Glacial, because the winter atmospheric pressure pattern of Japan has been basically unchanged since then.

In summary, factors including slope form, geology, climate and frequent fall of volcanic ash worked together to lower the land potential for tree growth in the lowlands. This caused recession of thick forestation in spite of temperatures high enough for tree growth, resulting in strong freeze-thaw action during cold seasons. Thin snow cover in winter also facilitated the occurrence of periglacial landforms. The landforms are located far below the Last Glacial treeline determined by temperature, and thus can be called «extrazonal». Such extrazonal landforms, however, developed in broad zones of western Japan and Korea.

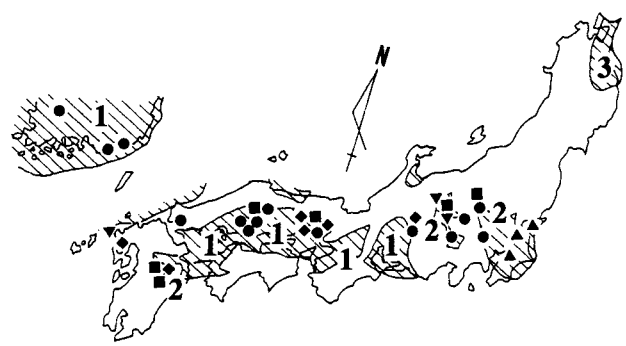

FIG. 1. Distribution of Last Glacial periglacial features in the lowlands of western Japan and south Korea. Square: erosional crest slopes, Diamond: depositional foot slopes, Circle: block streams, Triangle: asymmetric valleys, Reversed triangle: deposits with angular gravel. Hatched zone: Last Glacial treeless and/or sparse forest areas (1: caused by slope form, geology and climate unfavorable for the recovery of disturbed forest, 2: caused by frequent fall of volcanic ash, 3: caused by low temperature).

HIROO OHMORI

Morphotectonic evolution and relief forming processes in Japan

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The Japanese Islands are of a part of inter-plate island arcs with violent crustal movement and located in a warm-humid climatic region with heavy rainfall causing active mass movements. Under the natural conditions, the landforms of Japan have been quickly and continuously changed due to the active tectonics and intense erosion. The geomorphological processes have caused serious damage by frequent occurrence of earthquakes, volcanisms, landslides, debris flows and many other kinds of natural hazards. In order to predict and prevent the hazards, contemporary crustal movements and hazardous events have been quantitatively surveyed especially these three decades. Digital altitude data were published and analyzed to clarify the regional characteristics of landforms over the Japanese Islands. Vertical displacement during the Quaternary was also investigated over the Japanese Islands. Most of the active faults and folds in the Japanese Islands were precisely surveyed to clarify their activities in connection with earthquake prediction programme. Levelling surveys have been also carried out at short intervals especially along the Pacific coast of Japan. Damage caused by mass movements such as landslides, slope avalanches and debris flows has intensively surveyed over Japan every year since 1975. From these observations, contemporary or recent rates, frequency and magnitude of both tectonics and mass movements have been evaluated. Through analyses of their spatial and temporal characteristics together with study of geological structures of Cenozoic, the study of Quaternary tectonics and geomorphological processes has markedly advanced, revealing historical complexity and regional characteristics of morphotectonics and relief forming processes in Japan.

The morphotectonics have been progressed in relation to the Quaternary crustal movements characterized by the recent plate tectonics which are caused by the relative movements among four plates. Due to regional variation in the stress caused by plate motion, Japan is divided into 5 morphotectonic terrains each of which is divided into two sub-terrains by a great tectonic line or a volcanic front. Each sub-terrain shows its own tectonic type and rate of faulting, folding and warping, and its own landform features. The resultant rates of contemporary inter-seismic and co-seismic movements revealed by analysis of precise leveling surveys, those calculated from altitude of the raised shorelines of late Pleistocene marine terraces and those estimated from Quaternary vertical displacement show a good correspondence in mode and rate to each other. Thus, it is inferred that the landforms of Japan have been developed by the presently progressing tectonic processes.

Relation between mean altitude of mountain and its mean Quaternary uplift rate is expressed by a function. It shows a static relation between uplift and denudation resulting from concurrent tectonics and denudation through the Quaternary. Ratios of denudation to uplift show that Japanese mountains have been considerably denuded, over 30% for some mountains. Coupling of two functions; one expresses the relation between contemporary denudation rate and mean altitude dispersion of drainage basin and the other expresses the relation between mean altitude dispersion and mean altitude of drainage basin, indicates that denudation rate increases with mean altitude, in harmony with landslide occurrence increasing in volume with altitude dispersion. So the earth materials in the area with a large altitude dispersion are inferred to be highly stressed by active tectonic movements. Denudation processes may be a process to release the stress stored in earth materials.
A sequence of changes in mean altitude resulting from concurrent uplift and denudation simulated based on the above relations indicates that the landform development is divided into three stages; the developing, culminating and declining stages. Japanese mountains show various stages from the earliest to latest substages of the developing stage. The stages depend on the uplift rates by tectonics which reflect the plate motion and geological structures. The higher the uplift rate is, the more advanced the stage is, except for the three mountains in Central Japan whose stages seem to be nearly the culminating stage, being independent of uplifting.

TORU OKAMOTO

Fossil periglacial phenomena on karst since the Last Glacial Stage in Akka Karst, Northeastern Japan

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The karstic areas in Japan are mostly covered with eolian deposits, for example, tephras and long-range eolian dust transported from inland China. These eolian deposits are used as not only important time-markers but also implications of environmental changes. It is probably useful to provide more detailed information of surface environment in karstic area than in other rocks, because superficial deposits have well remained in dolines developed in karst. Furthermore, most sediments in caves have remained essentially unaltered since initial deposition. The purpose of this paper is to clarify fossil periglacial phenomena since the Last Glacial Stage in Akka Karst, northeastern Japan.
The Akka Limestone is distributed in the northeastern part of the Kitakami Mountains. The Akka Limestone, which has 50 km wide in N-S, 1-4 km wide in E-W and NNW-SSE strike, is a member of the Akka Formation (700 m thick) which consists of bedded limestone, alternating beds of limestone and chert, and chert in upward sequence. The Omoto River, Akka River, and Osanai River flow eastward from non-limestone area of the Kitakami Mountains and dissect the Akka Karst into blocks of karstic plateau up to 400-700 m above sea level. More than 100 caves have been recognized in Akka Limestone. The climate is characterized by warm humid summers and cold wet winters. The mean annual precipitation and temperature are about 1,300 mm and 10 °C, respectively. Precipitation is evenly distributed throughout the year with much rainy season July to September. Snow often falls during December to March.
In the study area the limestone bedrock is overlain by several late Quaternary tephras which mostly erupted from Towada caldera and Iwate volcanoes. The tephra overlying a slope indicates that the slope has been stabilized since the tephra fell. On the other hand, absence of a tephra which is usually found at the bottom of dolines or the foot of slopes implies slope instability after the falling of tephra. In order to estimate the changes of slope stability, tephrochronological study was undertaken at many exposures and pits. The identified marker tephras in the study area have been as follows: To-a (Towada-a: 915 AD), To-Cu (Towada-Chuseri: 5.5 ka BP), To-Nb (Towada-Nanbu: 8.6 ka BP), To-H (Towada-Hachinohe: 12-13 ka BP), Iw-Od (Iwate-Oide: 35-40 ka BP), To-OP I (To-Okoshi I, 60-70 ka BP).
Pleistocene tephras are observed on the limestone plateau. At exposures on the edge of the plateau it is found that To-OP I is unconformably covered with loamy soil included To-H, and that buried chert and limestone breccia layer with loamy matrix is directly overlaid by Iw-Od which covered with slope deposits containing limestone and chert clasts. The former was probably formed before To-H fall. The latter is considered to be solifluctional deposits, because it has terrace-like forms and angular materials well oriented parallel to the former slope direction. Thin humus horizon also developed in the uppermost part of this breccia layer. Therefore, formation of breccia layer was probably ceased before Iw-Od fall.
In the Central Kitakami Mountains two periods of mass movement by periglacial processes are confirmed during the Last Glacial Stage. The first period was in the early Last Glacial, around 50 ka BP, and the second was in the late Last Glacial, between 30 and 10 ka BP. At such times, involution and solifluction lobes were formed in the Northern Kitakami Lowland area.
The formation age of breccia layer is in accord with first period of mass movement around 50 ka BP. Unconformity was formed before To-H fall. This formation probably agrees with second period of mass movement between 30 and 10 ka BP. On the steep slopes there are not Pleistocene tephras at all. At some exposures on gentle slopes, it is often observed that greenish black soil derived from limestone bedrock is directly covered with To-Cu. This indicates that Pleistocene tephras had already been denuded before To-Cu fall. Therefore, it is considered that most of Pleistocene tephras on the slopes in Akka Karst were re-

moved by periglacial processes such as solifluction in the cold phases of Last Glacial. On the steep slopes frost shattering of underlying bedrock was probably predominant, because bedding plane and joint are well developed in the Akka limestone. It is probable that collapse of some doline rims located at margin of the limestone plateau were caused by periglacial processes. During these periods karst depressions was infilled with soliflucted debris.
In order to obtain more detail reconstruction of environmental changes in the study area, it is necessary to compare the deposits of slopes, dolines and caves, and to date their ages.

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Geomorphic and environmental controls of earthquake-induced landslides

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The Kobe Earthquake (Southern Hyogo Prefecture Earthquake) of a Richter scale magnitude of 7.2 struck Kobe City and environs including a part of Osaka City, resulting in 6,334 casualties and leaving about 320,0 homeless people. Wooden and concrete buildings and other concrete and steel structures in the Osaka-Kobe urban belt, which is located between the sea and the Rokko Mountains, are heavily damaged. Landslides were induced by the earthquake at about 700 locations in the Rokko Mountains and the neighboring mountains. These landslides, however, caused little hazards compared with those by the ground deformation in the urbanized areas. Potential hazardousness of these landslides is still significant, since much quantity of debris will be transported to the urban areas which is close to the mountains, at the times of subsequent rainstorms.Topographic conditions of the occurrence of the earthquake-induced landslides were discussed by many researchers but only in terms of statistics. This paper discusses the geomorphic and other environmental controls of these landslides in terms of material, process and present-day trend of the geomorphic evolution.The Rokko Mountains were once entirely deforested by over-harvesting of wood, root and humus soil, but were reforested between the 19th and 20th Centuries. A great rate of weathering, due to the fracturing of granitic rock bodies which is subject to rapid orogenic movement, and to chemical alteration by the groundwater which is enriched with carbonate ions, has responsible for swarms of rainfall-induced landslides of an average return period of about 30 years. Large-scale earthquake-induced landslides are also suggested to have occurred in the pre-historic age. The features of the landslides induced by the Kobe earthquake in 1995 was much different from those of the landslides ever experienced in the Rokko Mountains and even in the other areas in Japan.No large-scale landslide occurred. Slumpings of considerable areas occurred at seven sites, but the displacement was small except for one site which resulted in 34 casualties. Most landslides were surficial and of small areas. The landslide scars of this category suggested tensile failure in majority of the cases (classified as debris fall), and shear failure in other cases (classified as debris slide). Numberless rockfalls took place but falls of the rock block(s) of a volume of more than $30m^3$ occurred only at four sites. Debris falls were concentrated along the zone of aftershock where the earthquake motion was heaviest at the time of the main shock. Debris slide were more scattered around this zone. The slumpings and the major rockfalls were much scattered suggesting that geology and topography were major controls.Topographic conditions of the occurrence of debris falls and debris slides were analyzed using the aerial photographs and a topographic map of 1:5,000. Since these landslides were of a small areas, local topographic features were considered according to the scale of local topographic texture without choosing a fixed grid spacing. Three classes were identified for the curvature of the contour lines and that of longitudinal profile, yielding nine categories. Among the categories of convex contour lines, landslides occurred preferably on the convex profiles, which are frequently found along the summits. Such topographic conditions are not preferable for rain-induced landslides. This mode of the occurrence has been reported in many case studies of the earthquake-induced landslides in Japan. Among the slopes of straight contour lines, those of straight profile (planer slope) were preferable for landslides. Many landslides (of both types) occurred on a steep cliffs, which are frequently found along the major faults in the Rokko Mountains and with the aspect coinciding with the strike of the pertinent fault (according to Okimura, 1995), but have been reported in few other case studies. Among the slopes of concave contour lines, the landslides do not concentrate to a particular profile type, although the statistics of the slope angle shows characteristic tendency of debris falls and debris slides concentrating on the concave profiles. Under this topographic condition, debris falls occur on relatively gentle slopes with a gradient range of 0.3 to 1.0. It suggests the control of the thickness of the weathering mantle and/or the wetness. On the other hand, most debris slides occurred on the slopes of a gradient range over 1.0. This type of debris slide were usually found within or in the margin of the scar of old (undated) landslides which had presumably been induced by rainstorms. Naturally, such landslides are much smaller than the former landslides. Rapid weathering is responsible for this type of debris slides which have been reported in few other case studies in Japan.The Kobe Earthquake of 1995 occurred in the midst of dry season, and the preceding rainy season had exceptionally small precipitation. The control of the mechanical properties of dry weathered granite is evident in the mode, number, distribution and location of the earthquake-induced landslides. In such cases, the effect of vegetation seems relatively significant, since the cohesion by adsorbed water becomes negligible.

MERVIN OLIVIER[1,2] & GERALD GARLAND[1]

Data collection and analysis for the study of foredune formation on the East Coast of South Africa

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As part of a study assessing the effects of inland impoundments on the lower reaches and adjacent coast of the Tugela river, Natal, dune formation and growth was surveyed in detail at regular intervals for a period of four years. Amongst the techniques used were Abney level cross sections, tacheometric and theodelite mapping, and real-time Gps surveys. An historical perspective was obtained from analysis of air photos from 1937 to 1994. To analyse the data certain digital terrain models were employed.

This paper critically reviews the results of survey and analysis techniques used, discusses a number of difficulties encountered and makes suggestions for future surveys.

JEFF OLLERHEAD

Quantifying shoreline geomorphology at Cape Jourimain, NB, Canada

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Cape Jourimain is the point on the New Brunswick shoreline where the Confederation Bridge to Prince Edward Island is attached (fig. 1). This area was studied extensively prior to the granting of government approval for construction of the bridge. Since construction began in 1995, a wide variety of ongoing studies has been conducted in the area, both to enhance the existing database and as part of efforts to monitor numerous environmental parameters that may be influenced by bridge construction. The first objective of this research project was to document the shoreline geomorphology and sedimentary characteristics of Cape Jourimain, New Brunswick, as work on the Confederation Bridge began in this area. A second objective is to re-measure some aspects of the shoreline geomorphology at Cape Jourimain over the period 1995-1997. Thirteen shoreline profiles were established in the study area in 1995 and measured using standard surveying and echo-sounding techniques. Six additional profiles were established in 1996 based on the 1995 results. These profiles will be re-measured several times a year for the next few years. Seventy bottom samples were collected in 1995 from a grid pattern covering the study area and analyzed using standard sieving techniques to establish their composition and grain size characteristics. An additional thirty-four bottom samples and eighteen dune samples were collected in 1996 to enhance the work done in 1995. These data along with visual observations made at each site are being used to map bottom composition in the study area. The preliminary results indicate that the sediments offshore tend to be poorly-sorted sand, pebble, and cobble sediments, while those closer to shore tend to be well-sorted medium sands.Investigations are also being undertaken to determine the recent and longer-term evolution of the sandy barrier systems that flank Jourimain Island (Figure 2). These barrier systems are of particular value because they protect a Canadian Wildlife Service sanctuary from wave attack. Their recent evolution (< 50 years) is being documented using recent surveys and aerial photographs. Their longer-term evolution (50-1,000 years) is being investigated using historical maps, historical written records, and the assessment of sand dune ages using optical luminescence dating techniques. Preliminary evidence suggests that the northwest (NW) barrier system is migrating slowly landward with rising sea level and that there is a sufficient supply of sand to ensure its integrity. In fact, there is evidence that the dunes near Gunning Point (see Figure 2)

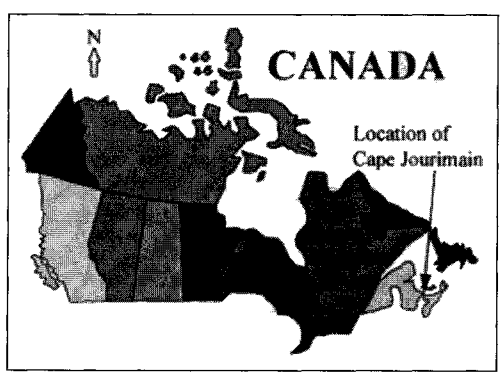

FIG. 1 - Location of Cape Jourimain, NB.

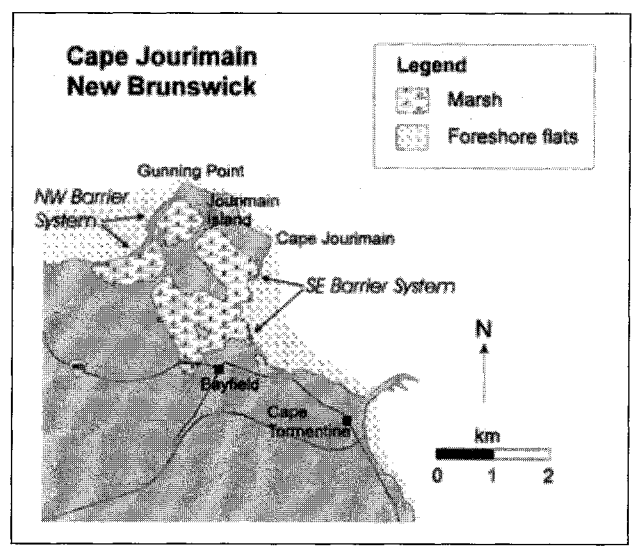

FIG. 2 - Cape Jourimain, NB study site.

have been accreting at a noticeable rate over the past few decades. On the other hand, the southeast (SE) barrier system appears to be migrating landward more quickly than the NW barrier system and eroding at the same time. Historical evidence indicates that the road that used to follow this barrier system washed away several times between 1915 and 1920 (it has never been replaced). Understanding the recent geomorphic history of this area is complicated by various types of human disturbance ranging from the construction of dikes by the Acadian People in the 1700s to the present construction of the Confederation Bridge.

CLIFFORD D. OLLIER

Geomorphic constraints on tectonic theories

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Too often geomorphologists have accepted tectonic hypotheses from geologists and geophysicists instead of starting from their own basic data. In contrast, tectonic geologists and geophysicists often invoke uplift (for example over subduction sites or thermal domes) without any consideration of how such uplift will affect landforms. In reality many landforms are older than the tectonic movement, and severely constrain possible tectonic interpretations. Changes in elevation and slope, effects on drainage patterns, and distribution of regolith are the most obvious constraints on tectonic theories. Planation surfaces indicate long periods of tectonic stability. Where present such surfaces deny simultaneous folding and uplift, commonly assumed in hypotheses of compressional mountain building. Through feedback processes such as isostatic response and gravity spreading, some tectonic processes are actually driven by erosional processes.

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The mechanism inducing the infiltration rate lowering of Unzen Volcanic Ash

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After volcanic eruption, surface infiltration rates of the tephra deposits have been reported extremely low (*e.g.*, Allen, 1981, Hendrayanto & *alii*, 1995), which sometimes causes debris flow (Yamamoto & *alii*, 1980) or rapid surface erosion (Collins & Dunne, 1988). However, the mechanism still remains unresolved. Here, the authors studied the mechanism inducing the infiltration rate lowering of the Unzen volcanic ash through permeability tests using varying electrolyte concentration, Esp (Exchangeable Sodium Percentage) measurement of the fallout deposits, and Sem (Scanning Electron Microscope) observation.
The eruption of the Unzen volcano occurs from Nov. 1990, and much volcanic ash deposited around the Mountains (fig. 1). Debris flow from ash deposited area has been frequently occurred. The experimental results of the permeability tests showed that the permeability decreased with the number of experiments using distilled water, whereas the permeability kept constant using electrolyte (tab. 1). Sample surface cone penetrometer strength became higher for the distilled water case, whereas the surface remains soft for high NaCl concentration cases (tab. 1). The Esp in the field condition is sufficiently higher than the forest soil (tab. 2). These results indicate that that the mechanism of infiltration lowering of the Unzen volcanic ash is due to formation of chemical crust by physico-chemical processes of the ash. The observation of the Sem also support the results. The experimental results suggests that infiltration rate of Unzen volcanic ash could be increased by applying electrolyte for reducing surface runoff and debris flow initiation.

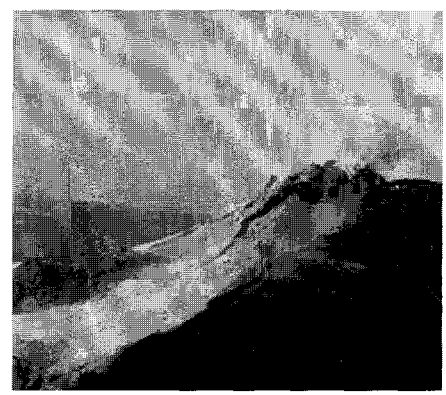

FIG. 1 - Unzen Volcano (July 24, 1993, Ministry of construction).

TABLE 1. The permeability tests using varying electrolyte and the strength of the soil surface after 13 permeability tests

Electrolyte	Permeability (First experiment) (mm/h)	Penetrometer strength (13th experiment) (mm/h)	Penetrometer strength (after the experiment) (kgf/cm^2)
Distilled water	6.00	4.94	18.0
0.005N NaCl	6.78	6.83	9.5
0.05N NaCl	7.58	6.61	8.0
0.5N NaCl	5.59	7.08	5.5

TABLE 2. The result of chemical characteristics of the soil

Depth (cm)		CEC (meq./100g)	ESP (%)
2.0-7.0	volcanic ash	0.74	10.0
7.0	forest soil	8.00	0.9

D. OOSTWOUD WIJDENES, J. POESEN,
L. VANDEKERCKHOVE & E. DE LUNA

The effect of tillage on the stoniness of top soils

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Many agricultural fields in the Mediterranean and elsewhere are characterised by a high amount of rock fragments at the surface. While this traditionally has been viewed as a problem with respect to tillage and plant growth, recent research showed many positive effects such as reduction of runoff and soil erosion and enhancement of infiltration. According to the concept of kinetic sieving the disturbance of a mixture of particles with different diameters will result in the largest particles moving upwards and the finest particles moving downwards. Following this principle the objectives of this paper were:

– to determine whether the large amount of rock fragments of the top soils of cultivated fields in Southeast Spain could be explained by the disturbance by tillage and,

– to determine the number of tillage passes necessary to reach a steady state (no more change).

Soil pits were filled with four layers (each 4 cm thick) of air-dry rock fragments, each layer containing a known distribution of rock-fragment sizes. The pits were subjected to different tillage frequencies by a caterpillar tractor pulling a chisel with a duckfoot. The experiments demonstrated that the tillage operations had a significant influence on the vertical movement of rock fragments in the soil profile. One series of experiments contained the coarsest fraction at the bottom and the finest at the top of the profile and another series showed a homogeneous distribution with depth. For the first series the results showed that after only two tillage passes the coarsest fraction dominated the top layer (34% by weight) and the finest fraction dominated the bottom of the tilled layer (51% by weight). Subsequent tillage increased the sorting of particles in the plough layer but at a much slower rate. The second series showed an even quicker rate at which large rock fragments moved to the surface. This inverse grading may explain the high percentage of rock fragments of top soils of cultivated fields, especially in many parts of the Mediterranean area where soil profiles are often shallow and stony.The implication of this is that farmers can reduce the risk of erosion and conserve moisture by ploughing stony soils only one to two times under dry conditions. This practice is relatively cheap and simple and can be easily applied in many areas. The experiments showed that excessive ploughing is not necessary, which is fortunate since frequent ploughing, particularly at steep slopes, can cause serious tillage erosion.

NATALIA I. ORLOVA

Relief, crusts of weathering (CW) and placers - co-evolution

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For USSR several epochs of relief planation and CW formation were distinguished as synchronous. But lately at last years it was established that the ages of these both epochs are markedly displaced as determining by different factors. So the general surfaces of planation cannot be simply identified with definite CW eighther for vast regions or for large morphostructures. The profound weathering was going «continously-intermittently» migrating at time and place. On morphostructures with favourable climatic, tectonic and palaeogeomorphological conditions took place the superimposing of weathering of successive epochs and on a whole at the same time - erosion and re-deposition of the waste of CW. The age «sliding» of stratigraphic boundaries is especially well expressed in comlicated transition zones between oscillating tectonic blocks.

CW can be exploited in situ as useful deposits or can form the parts of polygenetic placers. It can be clearly traced for the ancient complicated placers of long formation. In several regions there are revealed the «clusters» with CW of profound weathering, of various types, thickness and ages. There are various placers from exposed eluvial up to deeply buried fluvial ones (valley and gully types). On morghostructures where areals CW were not formed or eroded only linear roots of CW along fractures and relatively poor and shallow fluvial Q_3-Q_4 placers can usually be found.

Thus the favourable palaeoclimatic and geomorphological conditions give the general orientation for researches of CW and related placers; the presence of remnants of the ancient poly-aged CW of profound weathering or shows of their former development directly indicate on positive perspectives. The geomorphological mapping and analyse are important for all the scales and stages of researches. The examples will be demonstrated.

NATALIA I. ORLOVA[1] & MIKHAIL V. PIOTROVSKY[2]

Problems of megaregional and global geomorphological mapping

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Geomophological mapping remains the irreplaceable means of information and investigation. The most effective

are the complete systems of general concepts, relief claasications, legends and use of cartography means, providing the compilation of comparable maps of every scales and territories. Such system was elaborated at Moscow University; similar principles are widely used in Russia and other countries.
The basic maps must give the objective and expressive image of real relief stressing on reliable features of genetic importance e.g. relief patterns of tectonic origine. Such mapping though well elaborated requires now the further development as participating in the progress of Earth sciences. The megarelief and global mapping become especially important. It corresponds to the destinity of Iag as all-World organization. Iag is in need of such maps as means for common vision of the Earth, comparison of its parts, discussions and further works of the kind. The existing maps show that they are necessary for investigation of principal problems of geomorphotectonics; general evolution of the Earth, deep mechanisms, solution of contradictions between fixism and neomobilism etc.
As immediate measure there can be recommended the publication in English of the Geomorphlogical Map of the World 1:15 mln, eds. N. Bashenina & O. Leont'ev, published in Russian at 1988. This Map as also similar ones is well proved. It is not obsolete and can be fast re-published with non-essential improvementa. The preparation can be realized by Russian co-authors of the Map. The proper recommendations and decisions of the Conference on this work and printing of the Map are necessary. The compilation of the geomorphological map of Asia (and further Eurasia?) on initiative by prof. Chen Zhiming also must be supported.

KHAIRULMAINI BIN OSMAN SALLEH

Route evaluation and selection for a 500 kilovolt electric transmission line in Malaysìa: an environmental assessment

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This paper describes a methodology for selecting a 500 kilovolt (kV) transmission corridor using various environmental and other criteria and applies the approach to a transmission line siting problem in Peninsular Malaysia. Two main corridor alignments and varoius sub-alignments are investigated, each investigation covers diverse physical and human environments. Corridor selection is based on a factor scoring technique of environmental characteristic measured along the alignments. The major factors considerd are the cost of construction, opration, and maintenance of the transmission cables and towers (pylons), land costs and the impact on the human and physical environment. Routes were ranked on their overall total weighted factor scorces (Otwfs), with the lowest scores being the most attractive.
One alignment located towards the coast would involve very high development and environmental costs (highest Otwfs value), because it cuts across extensive area of swamps and peatland, rich in flora and fauna. An alternative route, located towards the inland of the Peninsular, was best in terms of low development and environmental costs (lowest Otwfs value). However, it had high human costs (incurred in relocating settlements, industries, schools etc.). This assessment is designed to help decision makers evaluate the nature of the tradeoffs for this tyoe of important infrastructure projet.

ANNA B. OSTROVERH

The estimation of relief stability of urban territories

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The estimation of relief stability of urban territories upon action of technogenic loads is actual problem in the modern applied geomorphology. Ecologic situation of urban territories is forming as an integral action of synenergetic natural and technogenic factors whose relations may determine the range of time-spatial environment changings. As one of the basic elements of landscape the relief is exposed to the most significant transformation which in some cases cause to lower stability of geomorphology systems especially as a result of disbalanced technogeneous action on geomorphological systems when the negative endogenic and exogenetic processes become active and consequently zones of geoecologic risque arise.
Zoning of urban territories on geoecologic risque rate may be effectively performed by estimation of relief stability upon technogenic loads. Under the engineering geomorphology researching we consider the concept of relief stability as the ability of all landforms to withstand the technogenic load keeping its structure and functional character invariant in some limits. With the aim of thorough analysis we propose to consider the urban territory as a nature-technogenic geomorfology system with account of endogenic, exogenic and technogenic factors of relief making processes. The author proposes an practical method of relief stability estimation of urban territories of Kyiv the capital of Ukraine. When studying the urban natural-technogenical geomorphologic systems we analyse the functional connection and interaction of natural and technogenic relief elements on the basis of historic-geomorphogical, morpholitological and geomorphodynamic approach.
The historic-geomorphologic analysis of urban territory is based upon complex usage of historic and archeologic data to determinate the main stages of urbanization as a time

process, the character and duration of technogenic actions on relief and depth of technogenic transform of relief as well.
With help of historical-geomorphologic analysis of urban relief of Kyiv, we complete the general image of usage of geomorphology objects through historic periods and define three main stages of urbanization which corresponds with an level of technogenic loading on relief:
1. development of territory without significant transformation of relief (pretown stage);
2. substaial transformation of relief without considerable negative effect arised (middle ages, new history);
3. intensive urbanization with area of geomorphologic risque arised (modern stage).
When considering the stability of urban territories we define such three main bloks of data base for the program of risque rate estimation:
I. Estimation of natural geomorfologic conditions.
We perform analysis of natural stability of urban natural-technogenic geomorfologic system elements such as morphostructures, morpholitologic complex and morphodynamic conditions of territories as a whole.
II. Estimation of the technogenic loads .
We fulfil systematization the technogenic statical and dynamical loads and calculate the integral intensity rate of action on natural relief.
III. Estimation of natural-technogenic risque.
This block contains the information about defects of territory upon negative geomorphologic-technogenic processes, the forecast of their activation as a result of technogenic loads encreasing.
Proposed practical approach to the geomorphogical risque estimation was used on the Kyiv city territory (Ukraine). The set of geomorphologic engeneering maps was composed on modern stage of urban natural-technogenic geomorphologic system development and prognostic map of geoecologic risque as well.

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Nojima earthquake fault associated with the 1995 Kobe earthquake, Central Japan, and its degradation

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The Nojima fault on the northwestern coast of Awaji Island, south of Kobe, was reactivated in association with the Jan. 17 Hyogoken-nanbu earthquake. This fault rupture was about 10 km long and was dominated by right-lateral offset (max. 1.8 m) along a high-angle reverse fault which has a maximum vertical displacement of 1.3 m uplift on the southeastern side. The surface feature of the Nojima earthquake fault includes various types of deformation, such as fault scarp, en echelon cracks, minor pull-apart basins and pushed-up bulges, offset of streams and ridges, fences and roads.
We repeated the measurement of seven profiles of the fault scarps at two areas (Hirabayashi to the northwest and Ogura to the southeast) for approximately one year following the earthquake. The original profile of the scarp was overhanging scarp at Hirabayashi and Ogura, corresponding to the 70-80 dip. of the fault plane. The fault scarp at Hirabayashi displaces Plio-Pleistocene siltstone of Osaka Group, overlain by a thin bed of unconsolidated gravel. The Ogura area is entirely underlain by the Osaka Group. Scarp degradation at Hirabayashi occurred by collapse of the gravel bed and proceeded more quickly than at Ogura, where the fault scarp degradation proceeded mainly by exfoliation of the Osaka Group siltstone. The degradation occurred at a very fast rate until March at Hirabayashi and until June or July, 1995 at Ogura. Since then, the degradation has been very slow. Our data strongly indicate that the scarp profile was initially controlled by the dip of the fault plane, and scarp degradation has been primarily controlled by lithological factors. The degradation of Nojima earthquake fault scarp has proceeded much more quickly than normal fault scarps in the USA where observations of the initial stages of scarp degradation have been carried out.
The extremely rapid degradation of the Nojima fault scarp in weak Neogene siltstone may, in combination with rapid cultural modification of the landscape, explain the paucity of geomorphic scarps along the numerous active faults in Japan. This observation may also have implications to tectonic geomorphology and paleoseismicity studies in other countries characterized by weak bedrock and moderate to high rainfall regimes.

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The role of channel and floodplain storage of fine-grained sediment in the suspended sediment budget of the River Tweed, Scotland

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The storage of fine-grained sediment within the channel bed and on floodplains represents an important component of the sediment budget of a drainage basin. Furthermore, there is increasing recognition that such areas of sediment storage also represent important sinks for fine-grained sediment-associated contaminants, and that they may act as a source of such contaminants if the stored sedi-

ments are subsequently remobilised. However, relatively little information currently exists regarding the magnitude of such storage within the context of the suspended sediment budget of large river systems, and an attempt has been made to quantify the storage of fine-grained sediment within the channel and on the floodplains of the River Tweed (4390 km^2), Scotland. The amount of fine sediment stored within the channel bed has been estimated by resuspending the material deposited on the bed along transects at 10 locations throughout the basin. Caesium-137 measurements have been used to assess the magnitude of suspended sediment storage on floodplains during the last ca. 40 years. A combination of bulk and sectioned cores have been collected along transects perpendicular to the channel at 11 sites in order to examine the spatial extent and magnitude of sediment deposited on floodplains during overbank events. These estimates of storage are then compared to the suspended sediment yield measured at the basin outlet.

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Thirty years of surface change in the Zinder area (Southern Niger): geomorphological evolution and relation with desertification

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The severe drought which affects the whole Sahelian area since 1968 together with human impacts have generated serious environment modifications and regional climate change. Indeed, in Niger the annual rainfall trend went downward of 40% from 1951 to 1994 while the human population has been multiplied by three on the same period. This provoked an increase of the deforestation {augmented of a factor three from 1951 to 1994) in the region which, together with poor land-use practices and a dramatic overgrazing, have contributed to a startling land degradation.

These environmental variations are highlighted by a multitemporal analysis based on aerial photos (1958 and 1975) together with Spot (1987) and Landsat (Mss and Tm) 1973, 1976 and 1987) satellite images which provides information about land cover evolution as well as about change in the geomorphology of the Zinder area (Southern Niger) over a thirty-year period.

The data demonstrate that modifications of the geomorphological features occurred mostly during the two severe periods of the drought which affected the whole Sahel in the early seventies (1972-1974) and during the eighties (1982-1987). Indeed, the savannah densely covered by trees in 1958 gave way to a totally bare surface in 1975. In 1987, on the same area, the sandy soils were eroded by the wind and sometimes the soil went totally away and a lateritic crust became visible.

The absence of vegetation cover augments the wind erosivity as noticed by the reactivation of the top of the last interpluvial dunes (18000 B.P.) as well as by the creation of new dunes. But the wind erosion evolution is also testifield by the dramatic increase of days affected by airborne dust particles which augmented of a factor ten in Niamey during the dry season (October to Avril) from 1951 to 1994.

José Luis Palacio-Prieto
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Hurricane Roxanne's effects on the coastal geomorphology in southeastern Mexico

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Hurricanes are responsible of important geomorphological changes along coastlines. For the southeastern gulf coast of Mexico, the frequent strike of hurricanes is reported to have a major influence on the configuration of the shoreline, where marine transgresions score locally hundreds of meters. This paper is focused on the geomorphological effects of the Hurricane Roxanne (October 8-19, 1995) along the shoreline of the State of Campeche, southeastern Gulf coast of Mexico. The area corresponds to the contact of the Yucatan limestone platform and the deltaic sedimentary deposits of major mexican rivers draining to the Gulf of Mexico. Special enfasis is given to the interpretation of erosion-accumulation features and damage detection on road infrastructure, closely related to the geomorphological evolution of the coastal area.

The use of alternative remote-sensing tools based on a color video remote sensing system for a rapid assessment is also stressed. An aerial survey of the coast of the State of Campeche, Mexico, was carried out after the strike of hurricane Roxanne. Two video cameras were used to survey the damages to infrastructure and detection of morphological features along the coast. Video images were digitized and enhanced using multi-media software and finally integrated and interpreted in the context of a geographical information system.

The surveyed coast may be divided in two: a) an erosive one corresponding to the northern part and b) an accummulative to the south and west. Main damages were detected where the roads run close to the shore (up to 150 m far from the coastline) and in those places where ancient channels obturated with recent sedimentation events are present.

Valentina P. Palijenko

The geomorphologic diagnosis of neotectonically active faults

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The diagnostics of neotectonical activation along the faults is one of the actual geodynamical problems. In cases of closed platform structures which are often characterized with absence of direct indication of movements along faults, of weak differentiability in space of neotectonic activity and mainly long periodical activation, the geomorphologic diagnosis is the mostly effective method. To substantiate the global and regional neogeodynamic models which accounts the spatial differentiation of stress fields, various kinematics and activity of structures we had distinguished the regularities of disposition and interaction of neotectonically active faults. The geomorphologic diagnostics of neotectonic activation are performed in the some following stages:

1. the exposition of dominant geomorphologic indicators of activity and their paragenetic complexes,
2. zoning of territory on informatively degrees and reliability levels of various indicator or their combination,
3. the exposition of spatial regularities of neotectonical activation along faults, determination of zones of their interaction and mutual influence,
4. quantitative parametrization of faults with data of total amplitudes and gradients of vertical and horizontal movements velocities involved for active zone classification.

As a result of step by step analysis of latest and modern tectonic activation it is performed zoning of Ukrainian territory with an account of their differences, which are observed in kinematics, dynamics, in history of development and with account of moment of the last activation along faults which is registered by geomorphologic indicators. Geomorphologic indicators of shear, extentional, up-and downthrown fault of tear deformations are distinguished. The special attention is put to approbation of geomorphodynamical approach to diagnosis of horizontal movement along closed faults in the limits of plain-platform morphostructures. It is established that in ranges of Late Oligocenic, Late Oligocenic-Middle Pliocenic, Middle Pliocenic-Anthropogenic and modern stages of morphogenesis the geomorphological indicators are differ substantially. The events of maximal activation of reliefmaking deformations of earthcrust along fault with compression paroxysm in Late Eocene, Late Oligocene, Middle and Late Miocene, on Pliocene-antropogenic interface which are typical for the alpine-Asiatic orogenic belt and for adjacent intracontinental plain-platform morphostructures. In the modern stage fault raptures develop in pulse (with frequent seismic events), creep and pulse-creep regime.

As a whole the time-spatial discrete activation of deformation along faults as well as informative multicipherence of geomorphologic indicators are inherent to neotectonic and modern stages. The quantitative parameters of fault dynamics in different time intervals and zones of dynamic influence of deep seated faults are determined on the basis of large scaled field researches.

Knowledge about neotectonical and modern activation along faults were used for seismic zoning of Ukraine, for distinguishing of geomorphodynamical and actuotectonical risqué zones, for substantiating of potentially ecodefective technical structures, of toxic material depositories etc.

ANDRÉ PANCZA

Les «moraines de névés»: liens entre les éboulis et les glaciers rocheux

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Les observations et mesures effectuées depuis 6 ans dans les Hautes Alpes valaisannes nous ont permis d'étudier d'une part, la vitesse de déplacement des glaciers rocheux et d'autre part, leur alimentation en matériaux par les éboulis de pente. Situées dans de petites vallées suspendues * entre 2650 et environ 3000 m d'altitude et orientées à l'ubac ces formations connaissent actuellement une évolution particulièrement dynamique (Pancza 1993). Leur disposition est classique: parois rocheuses gélives qui surmontent les éboulis, ces derniers dominant à leur tour des glaciers rocheux allongés et lobés. (King & *alii*, 1987).
Les parois rocheuses ont une centaine de mètres de hauteur. Elles sont constituées de gneiss ou de quartzites appartenant à la nappe du Gd. St. Bernard et sont particulièrement sensibles à la gélivation. Aussi, ces parois alimentent-elles en gros blocs (décimétriques et métriques) les éboulis de pente. Le recul actuel des parois varie entre 1 et 1,6 mm/an. Des évolutions de même importance ont été constatées dans d'autres sites des Alpes (Barsch 1977 et Francou 1988). Parmi les éboulis ce sont les formes en talus qui prédominent avec une pente très inclinée variant entre 36 et 38°. Les dépôts de pente en forme de cône, plus rares, possèdent également une forte déclivité en amont, mais leur pente diminue (24 à 28°) vers leur extrémité avale.
Les éboulis conservent une couverture de neige résiduelle tard dans la saison (mi-août) quant aux talus les mieux abrités, ils portent un névé pérenne de neige durcie. Ces névés forment une carapace plus ou moins détendue lors des périodes de fusion et ils servent de plan incliné pour les blocs détachés et mobilisés depuis les parois. Aussi, assiste-t-on au bas des talus à une accumulation des blocs ayant transité sur l'éboulis. Ces matériaux s'assemblent et s'entreposent donc dans cette frange bien précise en prenant la forme d'un cordon ou rempart, perpendiculaire à la pente. Ces accumulations sont asymétriques: moins de 30° vers l'amont et 38 à 42° vers l'aval.
Ces «moraines de névés» ou bourrelets-protalus (Francou, 1989) se forment vite ** et ensevelissent une importante quantité de «neige de printemps» d'une densité proche de 0,7. Les dimensions de ces protalus en forme de triangle asymétrique atteignent une hauteur de 2 à 3 m sur une dizaine de m de largeur. Immobiles pendant les années de leur mise en place, ces «cordons de gélifracts» entament une lente reptation vers l'aval lorsqu'ils ont atteint leur dimension requise. Ce mouvement, d'une vingtaine de cm par an, s'accélère et atteint après quelques années plusieurs dm par an. La neige du névé, incorporée dans la masse des bourrelets ainsi qu'un enrichissement en glace dû aux conditions climatiques favorisant le maintien du pergélisol, garantissent la formation du système blocs - glace interstitielle susceptible de déformation et de fluage.
Les glaciers rocheux sous-jacents conservent bien, pendant un certain nombre d'années, la trace des bourrelets protalus qui s'émoussent puis s'effacent au fur et à mesure que le protalus s'incorpore dans le mouvement de masse.
Six années d'observations et mesures attestent qu'il existe dans l'alimentation des glaciers rocheux un lien de filiation indirecte entre ces derniers et les talus d'éboulis qui les dominent. Ce lien se traduit par la mise en place sans cesse renouvelée des bourrelets-protalus qui, dans les conditions climatiques actuelles, interviennent en tant que relais ou courrois de transmission entre les deux formations de pente.

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* Dans le vallon de Tracuit localisé au fond du Val d'Anniviers et dans le vallon de Gruob sur le versant oriental de la vallée de Tourtemagne.

** Les mesures attestent une masse d'environ 5 m 3 de blocs qui viennent grossir chaque année un bourrelet long de 12 m.

ANDREY V. PANIN

Catastrophic rates of river incision: case study of Alabuga River, Central Tien-Shan

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River Alabuga (length 180 km , basin area 5820 km^2, mean annual discharge 28.6 m^3/s) is a left tributary of the Naryn River with the point of conjuction at 41.5°N, 74.7°E, 170 km south from Bishkek, the capital of Kyrgizstan. The basin occupies altitudes 500-3000 m.a.s.l. and is characterized by semi-arid climatic conditions (annual precipitation 250-400 mm). In the upper course the river drains the Arpa depression, then in a gorge-like antecedent valley it crosses the Dzaman-Too Ridge and in a 85-km lower stretch flows within the Middle-Naryn depression. Here the valley is incised by 500-800 m into Neogenic molasses, mainly lacustrine aleurites. The roof of the 50-150-m thick Late Pleistocene valley infill (cobble-boulder cemented conglomerates) makes up a 4.0-4.5-km wide alluvial plain. The Holocene valley 0.6-1.7 km wide enclosed into the alluvial plain dissects through the Late Pleistocene conglomerates and deepens into the underlying aleurites making a canyon 0.2-0.5 km wide and 50-60 to (downstream) 15-20 m deep. Meanwhile historical evidences show that in the IX-X and probably even at the end of the XIV centuries this canyon did not exist and river channel was rather broad and shallow.
Several methods were used for dating erosional terraces and estimation of downcutting rates. For the last 4-100 yrs dendrochronological (the age of pioneer vegetation) and

cartographic (comparison of map time series) methods were used as well as direct instrumental measurements of channel lowering. For the older period (200-1300 yrs) local terraces were dated by desert varnish thickness h on cobble surfaces, the varnish growth curve ($h = 0.022\ t^{0.5}$) being tested on independently dated surfaces, including historical and archaeological objects.

Terrace dating have revealed that during incision into the lower part of conglomerates between 200-1300 yrs ago downcutting rates were appr. 0.5 cm/yr. Assuming these rates typical for incision into this kind of substratum the beginning of river incision into Late Pleistocene alluvial plain and formation of the modern valley is dated by 7-8 ka BP. Some 200 yrs ago the river channel have reached the roof of underlying aleurites, and downcutting rates rised by an order (10-30 cm/yr). Contemporary (last 15-20 yrs) downcutting rates vary along the river. At the mouth their values of 0.4-0.9 cm/yr are quite normal, but upstream they rise locally up to 15-30 cm/yr and more which is unusual even for mountaneous streams. For example, from direct measurements at the Dzergital pumping station (40 km upstream from the mouth) only during 1983-1987 yrs the river had incised by 2.0 m. Such rapid deepening inerferes considerably in normal operation of water intake stations and bridges.

An important factor of fluvial dynamics is channel alluvium deficiency. Because of the geomorphological features of the basin the amount of bedload coming from the upstream antecedental stretch is negligible. Along the lower 60-km course bed load rises due to bank and gully erosion and at the mouth it is estimated (by indirect methods) as 150-170 thousand m^3/yr. Rise in bedload leads to the change of channel pattern: it transforms from incised meanders to a straight split channel. Also bank erosion rates rise from 1-3 to 10-15 m/yr.

The case of Alabuga River illustrates that in mountaneous streams channel deepening may reach catastrophic rates under conditions of weak bedrock and channel load deficiency. Rapid downcutting may be initially revealed from distinct morphological features (valley terrace and floodplain morphology and constitution). If those are discerned, fluvial history and contemporary dynamics should be studied in detail before engineering works.

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Analysis of earthquake-induced surface effects in the Modena province: first approach in the area of Montese (Northern Apennines, Italy)

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Earthquake-induced surface effects have caused tens of thousands of deaths and thousands of billion liras in losses worlwide in this century; in many earthquakes, the resulting surface effects have caused as much or more damage than other effects of seismic shaking. The Italian territory, because of its geological set up and seimic activity, faces a potential hazard from earthquake-induced surface effects, especially as regards landslides.

This poster, illustrates a research facing up to this difficult subject by means of a multidisciplinary approach: tectonics, seismology, geology, hydrogeology, geomorphology, soil/rock mechanics have been considered. In fact, the contribution of the fundamental disciplines in a research aiming to define a methodology for the identification of the risk associated to surface effects of earthquakes is necessary, all the more so because this risk has to be envisaged as an interdipendent part of the whole seismic risk.

The Montese area is located in the mid Apennines of the Modena Province (altitude between 400 and 1000 metres). This area has been chosen because during 1994 it was in the epicentre of three earthquakes (M=1.5-1.8) recorded by the Modena province seismic network and moreover because during the night of the 31st December 1995, owing to a V MCS degree earthquake (M=3.8) which affected the higher sector of the north-western Apennines, a landslide of 500,000 square metres with a width of 500 m and a length di 1 km was triggered.

The research was carried out in order to: 1) recognise the base elements for the definition of a seismotectonic and seismogenetic picture of the Modena province, aiming at a future seismic zonation; 2) verify in an area affected by earthquake-triggered landslide of a methodology for the identification of prone areas that could be used by competent agencies. The research, carried out in the framework of the activities of the European Center on Geomorphological Hazards (Cerg) of Strasbourg, has been organized according to the following studies at different scale:

A) Small Scale Studies (Studies on province of Modena): 1) Research on the seismological and seismotectonic characteristics of the Modena Province (elaboration of a seismic epicenter map, preparation of a seismic catalogue of the earthquakes in the Modena province, elaboration of a geological-structural map, elaboration of a Quaternary active faults inventory); 2) historical and bibliographical researches on earthquake-induced surface effects in the Modena Province (realization of a medium scale location maps of earthquake-induced surface effects; implementation of data sheet for earthquake-induced surface effects characteristics).

B) Large Scale Studies (Studies on area of Montese): 1) Study of the geomorphological characteristics (implemen-

tation of a geomorphological map and inventory of the main landslides); 2) study of the geological and hydrogeological characteristics (implementation of geological - structural and hydrogeological maps); 3) study of the geotechnical and geomechanical characteristics (geomechanical characterisation of rocks and complex formations, implementation of contour plots of structural data, analysis of spacing and Joint Roughness Coefficient distributions and of joint wall compressive strength, elaboration of maps of geomechanical classification of rock slopes; 4) factor mapping and correlations (hazard mapping and risk analysis of the investigation area; application of the rock engineering systems).
In the poster the main documents prepared within the framework of the research are shown.

MARIO PANIZZA[1], ALESSANDRO PASUTO[2] & MAURO SOLDATI[1]

Geomorphological mapping as a fundamental tool for landslide management: the example of Cortina d'Ampezzo (Dolomites, Italy)

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Mapping is in most cases a necessary step in geomorphological investigations aiming at landslide management. Maps may consist of either basic documents such as geomorphological maps and landslide maps or of landslide susceptibility maps and hazard zonation maps.
After a brief review concerning the use of mapping in landslide studies in different countries, the maps produced as a result of geological and geomorphological investigations carried out in the area of Cortina d'Ampezzo (Eastern Dolomites) are presented. The study area has often been affected by landslides of various types and sometimes of considerable dimensions, some of which are still active today. Because of intense urbanisation and the interest which this region holds for tourism, the presence of some active landslides and of a large number of dormant ones makes this area particularly vulnerable and subject to high geomorphological risk.
From the cartographic standpoint, the first achievement was a geomorphological map at the 1:10,000 scale, produced following the Italian methodology and legend. Besides geological data, this map includes details on the general slope morphology and related processes and, as far as landslides are concerned, defines the type of failure, the degree of activity and the main associated features. This map was the basis for the elaboration of a 1:25,000 scale map in which gravitational deposits have been grouped into landslide units. A landslide unit has been defined as the association of landslide accumulations strictly connected in space and time: it can consist of a single main landslide and successive reactivations or of a superimposition of accumulations caused by repeated activations of a main scarp; it can also be due to neoformation scarps affecting a landslide body. A landslide unit is often marked by a detachment zone and by a preferential accumulation area well related from the spatial point of view; this reflects also on the prevalent lithological characteristics found within the unit itself. Other kinds of deposits (e.g. lacustrine or alluvial deposits linked to river damming or depressions formed along the slopes) may be included in a landslide unit. Scree slopes and talus cones found at the toe of the main landslide scarps are included in the unit, since they are genetically linked to the gravitational phenomena considered. Finally, the morphological features of the deposits belonging to a landslide unit generally show a close relationship with the main movement type.
The use of landslide units provides the reader an easier understanding of the complex geomorphological evolution of the area of Cortina d'Ampezzo and gives useful elements for landslide hazard assessment and management.

MARTA PAPPALARDO

Observations on some stratified slope deposits in the Gesso Valley (Italian Maritime Alps): typology and significance

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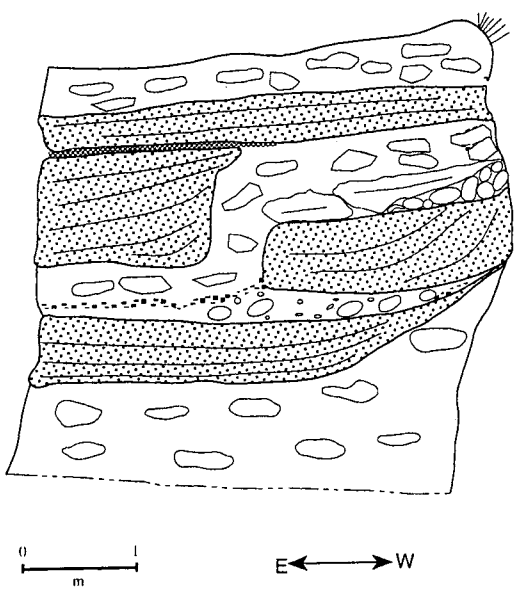
Along the slopes of the medium-lower Gesso Valley (Italian Maritime Alps) some stratified slope deposits can be found. The reason for interest in them is not their peculiarity, this type of deposit is well known in many other parts of the world, but the importance their presence and their characteristics assume in the correct interpretation of the paleogeographical evolution of the valley. Through them the activity of different morphoclimatic environments since the greatest expansion of the last ice age can be focused on.
In the Gesso Valley stratified slope deposits developed on limestones and marls outcrops belonging to the Delfinian Units, of Mesozoic age. They are widespread between 800 and 1100 m of altitude, and occupy the basal part of rocky slopes dipping 100% or more. The uplift movements of the Argentera Massif, infact, caused tectonic movements in the Delfinian Units, which were consequently back folded. Along the flanks of the resulting folds the valleys of the medium-lower part of the basin were dissected.
The dip of the slope deposits is roughly 40%. At the bottom alluvial terraces of first order overlap them. Their thickness varies from a few dm to some tens of meters. In the thinnest sections stratification does not appear evident. At present they are inactive.

A «typical» deposit was chosen, and two sections were taken into account: a frontal section and a longitudinal one (figure). They showed an alternance of grain-supported and matrix-supported layers. The sedimentological analysis of each level revealed that these deposits can be interpreted as *éboulis ordonné* (according to the classical French terminology). Each layer, anyway, shows its own sedimentological peculiarities, either concerning the grain size, or their orientation and dip, their sorting within the level, their relative matrix abundance, the degree of cementation, the nature of its limits. It is impossible, therefore, to account for a true cyclical nature of the layers.
According to the facies of each level, in comparison with similar active deposits described in the scientific literature, an assumption is made about the processes responsable for the genesis of these deposits: they are hypothized to be congeliturbation phenomena, associated with rill episodes and grain flows. The deposits concerned are therefore likely to have formed in a typical periglacial environment, near the terminal part of a glacier snout, while this was retreating. Associated phenomena must have been an increase of rainfall, quick melting and widespread erosion.
These *éboulis ordonné* are located both above and below at least two morainic frontal ridges, dated to the Würm and to the Lateglacial; so their genesis was not synchronous, but formation stages of stratified slope deposits took place at different times, in different sections of the valley.



ISSAAK PARCHARIDIS[1], ANDREAS PAVLOPOULOS[2] & MAURIZIO POSCOLIERI[3]

Contribution of geomorphometric analysis to a comparative volcano-tectonic study of Vulcano and Santorini islands: clues for geologic risk areas

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In the southern Aegean sea there is a well known volcanic island complex represented by the Santorini (Thera), Therassia, Aspro (Aspronissi), Nea Kameni and Palea Kameni islands (fig. 1). The last two are the actual active volcanic centers; the general form of the islands and the land distribution is due to the outstanding Minoan eruption (ca 1500 B.C.) which caused the formation of a caldera and the sea invasion. The Minoan eruption was characterized by huge volumes of pumice which covered the existing island. Several times, later, the volcano erupted again forming the Palea and Nea Kameni islands. The slopes of the island facing the caldera are very steep, almost vertical, reaching an elevation of about 200-300 m a.s l. Toward the outer periphery the slopes are, in general, much gentler. The highest point (566 m a.s.l.) of the island is found in the south east part of Thera and corresponds to a dome made up of crystalline limestones (Profitis Ilias) that represent, together with schists and phyllites, the more ancient island, before the manifestation of volcanism, whose beginning has been placed in the Upper Pliocene. The continuing volcanic activity up to nowadays (last eruption in 1950) and the related seismic activity exhibit a high risk for the human settlements and the unstable parts of the caldera walls.
North of Sicily, in the southern Tyrrhenian Sea, there is the volcanic arc of the Aeolian Islands, whose the southernmost is Vulcano, constituted by many overlapping volcanic structures (fig. 2). The older one is a stratovolcano, making all the southern side of the island and partially facing Sicily; its collapse formed Il Piano Caldera. Northwest of this apparatum, there is a more recent structure constituted by the Lentia complex, whose collapse produced again a volcanic depression, inside which La Fossa cone later grew. Four volcanic cycles have built up this cone, whose last and huge eruption (only explosive) occurred at the end of the 19th century at the summit of La Fossa, occupied at center by the so called Gran Cratere. The youngest and northernmost center in the island is represented by Vulcanello, facing the island of Lipari: the first eruption dates back to the II century B.C., the last to the XVI century. Vulcano exhibits a very high volcanic risk, especially in the region corresponding to La Fossa cone, because of the predominant explosive characteristics of the eruptions and the presence of human settlements. A major hazard problem concerns slope instability, strictly related to and sometimes triggered by the volcanic (nowadays mostly fumarolic) activity.
A comparison between the two described volcanic scenarios has been performed by carrying out a quantitative study of the geomorphological settings of Vulcano and Santorini. The analysis takes into account as input data sets

two detailed raster Digital Elevation Models and is addressed to identify uniform physiographic units and landforms outstanding from the geologic and volcanic hazards viewpoint. Differences and similarities between the two islands will be outlined.

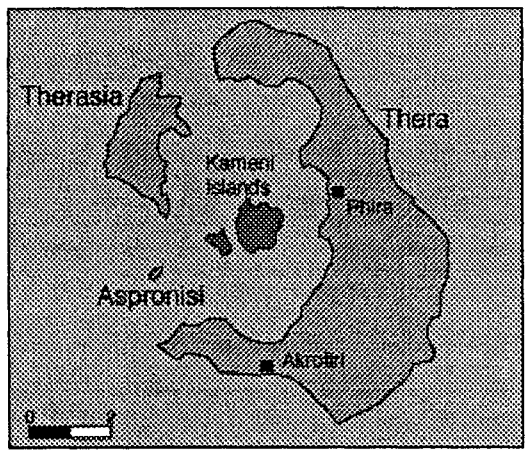

FIG. 1 - Sketch map of Santorini island.

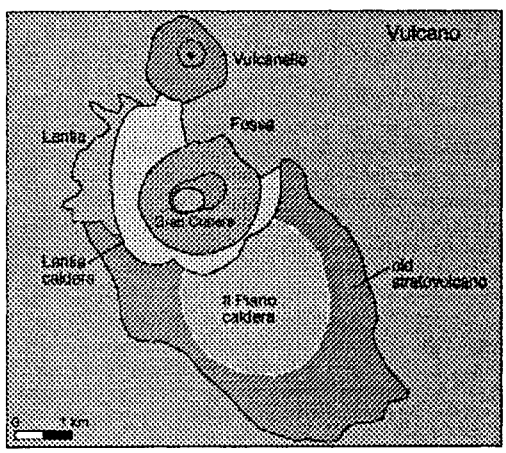

FIG. 2 - Sketch map of Vulcano island.

ANTHONY J. PARSONS

Sediment-transport competence of rain-impacted interrill overland flow on semi-arid hillslopes

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On semi-arid hillslopes soils are typically coarse-textured and stony, so that the supply of sediment for removal in interrill overland flow may be limited as much by the competence of the flow as by its capacity. Although competence has been extensively studied in river flow, equations developed in that context are inappropriate for predicting the competence of rain-impacted shallow flow where sediment entrainment is achieved dominantly by raindrop impact. In order to obtain a suitable predictive equation for sediment transport under these conditions, laboratory experiments were performed using a recirculating flume 4.80 m long and 0.50 m wide with a bed of fixed silica sand (median diameter 1.5 mm). Rain falling onto the flume was varied in intensity between 51 and 138 mm h^{-1}, flow was introduced from a header tank into the flume at rates ranging from 0 to 0.64 l s^{-1}, and experiments were conducted on flume gradients between 3.5 and 10°. Particles ranging in size from 3 to 10 mm were introduced into the flows in the flume generated under the stated ranges of rainfall, flow and flume gradient and the median transport distances of between 10 and 25 particles of each size were recorded. These experiments show that high transport distances of particles are achieved only when high values of rainfall energy are combined with high values of flow energy. The combined effect of the two energy sources on transport distance appears to be multiplicative, rather than additive. This multiplicative combination of the effects of the two energy sources is expressed in the following general transport equation which was developed from the experimental data:

$$M.L = (RE.FE)^{1.636}$$

in which M is particle mass, L is distance moved in unit time (cm min^{-1}), RE is rainfall energy (J m^2 s^{-1}) and FE is flow energy (J m^2 s^{-1}), and for which $r^2 = 0.53$. This equation provides the first available means for predicting sediment-transport competence of interrill overland flow. The equation is limited in its utility insofar as it has been developed using quartz grains and takes no account of variations in absorption of rain energy by natural ground surfaces.

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The morphosedimentary evolution of the river valleys in the Paris Basin (France) during the Late and Post-Glacial: climatic and human impacts

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The study of the Late-Glacial and Post-Glacial evolution of the river valleys in the Paris Basin has been realized in the frame of the rescue programme of archaeological exca-

vations (continuous cross sections), drillings and cores. The intercomparison of morphosedimentary data with other data supplied by archaeology, palynology, malacology, and palaeosoil (micromorphology) sciences enables us to analyse the reactions of the river dynamics to climate and human activities. The time frame is based on ^{14}C dates and on the stratigraphy of archaeological sites.

The Late-glacial evolution is largely controlled by climatic variations, and is characterized by very sharp events. It consists of two important sedimentation phases, approximately dated Oldest Dryas/beginning of the Bölling and Younger Dryas. Both phases are separated by a vertical cutting which occurred during the second half of the Bölling (approx. 12,500 BP), followed by an episode of dynamic stability and the Alleröd soil formation. Locally, cryoturbations show the magnitude of the cooling at the beginning of the Younger Dryas.

The Post-glacial started with a deep incision during the first half of the Preboreal.

During the Boreal and the Atlantic, the erosion/sedimentation dynamics decreased with the growth of the vegetation cover. The stream channels were progressively filled by organic matter-rich sediments and the watershed did not supply any more clastic material. During the second half of the Atlantic, the various indicators do not show any particular modification of the environment. However, the pollen data reveal, during Middle Neolithic times, the development of agriculture together with the scarce opening of the landscapes.

During the second half of the Subboreal, the increasing erosion of the slopes, favoured by the human activities, led clayey silts to fill the mean water channels; the increase of the river discharges generated numerous channels which were very active during the Bronze Age. Most of these channels were filled during the Second Iron Age (La Tène, beginning of the Subatlantic).

During Roman times, the main river valley floors continued to be filled with silts; the clastic sedimentation slowed down during the Middle Ages.

Finally, a big erosion crisis, marked by a thick silty fill in the valleys of the small contributors, is evidenced during the Little Ice Age.

This general scheme admits numerous fluctuations in relation with geomorphological and phytogeographical parameters; it will be detailed by a research programme aiming at precising and quantifying the various elements.

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Rock varnish in the geomorphological levels dating (Makhtesh Ramon depression in the Negev Highland)

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Rock varnish is a widespread feature of stony desert landscapes throughout the wourd. It is the product of complicated and specific physical and chemical processes under arid and semi-arid environments. It was revealed that chemical composition of these desert coatings, especially relationship between separate group of chemical elements, is age-dependent, therefore these ones have attracted considerable attention from archeologists and quaternary geologists when solving a challenge of both artifacts and native phenomena dating. As a rule, the object of such investigations are «mature» rock varnish coatings of considerable thickness (up to 0.5 mm) and of zonal structure.

Rock varnish patina occures widely on the different surfaces of the Negev Highland, but, as opposed to well known ones from the Death Valley in California, varnish coatings are here extremely thin (vanishingly thin in places), no more than 1 mk, which hampers their analysis by electron mictoprobe method, dating assessement and revealing aged relations with initial surface. The main objects of our investigation are different-age denudational levels within Makhtesh Ramon cirque, the unique structural-erosional depression formed in the Ramon anticline in the central part of the Negev desert. The highest of these levels (the ancient Makhtesh bottom) is propably of the Late Pliocene age. The stair of 6 terraces related to vadi Ramon and the 5 pediments connected to them are of the Quaternary age. Some of them have been dated by TL method (Kulikov) and were used as markers for the rock varnish dating and absolute age scale creating.

Rock varnish chemistry was studied by electron microprobe analysis (Camebax) with the special technic developed by Nechelustov for unpolished surface because of extreme thinness of patina. The distribution of chemical elements forming the basis of rock patina, Na, Mg, Al, Si, K, Ti, Cr, Mn, Fe, was determined; among them such elements as Fe, Mn,Si,Al,Mg are the most varied in content and can be viewed as indicators. Mineral composition identified by electron microscopy technique (Tem) with microdiffraction (Sivtsov) is the following: kaolinite, montmorillonite, chlorite, goetite, hematite, litioforite, Mg-Al asbolan, Ti-augite, etc.

Creating of foolproof methods of rock-varnish dating assessmant and revealing and aged relations between geomorphological levels was in the focus of our unvestigation. Because primary signs (element contens) dont show clear-cut change tendency from age, not only elemental concentrations but their ratios and products were taken into accont. products were used. The using of the original algorithm (put forward by Chizova) gives minimal determination error of calculated parameters. The generalized geochemical index, GI rv, for absolute dating of geomorphological levels based on this calculating model was suggested.

The calculated RV-age scale has been tested on the selected independent samples from the different-age levels of the Makhtesh Ramon (from 30 t.y to 1 mln y.). It can be used for dating of the varnished geomorphologic surfaces (river terraces, fans, pediments, slopes) in the Central Negev area.

IRINA E. PAVLOVSKAYA

The influence of neotectonic processes on the river valleys morphology in Belarus

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Belarus lies within the area of glacial accumulative relief. The thickness of the Quaternary cover amounts 80-100m and more on the most part of the region. Despite the concealing effect of the glacial morphogenesis an influence of fault and block neotectonics on the rivers network pattern and changes of river channels gradients can be distinctly traced.

Three areas distinguished by a degree of endogenic effect on the recent rivers are recognized. The first area covers territories with the Quaternary deposits thickness of 140-160 m and more.Tills dominate among the Quaternary accumulations. River valleys are mainly of the Late Pleistocene age. The river network has a dendritic pattern, slightly depending on fracture zones distribution. 36,2% of the total number of river profiles deformations are caused by fault tectonics. 80-100 m thickness of the Quaternary cover prevalence of the glaciofluvial deposits and the Middle Pleistocene age of river valleys are characteristic of the second area. The river network predominently follows the submeridianal fault zones . That caused the subparallel orientation of the main river and its tributaries as well as the curving of lower sections of the main river tributaries valleys at the right angle in places of their crossing of fault zones. The anomalies of river channels, conditioned by fault block tectonics makes 72.8%. The third area is characterised by insignificant thickness of the Quaternary cover (20-40 m). The glaciofluvial and alluvial accumulations prevail among the Quaternary deposits here. The river valleys formation dates to the Early and Middle Pleistocene . The most distinct dependence of channel profiles deformations on neotectonically active fault zones orientation is displayed in this area. The structurally caused anomalies make 82.1% of the total number of profile anomalies.

Besides changes of profiles and configurations of valleys, the neotectonic influence may be revealed in alteration of terraces width. Within the blocks of prevailing neotectonic subsidence a widenning of the flood-planes, the first and second fluvial terraces is registered. Neotectonic rising of separate parts of the large river basins provokes the terraces narrowing. In some cases terraces princh out and a valley acquires the canyon shape. This morphological transformations are accompanied by changes of the alluvium facies (perstrative and instrative alluvium of the flood-plain and meander facies prevail in subsiding locations, konstrative channel alluvium - in rising terrains).

Analysis of belorussian river systems configuration and morphology has allowed to establish that the degree of neotectonic processes reflection in morphological features of river valleys depends on thickness of the Quaternary deposits, prevailing genetic type of the Quaternary accumulations and the age of relief. Minimal amount of neotectonic deformations of the drainage network is observed within the area of Late Pleistocene relief with thick glacial deposits and till dominating among them.

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Late Cenozoic large-scale landscape evolution of the U.S. Atlantic passive margin

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The U. S. Atlantic passive margin has been fertile ground for the development of long-term landform evolution models. In this paper, we review large-scale landscape evolution models of the Appalachians to critically reevaluate the origin of Appalachian drainage, understand the role of late Cenozoic flexural isostatic deformation, and provide insights into the question of why North America is one of the few continents not widely recognized to have a Great Escarpment along its rifted margin.

Post-rift denudation of the Appalachian mountains over the past 180 m.y. has left few stratigraphic and geomorphic clues in the Appalachian landscape, but is well-preserved in the sediments of the Atlantic offshore basins. We propose that long-term denudation of the continent and offshore sediment deposition drives flexural isostatic deformation of the margin which we constrain with late Cenozoic fluvial terraces correlated to dated Coastal Plain marine deposits, and known volumes of sediment in offshore basins. Two simple geodynamic models, a one-dimensional line load model and two-dimensional distributed point load model are constructed and parameterized with results from previous, published studies. Model results strongly suggest that: (1) the primary late Cenozoic deformational response of the U.S. Atlantic margin has been flexural subsidence, (2) the Fall Zone is the landward geomorphic expression of a flexural hinge, and (3) nearly 100 m of post-20 Ma flexurally driven rock uplift has occurred west of the Fall Zone.

Post-rift flexural subsidence of the middle Atlantic margin produces a short, steep fall to base level for east-flowing streams. Steep fluvial gradients, coupled with the narrow outcrop width of resistant Piedmont and Blue Ridge rock-types, favored rapid growth and westward extension of Atlantic drainages and the concomitant dissection of any rift-generated Great Escarpment. Along the middle Atlantic margin, the drainage divide has migrated westward to the Allegheny Plateau where it forms the highly-embayed, east-facing Allegheny escarpment which typically has less than 500 m of relief. In contrast, the relatively subdued flexural depression of the southern Atlantic margin produ-

ced a longer, more gentle gradient to base level for Atlantic streams. The relatively gentle fluvial gradients, coupled with a wide outcrop belt of resistant Piedmont and Blue Ridge rock-types, has slowed the westward extension of east-flowing streams. Here the drainage divide is stalled on the Blue Ridge, forming a steep, east-facing escarpment with locally over 800 m of relief. The location of maximum late Cenozoic flexural uplift, coincident with the Blue Ridge crest, has worked to maintain the position of the modern drainage divide, slowing its westward migration.
The characteristics of the Blue Ridge and Allegheny escarpments in eastern North America broadly match those described as Type-1 and Type-2 escarpments respectively; however, important discrepancies remain. Our results are in agreement with other studies which conclude that eastern North America does not have a strictly Type-I Great Escarpment, that is, an escarpment inherited from an initial high-relief margin whose long-term expression is favored by minimal post-rift offshore sediment loading. Clearly, the U.S. Atlantic margin, especially the middle and northern portions, is dominated by subsidence driven by post-rift offshore sediment loading. Similarly, our analysis does not support the Blue Ridge and Allegheny front as strictly Type-2 escarpments, that is, escarpments well adjusted to rock-type and structure and etched into the landscape on the seaward side of a flexural peripheral bulge. For the Blue Ridge and Allegheny escarpments, the modern drainage divide is not everywhere coincident with the location of maximum landward flexural uplift, the escarpments are not everywhere well adjusted to rock-type and structure, and the preservation of Paleogene marine sediments in the southern Piedmont argues for rapid westward retreat of the initial rift-flank escarpment. The only true Type-2 escarpment on the Atlantic margin is the Fall Zone, which exploits the difference in rock erodibility between resistant Piedmont rocks and non-resistant Coastal Plain sediments and is best expressed along the steepest, seaward-facing portion of the flexural peripheral bulge. We conclude that the larger Allegheny and Blue Ridge escarpments are a hybrid between the Type-1 and Type-2 escarpments and share at least some characteristics in common with the Great Escarpments of the southern continents.

MANUELA PELFINI [1], MARCO NERI [2] & ALVISE CASANOVA [1]

Dendrogeomorphology as a method of dating seismic events along active faults: the case of the Pernicana Fault (Mt. Etna, Sicily, Italy)

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Dendrochronology today represents a proven method for dating geomorphological events of various types. Among such events, seismic and volcanic events should be included. Soil movements created by the activity of a volcano can cause damage to tree vegetation such as breakage of tree tops, root damage, tilting of trunks. Such conditions can lead to failure to produce rings, the formation of narrow rings or the formation of reaction wood (compression wood in conifers). The latter is formed when a tree starts to produce eccentric rings in order to return to its original vertical stance. Identification of these signs, with annual definition allows for indirect dating of events.
The objective of this study was to apply the dendrochronological method in order to date the activity of Mt. Etna occurring prior to instrumental records, in the area NE of the volcano characterized by the NE rift - Pernicana fault, an association of particularly active volcanic and tectonic units, associated with the activity of the NE crater.
A dendrochronological study was thus conducted on specimens of *Pinus laricio* in an area of about 15.000 m^2, along the Pernicana fault plane at about 1700 m above sea level. Over 300 trees were sampled, including several cores in areas several kilometers away from the fault, and their growth over time was analyzed in detail.. The tree specimens cover a time span of about 200 years. During this chronological time interval, at least 15 major periods of bad conditions affecting the vegetation were identified, plus another ten of smaller scale, at fairly regular intervals. The more distant trees, used as reference samples, had not recorded the stress periods observed in the samples collected along the fault and also excluded the climatic influence (records of climatic conditions) as no significant correlations emerged from the comparison with the meteorological data pertaining to the last 50 years.
Comparisons were then carried out with the volcanic activity of Mt. Etna and the macroseismic data pertaining to both the Pernicana Fault and the regional context. The quality of the volcanic activity data and the seismic data is particularly reliable only for the last 25 years and the comparison was thus concentrated, at the beginning on that period of time. The initial results obtained revealed that the volcanic activity had not significantly influenced the growth of the vegetation, with the exception of when it occurred together with telluric events associated with the eruptions themselves. To the contrary, the macroseismic activity of the Pernicana fault appears to have had a definite influence on tree growth, creating periods of stress repeated over time and of varying intensity.
This analysis led to the conclusion that even the periods of stress for the vegetation occurring between 1807 and 1970, can be correlated mainly with the macroseismic activity of the fault, revealing probable seismic activity that involved the study area. Moreover, the comparison showed that local earthquakes are those most felt by the vegetation, probably due to the strong macroseismic intensity related to the surface hypocenters, typical of the structure analyzed.

MANUELA PELFINI[1] & CLAUDIO SMIRAGLIA[2]

Geomorphological evidences of the recent advance of the glaciers in the Central Italian Alps

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For about twenty years (1965-1985) most of the glaciers in the Italian Alps have been advancing. In the main mountain groups of the central sector of this region (Bernina, Disgrazia, Piazzi, Ortles-Cevedale), the snouts of the glaciers have been moved downward some tenths meters on average from 1965.
Then, from 1985, the glaciers fastly retreated leaving new particular morphological features, mainly end and lateral moraines ridges. These new moraines have been observed in front of all main glaciers, either valley glaciers (Ventina and Forni Glaciers, for instance; the last one advanced more than 300 meters) or mountain glaciers (Castelli, Sforzellina, Gran Zebrù Glaciers, for example).
The morphology and the evolution of some new moraines, especially in the Ortles-Cevedale Group: Forni, Sforzellina, Gran Zebrù Glaciers have been examined carefully.
The landforms of the Sforzellina aud Gran Zebrù Glaciers are real frontal and lateral moraine complex, mainly formed by angular metamorphic debris. Near the snouts of the Sforzellina and Gran Zebrù Glaciers, there is, 20-30 meters far from the today ice-edge, a group of ridges (two and sometimes three); their thickness varies between 0,5 and 3 meters. These moraines have a steep distal side with a gentle proximal slope. Field observations and grain size analysis show that they are mainly formed by coarse debris; their genesis probably derives mainly from dumping of supraglacial debris along the growing snout slope.
The data of some meteorological stations in the Italian Central Alps (Sondrio and S. Caterina Valfurva in Valtellina) have been then considered for understanding the links between the origin of the above mentioned glacial landforms and the climatic variations. Between 1965 and 1985 a small reduction of summer temperature (less than 0.5 °C) as well as an increase of winter precipitation were observed.

MANUELA PELFINI[1], GIORGIO STRUMIA[1], ANDREA CARMINATI[1], SEVERINO BELLONI[2] & GIANCARLO ROSSI[3]

Response times of alpine glaciers, as defined by tree vegetation signs: the example of the Lys Glacier (Valle D'aosta)

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Glaciers represent an interesting source of information about the climate of the past, as they are valid recorders of climatic fluctuations. After a changes in temperature and precipitation, glaciers first change their mass balances and the equilibrium line altitudes, then the fronts either advance or retreat. However, there is a certain delay between the climatic forcing and a shifting of the glacier front. The response time for Alpine glaciers is often estimated using methods based on a linear correlation between front variations and the patterns revealed by several climatic parameters such as temperature and precipitation.
The purpose of this study was to calculate the response time for a sample glacier, the Lys Glacier in Valle d'Aosta. Front variation data is available for this glacier and the series starts from 1914. The study methods included dendrogeomorphological investigations, thus proposing a method that can be used even when suitable meteorological data series are not available. Four mean dendrochronological curves were plotted from data collected from the analysis of 216 larch trees. The curves correspond to areas from which the glacier retreated in time intervals that gradually reach more recent periods. The curves were then correlated with the glacier front variation data. The linear correlations were repeated by progressively breaking down the data into time periods differing by one year. In other words, first the immediate effect of climate on the trees and thus on the glacier was analyzed, and then analyzed again, based on time delays gradually increased by one year at a time, based on the supposition that the impact of climate on the glacier occurs in that year, or in the following years. The correlation coefficient r tends to drop after the year 0, corresponding to an initial immediate response of the glacier, to then increase the time period until the maximum point is reached, corresponding to a delay in glacier response to the climatic variations (an absolute value). This maximum is reached in the 5th year, which represents the delay between the two curves and thus the response time for the Lys Glacier. The value obtained refers only to the 19th century. Therefore, the result holds only for the time interval considered. The results obtained by correlating the mean dendrochronological data curves with the front variation data curves for the Lys Glacier, were similar to those obtained from the correlation between the temperature data and front variation data. The use of running means provided confirmation of these findings, adding to their validity in that the correlation coefficient, r, increased.
The reliability of the utilization of vegetation to evaluate the response times of Alpine glaciers was also confirmed by the fact that there was no delay between the climatic input and tree response.
The trees that are most suited to this type of investigation are those located outside the area of the maximum Holocene expansion of the glacier. Such trees probably are effected by the climate of the valley head without, however, being disturbed by their extreme closeness to the glacier mass. It should also be kept in mind that glaciers respond to a number of climatic parameters, although temperature has the greatest impact on Alpine glaciers. Thus the use of

a dendrochronological data series as the reference series represents a particularly reliable starting point because the delay is calculated in terms of a synthesis of the climatic variables, as implemented by the trees themselves. Moreover, this method has the potential for a vast range of applications. In fact, numerous valley glaciers reached wooded areas during the advance phase starting from the Little Ice Age and thereafter. Tree records of the events are thus available everywhere. Dendrochronological data series may therefore represent a valid tool for estimating the response times of Alpine glaciers.

GIOVANNI BATTISTA PELLEGRINI

Some applications of the new Geomorphological Map of Italy at 1:50,000 Scale. The Sheet (063) Belluno

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This poster aims to illustrate some possible applications of the Geomorphological Map of the Sheet (063) Belluno, such as the Geomorphological Asset Map and the Geomorphological Hazard Map.
The investigated area is in a Prealpine zone characterized by a great variety of landforms related to its lithological and tectonic features. Neotectonic is particularly important and its effects can be clearly observed expecially in the drainage network. The main features of this area deal with morphotectonic, glacial morphology, fluvial morphology and morphology due to gravity.
Study and mapping of landforms and processes, both active and inactive, give valuable informations to understand the evolution of the landscape. These informations help the decision-maker in the environmental management. Because of their scales the geomorphological map and the derivative application maps (geomorphological asset map and geomorphological hazard map) can not be directly used for urban plannings or for construction plannings. Instead, these maps are suitable for an identification of landscape resources and for regional planning, both for residential areas and for industrial areas.
The Geomorphological Map allows to define both those areas that must be protected and valorized because they are environmental assets, and those areas suitable for human settlements because there is no geologic or hydraulic hazard. In environmental planning active slope processes limit the use of certain areas. This means to consider not only the landslides, active or dormant, known and mapped, but also slopes that can be subjected to possible future failures. Other areas not suitable for settlements are those that can be flooded or that can be involved by fluvial erosion.
In the Belluno area other edification limits exist because the whole area is classified as a sismic zone (2nd category).
The Geomorphological Asset Map points out those features of the landscape that have a special value from a cultural and a naturalistic point of view and that should be protected and valorized.
The Geomorphological Hazard Map shows those areas where there are active geomorphic processes or that are potentially unstable, as it results from the Geomorphological Map.

FERNANDO X. PEREYRA

Break up of Gondwanaland and long-term landscape evolution of Pampean Plains, Argentina

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Until present there are not studies that relate the geomorphic evolution of Pampean Plains with its tectonic setting. The Pampean Plain has more than 600000 km^2, placed beetween 30 –38 S and 57 –65 W, in central eastern Argentina. It consist basically in a gently rolling landscape resulting from fluvial (large floodplains) and aeolian (loessic) accretion. The region tectonic setting corresponds to a passive margin (lower plate), composed of positive and negative elements. These are related to differential behavior due to the breaking up of Gondwanaland (Atlantic Ocean formation), mainly by reactivation of precambric and paleozoic ages structures. The positive elements are Sierras Australes, wich is a late Paleozoic-Triassic collision orogen, and Sierras Septentrionales, an older system of precambrian-early paleozoic ages. Northeast of the region, in subsoil and outcropping in Uruguay, is the Rio de la Plata Craton, also Precambric. Negative elements are: Salado Basin, an aulacogene (+ 6000 m of subsidence) and Colorado, Macachin, Rosario and Laboulaye intracratonic basins, all of these related to the opening of Atlantic Ocean, developed beetween late Jurassic and middle Tertiary mainly by tectonic subsidence. The development of these basins was partially responsible for the uplifting of neighbouring areas, possibly by upwarping: flexural isostasy because of denudation and subsidence of the basins by deposition added to the effect of domal uplift related to drifting and non uniform extension. These structures experimented some reactivation in upper Cenozoic by Andean Orogeny and the development of the passive margin.
The existence of two remnants of planation surfaces (coinciding with the ranges of Buenos Aires Province), partly eroded and fragmented by late mesozoic-tertiary uplifts is proposed. They resulted from the presence of a cratonic regime, formed by etchplanation, pediplanation and fluvial processes, probably during the Triassic-middle Jurassic lapse. Paleogeographic data show evidence of periods of subtropical climates for this region of Gondwanaland before the opening of the Atlantic Ocean. Planation surface of Australes Range was developed in early-middle Pa-

leozoic sedimentary rocks and was fragmented by cretaceous and tertiary movements. The surface is well preserved at 600-700 m. In the Septentrionales Range the planation surface lays beetween 450-600 m. It was developed mainly on precambric granitic and migmatitic rocks. In this range, different authors recognized deep weathering profiles.
Remnants of a planation surface could be also recognized in neighbouring areas. North, in Uruguay Republic, a fragmented surface ocuppies more of 100000 km^2. It was formed on granitic-migmatitic rocks of precambrian age (Early-late Proterozoic, Río de la Plata Craton). Thick continental cretaceous deposits related to erosion of weathering surfaces could be observed north-west of the planation surface. South of Colorado Basin is North Patagonian Cratonic area; also a remanant of planation surface (at 1000 m) of «gondwanic age» developed in precambrian-paleozoic granitic rocks partly affected by effusion of intraplate tertiary basalts. All these surfaces probably constitute fragments of a poligenetic planation surface developed before the breaking up of Gondwanaland. It is possible that an older planation surface was formed before the continental accretion that lead to the formation of Gondwanaland (post Brasilian cicle?).
Pattern of regional drainage is related to domal uplift, reactivation of early structures, the effect of Andean Orogeny and the basins' development. The integration of the intracratonic basins and Salado aulacogene was an important factor in the design of the drainage, probably following a large scale megacapture model. The Salado aulacogene could be an important foci of continental drainage outlet to a newly opened ocean. Finally, structural control of the Parana, la Plata and minors rivers by faulting and tilting of the Rio de la Plata Craton is streghtened by the design of the drainage. The scheme proposed here allows a new perspective for the interpretation of South American plains geomorphic evolution, related with the passive margin development, and could replaced the «andean» vision.

ANDREAS PETEREK

Studies on the late Neogene to Recent morphotectonic evolution of western Crete

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In the western part of Crete (west of Chania area) the morphostructural features reflect important influence of late Neogene to Recent tectonic activity for the development of the relief. Aspects on the morphotectonic structures has been published earlier by various workers (e.g. Angelier & *alii* 1982, Bonnefont 1971, Armijo & *alii* 1992).
The aim of the presented study is to evaluate the «time-table» of the tectonic activities from morphotectonic criteria. This includes morphotectonic field mapping of fault scarps as well as relief elements which are dislocated by faults (e.g. planation surfaces, river and marine terraces) or controlled by faulting (drainage pattern, alluvial fans). Field mapping is supported by the analyses of aerial photographs and satellite images.
The main fault zones of western Crete dissect the Neogene basins as well as the pre-Neogene «basement areas» that are built up by pre-late Miocene units (Creutzburg & *alii* 1977). Most of these faults already came active during the late Miocene to early Pliocene sedimentation of the Neogene deposits (cf. Frydas & Keupp 1996). Coarse conglomerates within the Neogene strata occur within the vicinity of synsedimentarily active fault scarps. Only slight degradation of the present fault scarps bounding the Neogene basins indicates intense vertical displacements along these faults during Pliocene and Quaternary times. These faults crosscut uplifted pediments and valley terraces developed within the footwall area. In many cases Holocene to sub-Recent reactivation of older fault scarps can be observed.
At the base of the Neogene basin fill, a paleorelief is exhumed showing a pronounced pre-late Miocene topography in the range of some hundred meters. However, identification of this paleorelief is not always clear due to differentially uplifted and downthrown «basement» blocks within the Neogene basins.
The topography in the «basement area» of western Crete is characterized by the step-like arrangement of individual fault-bounded blocks that bear remnants of planation surfaces. In the area central part of the study area an approximately 10 km wide and NNE-SSW trending intramontaneous graben segment has developed.
The western boundary of the Lefka Ori Mts. (2400 m) is represented by a NNE-SSW trending escarpment. Triangle facets and a poorly developed drainage pattern within the range front indicate Pleistocene to Recent fault activity. In the footwall of this fault a separate graben-like basin developed preserving remnants of Neogene sediments (Moni basin).
Quaternary and active faulting characterizes the morphology of the southern and western coastal areas of Crete as it is indicated by well contoured range fronts as well as steep and instable slopes. Most of the primary faults (master faults) are located off-shore. Secondary fault scarps and landslides are very common in the uplifted footwall that is represented by the island. V-shaped and deeply incised valleys indicate rapid uplift.

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Sediment flocculation: an important consideration for sediment transport studies in Fluvial Geomorphology

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Sediment delivery from a watershed involves the processes of erosion, transport and storage. The annual watershed output of the inorganic material measured is considered the sediment yield. Values of basin sediment yield are needed for a range of management purposes including estimates of erosion, reservoir longevity, and nutrient and/or contaminant loadings to receiving water bodies. For many years the movement of sediment within watersheds has incorporated the assumption of single grain transfers for particle sizes ranging from coarse sands right through to silts (< 63μm) and clays (< 2μm). In other words, we have assumed that all inorganic, mineral sediments are moving downstream as individual particles, and as such these finer materials are expected to be transported out of the river and reservoir system very quickly as they are too fine to settle in moving waters. Standard methods of grain size analysis (pipette, hydrometer and sedigraph analysis) require the removal of all organic matter and the dispersal of particles. Following this treatment the sediments are sized. These standard methods result in a biased representation of the size and densities of material which are actually transported in the stream. Using these sizes (and/or densities) for predictions of *in situ* settling will result in underestimates of the amounts stored in the channels or reservoir systems and overestimates of the mean grain size of the stored fine particles.

Inorganic particles in fresh water are known to flocculate, or combine in number with other mineral or organic material to create larger particles. This process increases the effective size of the particle and modifies its density. Both alter it's settling characteristics. In river systems where flocculation occurs, mineral material in the silt and clay size range can deposit in flow conditions which would not allow single grain settling. While most fluvial geomorphologists have observed the presence of fine grained sediments stored in regions with current speeds which should inhibit single grain settling, these observations are often not questioned or considered in sediment transport models. Reservoir age estimates are often wrong, one reason being that these fine sediments which are assumed to move through the system actually settle behind the the dam as flocs and act to fill the reservoir more quickly. The process of flocculation is enhancing settling within these fluvial systems - but our field and laboratory measurements do not consider this process.

By presenting data from the sizing of natural riverine sediments and results from settling experiments in a variety of Canadian rivers we would like to emphasize the significance of the flocculation process in fluvial geomorphology. The grain sizes of laboratory measured particles cannot be assumed to correctly reflect in stream processes yet these are the data that are most commonly used to estimate transport and storage processes in river basins.

JEAN-PIERRE PEULVAST

Late and Post-Orogenic evolution of large orogens and the problem of planation: a review

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The ancient orogens that form the structures of large parts of the continents are mostly bevelled by planation surfaces more or less covered by sediments. The largest of these surfaces are found on Precambrian shields but well planated surfaces are also represented in Palaeozoic to Cenozoic orogens as well (Europe, Mediterranean Basin, Eastern United States and Canada...). Some of them are disposed as large simple surfaces with residual reliefs. Systems of polygenetic or stepped surfaces are found in regions where the basement was ultimately deformed in relation with post-orogenic rifting or continental breaking up (rift shoulders, passive margins). Though these surfaces have been recognized and extensively studied for a long time, their origin and the mechanisms by which high mountains are finally planated are still under debate. A comparative study of several orogens of Palaeozoic to Cenozoic ages, inactive or still active, suggests the combinate influences of tectonic and erosive factors.

The formation of large planation surfaces implies conditions of equilibrium or positive balance between erosion and vertical movements. Whatever the mechanisms involved in this process may be, peneplanation, pediplanation, etchplanation..., more or less complete planation can be obtained 10 to 30 Ma after the end of orogeny, as shown by unconformities along the Scandinavian Caledonides or in the Variscan orogen. Mechanisms corresponding to tropical, arid, semi-arid or marine conditions or to conditions without present analogue, are often considered as the most efficient, but their effects are better understood in cases where preliminary breaking up and lowering of the relief could occur. As shown by several examples, such a reduction of relief is probably related to late orogenic evolution characterized by strong faulting and high rates of erosion. A Basin and Range type of landscape evolved in parts of the Variscan orogen before its final planation and burying. Elements of a somewhat similar evolution are described in parts of the Appalachian orogen of Canada where sub-Carboniferous landforms comprised fault scarps and residual reliefs of reduced height finally planated or buried below thick conglomerates brought by local and longitudinal streams.

More recent orogens like the Mediterranean ranges in the Aegean region and in Italy show the strong influence of extension, doming and faulting related to gravitational spreading and crustal thinning following major stages of crustal shortening and thrusting. As the process of plate convergence is still active, the development of pediments and planation surfaces was more or less hampered by vertical mo-

vements during Neogene and Quaternary. Nevertheless, breaking up of previous mountain ranges, high mobility and high rates of vertical movements and erosion in small units may illustrate some of the conditions that prevailed during some of the late stages of older orogenies before the end of convergence, planation and possible burying.
A review of the post-orogenic history of the Appalachians and of the Variscan area of Europe allows the identification of some factors that can explain this evolution :
– influence of the development of orogens - mainly collision orogens - on the morphoclimatic conditions,
– reduction and breaking up of large mountain volumes by gravitational spreading and surficial faulting on wide areas,
– distribution of previous zones of crustal thickening and corresponding weakening of the lower crust, where gravitational spreading had its most important effects during late orogenic stages,
– influence of these structures on the post-orogenic history and epeirogenic movements, distribution of zones of ultimate continenatal breaking up (ex.: opening of the Atlantic Ocean) and related development of simple or complex erosional landforms,
– influence of structural and lithological patterns of the previous orogens on the development of more or less achieved planation surfaces,
– relationships between tectonic styles of late and post-orogenic stages and the rates and processes of planation.
Taking in account these factors may also help understanding the distribution of late and post-orogenic sediments and many morphological features of present platform areas.

LEONARDO PICCINI

Evolution of karts caves in the Alpi Apuane (Italy): rapports with the morphotectonic history

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Karst systems act as high resolution recorders of morphotectonic and environmental changes. The main problem is to distinguish the effects of climatic changes from the effects of morphotectonic events. Currently the climatic factors have a strong effect on epikarst, while their effects on hypogean karst are low; for this reason the pattern of a karst complex reflects more the morphotectonic history of the landscape than the climatic changes; climatic factors occur more in the sedimentary fills and in speleothemes grow.
The Alpi Apuane are one of the most important and better studied karst area in Italy. About one thousand caves are known, including the deepest and the longest cave of Italy: the Abisso P. Roversi (1250 m deep) and the M. Corchia karst complex (about 60 km long, and 1190 m deep) respectively. The study of karst caves systems has allowed to put forward a model of their evolution in time and space; this model gives an important contribution to the understanding of the plio-quaternary morphotectonic history of this side of Apennines. The results of the research can be summarised in the following way.
The Apuane karst show a multi-phase history beginning with the denudation of metamorphic complex and the outcropping of carbonate formations (marble and dolomite). The development of caves first began in the south-western side widening progressively out to NE; this is a consequence of the structural setting and of the migration from SW towards NE of the collapsing tectonic of post-orogenic basins.
The spatial and morpho-genetic analysis of caves systems and relict-caves suggests the existence of three main development phases of deep karst. These different phases can be related to landforms such as plane surfaces and horizontal ridges.
The oldest karst caves formed in a landscape very different from the present-day one; in fact the presence of phreatic passages at more than 1500 m a.s.l. needs an hydrologic base level 1000 m higher than now. The presence of non-metamorphic sandstone pebbles in the upper passages of Corchia Complex suggests these phreatic tubes, and the other relict-caves, formed when the Apuane were a low-relief area, bounded on N and E by highlands of non-metamorphic rocks. Such landscape probably occurred during the Upper Pliocene, before or at the beginning of the collapse of the of Serchio and Magra tectonic basins.
The second, and more important, phase of karst gave origin to most of the phreatic caves, which are now located between 1200 and 1000 m of elevation. The caves of this phase are well related with old planation surfaces; these planes are probably remnants of a mature topography which developed during an early Quaternary phase of tectonic quiescence. During this time a closed basin of some tens of km^2 drained allogenic waters towards the Corchia karst system, allowing the development of large conduit-levels in it. In the north-eastern side of Apuane the carbonate rocks of metamorphic core complex were still covered from formation of other tectonic units.
The third phase of karst evolution is responsible of the formation of the phreatic tubes level now positioned between 700 and 600 m a.s.l.. This phase acted during Late Pleistocene, when Apuane had a morphological setting not very different from the present-day one. In the NE flank, towards Serchio valley (Garfagnana), this karst level is still active. On the contrary, in the seaward side the Late Pleistocene-Holocene regional uplift of Apennines caused the deepening of streams and the lowering of karst base level; new karst springs are located at 300 m of elevation and karst systems are now progressively rearranging their setting to the new hydrologic conditions.

HERVÉ PIÉGAY[1], G. BORNETTE[2], P. GRANTE[1] & A. LAPLACE-DOLONDE[1]

La dynamique de comblement des bras morts d'un système fluvial anthropisé, le cas de la rivière d'Ain, France

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Les zones humides, de plus en plus menacées par les activités humaines, recèlent cependant un fort potentiel écologique. C'est pourquoi, les gestionnaires souhaitent aujourd'hui restaurer certains de ces espaces, notamment les bras morts des zones périfluviales. Néanmoins, peut-on, et si oui comment, restaurer les bras morts qui ont atteint un fort degré de comblement? Quels sont ceux pour lesquels une restauration durable peut réussir compte tenu de leur durée de vie potentielle c'est-à-dire de la vitesse du comblement et des successions écologiques?
Le cas de 11 bras morts de l'Ain, âgés de 17 à plus de 100 ans et inégalement soumis à des impacts anthropiques, est ainsi étudié. L'objectif est de mieux comprendre les processus d'atterrissement, leur variation spatio-temporelle en fonction du degré de connexion existant entre le chenal principal et les bras mort afin de sélectionner ceux sur lesquels une restauration durable de la zone humide est possible.
Des variables morphométriques mesurées sur des documents photographiques et cartographiques de différentes dates et des indicateurs morpho-sédimentaires et pédologiques collectés sur le terrain ont fait l'objet d'analyses statistiques qui permettent d'individualiser des groupes de bras morts selon leurs dynamiques évolutives.
La vitesse de progression du bouchon alluvial varie ainsi de 1 à 19 cm/an, les valeurs les plus importantes étant observées dans les bras morts les plus anciens, seuls témoins d'une période de plus grande activité morphodynamique. La taille du bouchon alluvial dépend non seulement de l'âge du bras mais également de l'angle existant entre l'axe fluvial et l'axe du bras mort. La structure morphosédimentaire du bouchon diffère selon que le bras i) est issu d'un style en tresses ou à méandres, ii) se situe dans un secteur en exhaussement ou en incision.

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Late-Holocene emergence in Calabria, Italy

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A field survey along the coasts of Calabria has found little evidence of Holocene emergence, the greatest being no more than 1.0-1.5 m in elevation. A former shoreline (a thick crust of calcareous algae in growth position at about +0.6 m, capping an elevated beachrock slab) was dated 2900±60 yr B.P.
This emergence is recent, if compared to the time of the Climatic Optimum, and relatively slight, if Late Pleistocene uplift rates, which in some areas exceed 1 mm/yr, are considered. This apparent discrepancy can be explained by taking into account glacio- and hydro-isostatic effects of the last glaciation, which have produced subsidence at decreasing rates during the Late Holocene in a wide area around the former Scandinavian ice sheet which includes most of the Mediterranean.
According to the isostatic model by Lambeck & Johnston (1995), the average subsidence rate during the last 6000 years was of the order of 1 mm/yr near the coasts of Calabria. It is only when the subsidence rate of glacial origin became slower than the local uplift that emergence at a slower rate than that of the tectonic uplift trend could have begun. Such emergence is therefore a recent phenomenon, in the Holocene, and its rate is still much slower that that of tectonic uplift predominating in Calabria over a longer time scale.

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The plough as a geomorphic agent: intensities and consequences of tillage erosion in Mediterranean environments

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Field observations in intensively cultivated areas of southern Europe reveal that topographic curvature controls to a large extent the spatial patterns of rock fragment cover and of leptosols. It was hypothesised that this pattern can be explained by significant soil losses caused by tillage erosion. Therefore, a study was set up with the following objectives: 1) to quantify tillage erosion rates, and, 2) to investigate the implications of high tillage erosion intensities on Mediterranean landscapes.
Field experiments were conducted in the Guadalentin basin, southeast Spain, in order to assess rates of soil movement caused by tillage erosion. The displacement distances of rock fragments by tillage with a duckfoot chisel were measured by monitoring the displacement of tracers (painted rock fragments and aluminium cubes) on 5 sites having different slopes. The rate of tillage erosion for one tillage

pass with a duckfoot chisel, expressed by the diffusion constant (k), equals 282 kg/m for up and downslope tillage and only 139kg/m for contour tillage. Nomograms indicate that mean denudation rates in almond groves due to tillage erosion (3 to 5 tillage passes per year) can easily amount to 1.5 - 2.6 mm/year for contour tillage and up to 3.6 - 5.9 mm/year for up- and downslope tillage for a field, 50 m long and having a slope of 20%. These figures are at least one order of magnitude larger than reported denudation rates caused by water erosion in similar environments. Hence tillage erosion contributes significantly to land degradation. The downslope soil flux induced by tillage not only causes considerable denudation on topographic convexities (hill tops and spurs) and upper field boundaries but also an important sediment accumulation in topographic concavities (hollows and valley bottoms) and at lower field boundaries. Kinetic sieving (i.e. the upward migration of rock fragments) by the tines of the duckfoot chisel also concentrates the largest rock fragments in the topsoil in such a way that a rock fragment mulch develops in narrow valleys and at the foot of the slopes.
These results clearly indicate that tillage erosion is the main process responsible for the observed rock fragment cover pattern in the study area. Since the study area is representative for many parts of the Mediterranean where almond groves have expanded since 1970, the results have a wider application. They show to what extent intensive tillage of steep slopes has contributed to the increase in soil degradation, to changes in hillslope morphology (i.e. strong denudation of convexities, development of lynchets and rapid infilling of narrow valley bottoms) and to the development of patterns of leptosols and of rock fragment cover which control the spatial variability of the hydrological and water erosion response within such landscapes.

NATALIA PONIATOVSKAIA

L'annalyse géomorphologique de l'aire urbaine de Moscou

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L'aire urbaine de Moscou, comme toute autre partie de la surface terrestre, occupe une certaine position géographique, presente certaines caracteristique du relief et une somme de processus géomorphologiques. À cause du fort impact d'un complexe de facteurs téchno-génétiques, elle devient un facteur essentièl qui produit un éffet apréciable sur l'atmosphère, hidrosphère, biosphère et lithosphère, effêt qui dépasse beaucoup les dimensions de la ville proprement-dite.
En coéxistant sous les mêmes conditions climatique et structural-tectoniques, les composants naturels et techno-génétiques se développent en etroit contact, entre eux existant des interrélations et des interactions variées:
– des relations naturelles, historiques, génétiques et dynamiques entre les éléments du milieu géologique-géographique;
– échange hydrodynamique entre les éléments naturels et les composants techno-génétiques, qui implique les précipitations, les eaux de surface et souterrains et les acumulations liquides. Dans la ville l'échange de l'eau functionne en même temps par des voies naturelles (précipitations-drainage) et par des instalations hydrotechniques (conduits, systèmes de collection et drainage etc.);
– «engineer» relations, comme l'écoullement hydrodynamique dirigé par constructions hydrotechniques, et en plus, des relations entre topographie, hidrosphère, atmosphère et differentes installations d'ingénièrie.
Tous ces relations entre les élèments naturels et techno-génétiques du milieu urbain peuvent être en caractère direct ou inverse, les objets naturels étant plutôt passifs, en temps que ceux techno-génétiques-plutôt actifs.

MARION B. POTSCHIN & HARTMUT LESER

Geomorphological processes and sediments modifying geoecological conditions in the High Arctic (Northwest-Spitsbergen)

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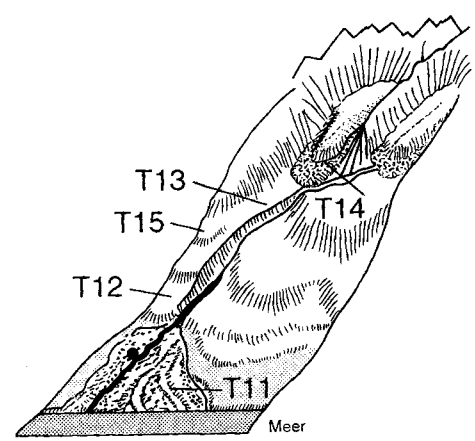
The investigated (approx.) 5 km^2 drainage basin (compare figure) was located on the south shore of the Liefdefjorden at almost 80°N (13°E) and is partly glacierised (approx. 35%). Because of the influence of the gulfstream, the climate has to be characterised, despite the high latitude, as mild.
Field studies were conducted to examine the environmental factors which influence or control water amount and soil water chemistry in the high arctic tundra. Specially, theses studies focussed on variations in solute chemistry during the high arctic seasons. For this purpose five princi-



ple monitoring sites (tesserae) and 12 additional test sites were set up throuout the draianage basin. The here important characteristics of the tesserae are given in the table below.
Although the landscape of the catchment looks very homogeneous on the first look, the test sites show major differerences in their ecological behaviour, as well in static as dynamic (seasonal) termes. Therefore, the topic of this paper is to demonstrate the influence of structure variables, like relief, substrate, soil moisture, vegetation, surface flow and interflow, on the modification of geoecological conditions in the high arctic tundra.
The amount and chemistry of soil water from the test sites vary heavily from each other. This is not only depending on the structure variables themselves, but also on the dimension under investigation. One geoecological varibale can vary within a reach of a few centimeters, but shows similar results for a larger area.

test sites	T11	T12	T15	T13	T14
[m] a.s.l.	8	50	85	145	355
relief	convex/concave little snow valley	smoderate convex water channel	shigh flatland areas (low inclined)	melt water channel	on top of an end moraine
microrelief	mudpits covered	mudpits	solifluction lobes	Mudpits, solifluction terrasses	
periglacial soil pattern	with lichen tundra and Taimyr-polygones	no/minor periglacial soil movements		small polygone pattern	
substrat (genetic)	marine sediments	lodgement till	lodgement till	till (many clasts)	clasts
soil type (FAO)	Gelic Cambisol	Gelic Cambisol (poorly developed)	Gelic Regosol		Gelic Leptosol –
soil depth. [cm]	60/70	25/30	110	30/40	no soil existing
max. depth of	141 / 25.7.90	162 / 25.7.90	140 / 16.8.90	147 / 07.8.90	
active layer [cm] /	109 / 11.7.91	131 / 18.7.91	131 / 10.8.91	129 / 10.8.91	–
date of year	111 / 05.8.92	114 / 05.8.92	132 / 05.8.92	145 / 05.8.92	
soil tension	dry	wet (all summer)	wet (all summer)	dried up heavily	
Ø [cm WS]	262	134	70	373	–
maximal [cm WS]	588	303	144	893	
vegetation (cover)	covers the whole area	small pattern of *Dryas octopetala* and areas without vegetation	moos tundra cover is almost 100 %	moos tundra cover < 50 %	lichen in little patches
humus layer	thick layer	moderate	thin layer	mineral test site	—

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Dynamics of bedload movement at high transport stage in dryland streams

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The literature on gravel-bed rivers is dominated by studies of channels with a perennial flow regime, low rates of sediment supply and a quasi-equilibrium channel form. Although such channels flow all year, bedload transport is commonly confined to a few days. Marginal transport conditions dominate because shear stresses greater than two to three times the threshold value are very rare. As a result, our understanding of gravel-bed river dynamics is largely restricted to conditions typified by low transport stages.
Floods that generate high transport stages have the potential to do large amounts of geomorphic work resulting in significant changes to channel morphology. Despite their importance, the extent to which the dynamics of sediment transport at high transport stages can be understood by simply extrapolating from marginal transport conditions is completely uncertain, largely because of the lack of field studies undertaken in coarse grained alluvial channels at high flows.
In this paper, we describe the nature of bedload transport at high transport stages using data obtained as part of a wider investigation into the sediment transport dynamics of dryland ephemeral streams. The analysis concentrates on synchronous measurements of bedload discharge obtained at a number of locations across the widths of the two streams during flash floods in which shear stresses reach eight times the estimated critical values needed for bedload movement. Particular attention is paid to the nature of the bedload-shear stress response and the temporal and spatial variability in transport rate.

ENZO PRANZINI

Cuspate delta evolution and related river course

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Cuspate delta growth and erosion make the beach to assume different shapes, which, in turn, induce wave approaching the shore to refract in different ways. If dominant wave crest is oblique to the shoreline, the cusp progradation can lead to the reversal of the net longshore drift on the exposed side, whereas on the lee side the energy of the wave approaching the beach is progressively reduced.
When river sediment load is negligible, with respect to longshore transport rate, a flat cusp is formed, the original longshore transport direction and rate are preserved, and river mouth migrates forced by the dominant wave (left figure).
Increasing river sediment load allows a more prominent cusp to grow, where wave energy changes from point to point because of the different exposition of the coast. The delta apex is strongly hit by waves, whereas on the lee side wave energy is more dispersed. On the exposed side, the longshore transport rate is gradually reduced until the shoreline is parallel to the wave front; further progradation induces a net longshore transport reversal (central figure).
Sediments reaching the river mouth are more efficiently carried off on the exposed side of the delta than on the lee side, where higher deposition rate occurs because of lower energy per shore unit. This asymmetric sedimentation makes the river to bend and face directly the dominant wa-

ve (central figure). Feed-back processes guarantee the stability of the new river direction, if sediment load is maintained.
During the erosion phase the cusp never assumes the same shape exhibited during the progradation phase (i.e. beach ridges and foredunes are beheaded and not exfoliated!), but a progressive return to the original direction of the longshore currents on the exposed side occurs (right figure). Sediments originally deposited on this side are eroded and, possibly, deposited on the other side.

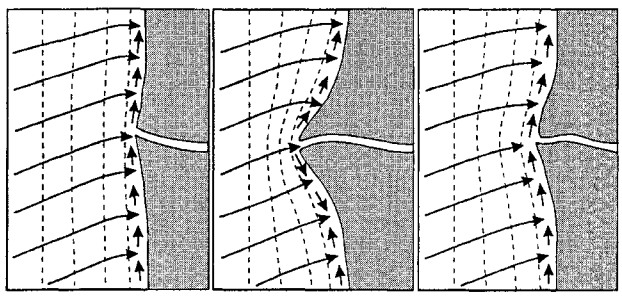

Fig. 1 - Longshore current directions and river course evolution during the growth and the erosion of a cuspate delta.

This cuspate delta evolution theory is the result of an «immediate inference» based only on shoaling processes' observation. Field validations have been searched in the morphology of two central Italy cuspate deltas.
Flowing through its delta, the Ombrone River turns from WSW to SSW. The original direction appears to be the consequence of the pressure of SSW waves approaching a NW oriented beach. This direction was maintained until the cusp grew slowly. During the upper part of the Middle Ages and in the Renaissance, woodland clearance induced a huge increase in river sediment load and the build up of an increasingly prominent delta. In the XVI-XVII century the river course reached the SSW alignment, and maintained it during a fast progradation phase ended in the mid-800's, when the present erosion stage began.
Variations in longshore sediment transport rates, caused by the delta erosion, were retrieved through a numerical model in which present wave climate was applied to 1883 and to 1977 delta morphology. Today a spit is connected to the southern lobe, crosses the river mouth and extends for approximately one kilometre northwards. A net longshore transport reversal probably occurred on the left side of this delta after 1977 because of an erosion rate of approximately 10 meters per year.
The Arno River delta underwent a similar evolution, and the Republic of Pisa, in 1606, had to divert the final river course towards West to facilitate water discharge during severe storms. Unaware, the Pisans had to face problems related to river migration towards the dominant wave direction!

ALBERTO PRESTININZI & GABRIELE SCARASCIA MUGNOZZA

Landslide hazard assessment: application of a new methodology

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Multivariate models are among the most used in landslide hazard studies. They are based on the isolation of most significant factors by the method of discriminant function, and on multiple regression line explaining relationship between the analyzed variables. These models have been applied with reliable results in small scale mapping, but their application to large scale mapping is not a simple matter. Indeed, land-use planning, aimed at specific risk zonation at scale 1:10,000-1:25,000, require probabilistic analysis based on quantitative geomorphological data, like type of movement and landslide morphology.
The present paper deals with the application of a computer-processed linear, logistic model for determining landslide occurrence probability. Interaction of active morphological processes and geological, climatic and anthropic factors determines the current state of the slope that can be successively described in the model by means of variables relative to landforms and processes identified in the field through detailed, applied geomorphological investigations. Such a model has been applied to areas surounding some villages in Southern Italy. Comparison between landslide map based on field surveys and distribution of the computed landslide probability shows the effectiveness of the studied model in the studied area. The methodology is currently being tested in different geological and geomorphological settings, in order to better improve its validity.

NICHOLAS J. PRESTON

Event-induced changes in landsurface condition - implications for subsequent slope stability

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Landslide episodes in the New Zealand hill country involve processes of displacement, evacuation, transport and redeposition of material throughout a catchment. Crozier (1996) considers that the response to these processes includes mechanisms described as regolith stripping, depositional loading and depositional hardening. These mechanisms have geomechanical implications and are thought to influence terrain resistance and subsequent erosional behaviour, thus affecting the inherent susceptibility of catchments to future landsliding.
This paper describes a change over time in overall catchment susceptibility to landsliding - specifically as a result of a series of large rainstorm-triggered landslide events on

the east coast of New Zealand's North Island. The response to these events is detectable as a change in the state of the landsurface. The contemporary landsurface condition of a unit area is both a product of the erosional processes that have already occurred, and a control on the susceptibility of that area to subsequent erosion. This is because the contemporary landsurface condition is an expression of the various slope and material parameters that determine strength and stress relationships, and hence susceptibility to landsliding. Change in landsurface condition of a given area is paralleled by a change in stress/strength parameters, and hence in the inherent stability of that area. Change in susceptibility is thus a reflection of change in the contemporary landsurface condition of a given area.

The Contemporary Landsurface Condition of the landscape can be classified with respect to the erosional and depositional processes pertinent to translational regolith slides and flows. Eight classes of Contemporary Landsurface Condition are recognised. These include surfaces defined as: «Undisturbed», «Old Landslide Scars», «Colluvial», «Alluvial», «New Landslide Scars» and three distinct classes of «Recent Landslide Debris» distinguished by their occurrence on either Undisturbed, Colluvial or Old Scar surfaces. These classes are characterised on the basis of geomechanical properties, such as regolith depth and material densities.

Using aerial photography, the distribution of Contemporary Landsurface Condition classes within the catchment of Lake Waikopiro in northern Hawke's Bay has been mapped for two historical occasions, covering a 23-year period in which at least five large landslide-triggering events occurred. Comparison of these maps shows the change in distribution of Contemporary Landsurface Condition classes, reflecting the migration of areas of susceptibility over time, and suggesting that the mechanisms described by Crozier (1996) are indeed operating.

Given that landsurface condition is a reflection of material properties that control stability, any change in distribution of Contemporary Landsurface Condition classes shows at least a change in the likely location and distribution of future landsliding. Further, change in relative frequencies of Contemporary Landsurface Condition classes indicates that susceptibility to landsliding for the catchment as a whole is changing. Inherent susceptibility to failure of discrete slope units has been modeled within a Gis on the basis of geomechanical properties associated with the different Contemporary Landsurface Condition units. Change in slope stability over time as a function of ongoing erosional activity is thus demonstrated.

DAVID M. PRICE

Thermoluminescence: chronology, provenance and site disturbance

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Thermoluminescence (TL) is generally well accepted as a means of establishing the depositional age of sediments which have been transported by wind or water. Less well known is the practise of determining the possible difference in provenance of sedimentary units which derive from differing source locations. Such evidence can provide valuable clues of changes in palaeo-wind directions or changes in river courses. Examination of the TL spectrum may also reveal evidence of site disturbance since the time of the last depositional phase such as may take place when a sediment has undergone bioturbation. This latter property may also be used as an indicator of tsunami activity where a coastal sediment has been deposited with little exposure to sunlight.

TL dating is dependent upon the stable storage of trapped electrons at lattice imperfection sites. These are created by minute amounts of ingrown impurities within the crystalline lattice and are implaced at the time of crystal formation. The ingrown impurities are therefore characteristic of the formation conditions and provenance of the sediment and give rise to characteristic TL peaks as the crystalline grains are heated to high temperatures. The TL spectrum exhibited is thus characteristic of the impurities present and the provenance of the sediment. Differences in characteristic spectra as exhibited by quartz grains separated from different units within a single sedimentary profile may therefore indicate different origin and past change in prevailing wind or river flow conditions. Similar formation conditions will however give rise to similar TL spectra prohibiting the use of this technique as a method of the identification of a change in sediment source.

A considerable solar exposure is required to reset the TL signal during the sediment transport phase. Upon deposition the TL signal begins to accumulate at a rate which is dependent upon the radiation flux derived from trace amounts of the long-lived isotopes of uranium, thorium and potassium present within the sediment itself. The lifetime expectation of an electron trapped in the deeper energy levels associated with quartz grains, which are often utilised for chronological determinations of sedimentary systems, is something like 1000 million years. At the lower energy electron trap levels the lifetime of an electron may be as brief as 10 hours at ambient temperatures. Heating the quartz grains separated from a sediment provides sufficient energy to increase the probabilty that electrons stored at deeper levels are released and return to their ground state. In doing so their excess energy is released in the form of light giving rise to a characteristic TL spectrum. Such energy releases occur as the quartz sample is heated through temperatures of 325°C and 375°C. The first of these, although quite stable, is much more easily reset upon re-exposure whilst the second requires a longer solar exposure for the resetting process to take place. Thus a comparison of the natural TL spectrum exhibited by quartz grains removed from a sediment with that displayed by similar grains which have been recently irradiated in the laboratory can provide evidence of re-exposure of the sediment since the time of deposition. An indication of incomplete resetting of the previously acquired TL signal prior to deposition such as that which can occur during a tsunami event may also be evident.

ANGÉLIQUE PRICK

Etude expérimentale de la gélivité des calcaires et intérêt de la détermination du degré de saturation critique

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La cryoclastie est un processus important en milieu périglaciaire. Les travaux expérimentaux les plus récents ont précisé l'importance, dans les études sur la gélivité des matériaux, de la simulation des conditions de température et d'humidité comparables à celles rencontrées dans la nature. La dilatométrie est la technique employée; elle permet de déceler les processus altérants prennant place dans l'échantillon avant qu'une altération ne soit visible à l'oeil nu. Les courbes dilatométriques obtenues lors du gel d'échantillons humides de calcaires français d'âge secondaire permettent de différencier la dilatation volumique de la roche liée à la transformation de l'eau en glace, et la cryosuccion, qui est à l'origine de migrations d'eau non gelée vers les cristaux de glace déjà formés. Ce n'est que quand les échantillons sont proches de la saturation et soumis à des gels relativement rapides qu'une dilatation globale est observée. Pour des échantillons relativement éloignés de la saturation, le volume peut diminuer lors du gel. Donc, l'altération liée au gel en milieu froid ne serait à attribuer que dans une minorité des cas à la formation de cristaux de glace et aux pressions qui en résultent sur les parois des pores. Comme d'autres auteurs l'ont déjà suggéré, une altération par humidification et séchage pourrait être un processus beaucoup plus efficace.
Les facteurs principaux influençant la réponse dilatométrique au gel sont le degré de saturation de la roche, la lithologie des échantillons (et tout particulièrement la porosimétrie) et la vitesse de refroidissement. En mesurant le module dynamique de Young d'échantillons de ces mêmes calcaires avant et après qu'ils aient été soumis au gel, on peut définir pour chaque matériau un degré de saturation critique au-delà duquel le gel causera des dommages. Ce degré de saturation critique dépend des caractéristiques des roches, et notamment de leur porosité piégée. Allié aux caractéristiques porosimétriques des échantillons, ce paramètre permet d'expliquer les divers comportements dilatométriques observés.

MARIA THEREZA PROST

Modifications de courte durée et de forte intensité de la ligne du rivage de la Guyane Française analisées par télédétection

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La Guyane française fait partie de l'ensemble des côtes basses et argileuses du nord du continent sud-américain, couvertes par la mangrove de front de mer et occupées par de vastes espaces paraliques subcôtiers, et dont l'évolution récente et actuelle est liée à l'impact du Système de Dispersion de l'Amazone. Ce grand fleuve a une décharge estimée entre 1.3 à 1.6 m^3/s (~18% de la totalité de l'eau douce apportée a l'océan mondial) e une décharge sedimentaire de ~11 à 13 x 10^8 tonnes/an. Environ 10 a 20% des sediments fins en suspension sont transportés par les courants maritimes de surface au long des côtes des Guyanes: une partie circule au large, sous l'action du Courant des Guyanes; une autre partie est «poussée» vers la côte par la houle et les alisés, donnant naissance à une dynamique originale, traduite par l'alternance - dans l'espace et dans le temps - de secteurs occupés par des bancs de vase (où se produit une progradation de la ligne du rivage et dévéloppement rapide de la mangrove) e de espaces interbancs (où l'érosion est active, avec déperissement de la mangrove et recul du trait de côte). Les vitesses moyennes de progradation et de recul, très importantes, mesurées par télédetection passive et active, sont de l'ordre de 200 m/an. La télédétection a également permis de calculer la vitesse moyenne de migration des bancs et des espaces interbancs vers le NW, de l'ordre d'un km/an. Ces processus, de courte durée et de forte intensité, sont a l'origine de modifications saissisantes de la ligne du rivage.

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Dimensional analyses of coastal foredune changes

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Existing models of coastal foredune change are largely based on two-dimensional changes (Vellinga, 1982; Kriebel & Dean, 1985). Some of the two-dimensional models are applied in conjunction with storm characteristics to relate dune erosion to storm recurrence interval (Larson & Kraus, 1989; Scheffner, 1989). Whereas the models generally predicted uniform erosion and a linear retreat of the dune line (Birkmeier & *alii*, 1987), alongshore variations in storm-related dune erosion have been demonstrated to occur in response to high frequency events (Psuty, 1992; Sherman & *alii*, 1992). This issue is recognized by proponents of the two-dimensional approach, but the variability has not been accommodated because of the complexity of the problem.
This study is an inquiry into the alongshore variability of coastal dune response to high frequency events. It is important to document the changes and variations in the changes associated with higher frequency storms because these

events have an immediate direct impact on the dunes, establish antecedent conditions for subsequent storms, and usually are influenced by the local beach and nearshore morphology and by human modifications of the system.
Five sites within the state of New Jersey have been selected to monitor the dune changes. Nine topographic surveys of 0.5 km long shoreline segments have been conducted between October, 1994 and September, 1996. Computer-generated terrain models of the study sites have been produced. The initial survey models form a basis for determining changes in dune form and dune volume. Repeated post-storm surveys are used to relate volumetric changes to storms of different magnitudes. In addition, the models facilitate the analysis of alongshore variations in dune recession resulting from the storms by the generation of cross-sectional profiles of the dune system at any desired interval. The pre- and post-storm cross-sectional areas are compared to determine the foredune changes and the alongshore pattern of erosion and accretion.
An examination of three of the study sites provides a comparison between a natural control site and two examples of developed sites. One comparison involves a measurement of cross-sectional foredune area, derived from transects spaced at 15m intervals, to characterize alongshore and intersite variation. Between October 1994 and September 1996, the cross-sectional area data show a variation of net change from -8m^2 to +9 m^2 within the natural area, and from –10 m^2 to +16 m^2 and from –8 m^2 to +4 m^2 within the developed areas The cross-sectional data set also records the effects of a 5-year recurrence interval storm in January, 1996. In the natural site, the storm-related dune change varied between –12 m^2 and +7 m^2. Within one developed site, the change in cross-sectional area varied from -15 m^2 to +5 m^2, whereas in the other developed site the variation was from –12 m^2 to +3 m^2.
The study demonstrates that with single events, there are areas of dune accretion as well as erosion within short segments of the shoreline. These variations establish antecedent conditions for future modification of the dune system. In the developed areas, some of the alongshore variation of dune change associated with the high frequency storm events is related to beach structures and human manipulation of the dunes.

PIER PAOLO PUTZOLU

Morphotectonic features of the high Garfagnana and south-eastern Lunigiana (Nothern Appenines) with the contribution of quantitative geomorphic analysis

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The two graben of the Lunigiana and Garfagnana represent a sector of the northern Appenines which is of particular sismogenetic interest and the study area corresponds to the tectonics displacement that separates the two depressions. The geological-structural picture is characterized by a complex exstensional structure of post-Miocene deformation which affects pre-existing compressive structure of the fold-thrust belt. Outcrops of many formations belonging to four different tectonic units («Autoctono Apuano», Tuscan Unit, Canetolo Unit, Ottone-S.Stefano Unit) and other Quaternary continental deposits, produces a considerable lithological variability and a consequently varied morphostructural answer in many sector of area.
This morphotectonic research used both detailed traditional geomorphological surveying and some techniques of quantitative geomorphic analysis, together with comparison between the data collected with these two techniques and field measurements of more than 1000 orientations of joints of the competent rock tipes.
In particular the quantitative geomorphic analysis was aimed at a greater understanding of the morphologic and morphodynamic features of the relief and the relation between these and the drainage network. The maps produced in a first phase were :a drainage network map, a map of relief amplitude and a drainage density map. An analysis was then carried out of the geometrical arrangement and organization of the drainage networks of the partial basins with a calculation of morphometric parameters. Finally, there was a quantitative identification of preferential stream channel directions with statistical analysis of azimuthal distribution of the fluvial segments.
Comparison between the data of the geomorphological surveying, quantitative geomorphic analysis and the joint measurements identified some morhological elements which seems to be conditioned by tectonic directions. The main morphotectonic lineaments in the south-eastern Lunigiana have dominant directions of E-W, ESE-WNW, NE-SW and approximately N-S, whereas directions of the high Garfagnana are NNE-SSW, ESE-WNW e NNW-SSE. Analysis of azimuthal distribution of the fluvial segments for each order showed in the segments of the lower order (I° and II°), associated with probable more recent deformations, a clear prevailing direction of E-W and subordinately a direction close to N-S. In the higher orders in the Garfagnana there is a prevailing NNW-SSE direction of the axis of the river Serchio graben and in south-eatern Lunigiana a NE-SW direction of the transversal elements of the axis of the river Magra graben. The values of the morphometric parameters of the drainage network show a high degree of disorganization an disequilibrium in most of partial basins. However, there is a prevalence of capture phenomena of the drainage network and of linear erosive processes on both the Apuan massif and on the Lunigiana sector of the study area.

MOHAMED QARRO & MOHAMED OUAHID

Effect of anthropic actions on quantitative vegetation dynamics of Bouhsoussen forest in central Plateau (Morocco)

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The vegetation dynamics study of Bouhsoussen forest is Studied on area of 32,236 ha. The data obtained from planimetring of stand types of two maps according to two references dates, 1963 and 1991 allowed to quantity cover trend. The quantitative approach is based on comparing the area of two vegetation maps (1963 and 1991). This analysis considered two parameters: cover rate and vegetation type (dominant species).
The regressive evolution of vegetation types is due to the high anthropic pressure expressed by cattle overgrazing, wood ouvercutting for domestic needs and vegetation clearing for shifting cultivation.
The anthropisation phenomenon is increased by severe climatic conditions characterised with a long dry period (up to 6.5 dry month/year) and by impact of frequent successive dry periods (2 to 3 year). This impact depends on vegetation type and development, animal carrying capacity and usage right offered to riparians. The overuse of vegetation resources encouraged by low fees paid for violations.
The relationship between reduction stand area, anthropic and environmental parameters, analysed by multiple and stepwise regression, showed that the two important factors of degradation are overgrazing and vegetation clearing.

PERIKLI QIRIAZI & SKËNELER SALA

Les mouvements de terrain en Albanie et rôl de l'homme

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L'extension des mouvements de terrain est de très élevée en Albanie. Elle correspond à un ensemble de conditions très favorables: fréquence des roches a cohésion limitée (facie argilomarneux) jusque au 58% du pays et tectonisation intense des structures à differents régimes de mouvements néotectoniques; relief sourtout collinéen-montagneux (80% du pays) caracterisé par des hautes valeurs de fragmentation et des fortes pentes des versants; grande quantite de precipitation (la moyenne 1480 mm/an et son maximum 3100 mm/an) et régime très irrégulier etc. Cetté grande extension est stimulée par la activité humaine laquelle était sur tout brutale durant la période communiste: 2800 ha de forêts sur les versants étaient transformées en terre cultivable (sourtout en céréales); la négation est endommagée à cause d'exploitation intensive par les hommes et pour ses bêtes etc. L'essai typologiques met en relief le caractére, varie et composite des movements de terrain qui associent les glissements coulées ou écroulements et inmpliquement substratum et depôts superficiels.

JOSÉ PEREIRA DE QUEIROZ NETO

Les rapports sols et reliefs dans les tropiques humides: vers de nouveaux paradigmes?

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Les interprétations classiques de l'évolution des formes du relief ne laissent à la pédogenèse qu' un rôle secondaire: les sols ne seraient que la part superficielle d'un système complèxe, où la Stratigraphie/Lithologie, l'Hydrologie et la Géomorphologie constitueraient les facteurs prépondérants. La caracterisation des sols n'était faite que pour confirmer l'âge des surfaces d'érosion ou alors pour identifier d'eventuelles superpositions de matériaux différents, témoins d'actions érosives passées: la pédogenèse témoignerait, tout simplement, la plus ou moins grande stabilité du relief. Certains critères étaient employés dans la définition des sols: leur degrée d'alteration, la présence de differentiations verticales signalés par des «stone lines», par des horizons sombres enfouis, par des différences de couleurs entre horizons, par la présence de niveaux de concrétions ou de cuirasses ferrugineuses.
Des résultats recents obtenus par l'emploi du procedé de l'analyse structurale des couvertures pédologiques ont permis de constater: 1) la continuité latérale des sols sur les versants, conduisant à la reconnaissance de systèmes pédologiques en équilibre dynamique et de systèmes à transformations latérales; 2) la continuité verticale des profils de sol et d'altération des roches; 3) l'action de la mesofaune dans la genèse de nappes de cailloux et d'horizons sombres de profondeur; 4) l'action de la gravité dans la migration de cailloux en profondeur; 5) le cuirassement a partir de l'altération des roches et la formation des sols a partir de la cuirasse; 6) l'action géochimique dans l'incision des vallées et des dépressions; 7) enfin, l'alternance, la succession et la simultanéité des processus morphogenètiques et pédogenètiques.
En conclusion, ces résultats ont permis de mieux évaluer l'importance de la Pédogenèse pour la Géomorphologie: 1) la circulation interne des solutions du sol est aussi importante que l'érosion dans le façonnement du modelé; 2) les couvertures pédologiques en équilibre dynamique sont des témoins d'actions érosives moins actives, tandis que les systèmes à transformations latéralles témoígnent des deséquilibres hydriques (changements climatiques?, neotectonique?, changements du niveau de base?); 3) la présence des «stone lines» de même que des horizons sombres témoignent la bioturbation des sols; 4) la genèse des cuirasses férrugineuses répresentent une étape de l'altération des roches et de la formation des sols; cependant, étant assez resistantes à l'érosion, ces corps férrugineux peuvent marquer le relief par des ressauts.

JORGE RABASSA[1], MARCELO ZÁRATE[2], TIMOTHY C. PARTRIDGE[3], RODNEY MAUD[4], MARCELA CIOCCALE[5] & CLAUDIO CARIGNANO[5]

Gondwanic relict palaeolandscapes in cratonic areas of Argentina

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Relict landforms (peneplains, pediplains, bornhardts, rocking stones, core rocks, palaeoweathering profiles, etc.) of Late Mesozoic-Early Tertiary age, have been identified since long ago in South Africa and Brazil. Similar landforms have been recognized in Argentina, following the South African methodology as summarized by Partridge & Maud (1987). The works of Du Toit (1927) and KING (1967), among many other South African and Brazilian authors, have been used in the preparation of the theoretical, conceptual framework for this paper.

During Early Cretaceous times, the present territories of Argentina, as well as the rest of South America, were still physically linked to South Africa as part of the Gondwana Supercontinent. Dominant climate was humid tropical-subtropical for most of its emerged lands. Relict landscapes in Argentina would have been generated during Jurassic-Cretaceous, up to Palaeocene times, under climatic conditions which were very different from those existing today. These relict landforms have been observed in the Tandilia hills (core stones, rocking stones, palaeoweathering profiles), the Ventania ranges (silcretes and silicified slope breccias), the Northern Patagonian Massif (erosional surfaces, deep palaeoweathering profiles, kaolinization processes), the Sierras de Córdoba (high «pampas» or erosional surfaces, core stones, bornhardts, palaeoweathering profiles) and the Deseado Massif of Southern Patagonia (extensive erosional surfaces). In Ventania, the densely silicified Cerro Colorado Breccia fills a drainage network eroded into the Late Palaeozoic sedimentary rocks. These breccias have been tentatively correlated with Du Toit's «High Level Gravels» and their associated siliceous duricrusts of the Southern Africa Cape region, which age is bracketed between 63-54.8 Ma, thus providing a minimum age for the underlying fluvial palaeolandscape. However, due to other regional interpretations, the breccias may be even older (Cretaceous). The Pampean intracratonic tectonic basins, such as the Colorado, Paraná, and Macachín basins, were initially filled by Cretaceous basalts, related to the Southern Atlantic rifting process. In the western margin of the Northern Patagonian Massif, the Jurassic(?)-Cretaceous erosional surfaces were fluvially eroded and the resulting drainage landscape was infilled by Palaeocene-Early Eocene (ca. 55 Ma) volcanics and highly-siliceous pyroclastics. The Sierras de Córdoba high «pampas» are locally covered by Cretaceous basalts and sedimentary rocks, which fill shallow depressions carved into the relict erosional surfaces. However, in the Sierras Pampeana region, the palaeolandforms have been severely affected by Tertiary Andean tectonism, and their reconstruction is more difficult.

The preservation of these ancient, relict palaeolandscapes, which were never buried afterwards and remained as portions of positive elements since then, is interpreted as a consequence of their development over hyperstable regions of Argentina. Their recognition in the field and subsequent interpretation is of high relevance because: (1) it explains the cratonic morphogenesis as part of Gondwana and its persistency for at least 60 Ma; (2) it provides a new approach in the interpretation of the Pampean and present submarine-platform, Cretaceous-Early Tertiary tectonic basins; (3) it offers an appropiate conceptual scheme for mineral exploration of such ores as kimberlites or bauxites; (4) it favours the geomorphological interpretation of the Argentine cratonic regions with a «Gondwanic vision» that should replace the «Andean vision», until now dominating the Argentine geological literature.

ZOFIA RACZKOWSKA

Nivation in the Tatras in comparison with other mountain areas

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The geomorphic processes operating around the snow patches on the high-mountain slopes are presented.

The studies of nivation in the Tatras were carried out on the northern slopes of the High Tatras, above the timberline (1500 m a.s.l.), on the slopes developed on granite bedrock. The studies mainly concerned thermal conditions of weathering, meltwater runoff, material transport and the impact of snow patches on the accumulation processes developed on debris slopes. It is concluded that the key factor in the intensification of processes is increased moisture availability rather than the microclimatic effects of snow patches. If compared with weathering, present-day transport processes and deposition appear to be more active. Nevertheless, the activity of the above processes varies with the meteorological situation.

Erosional effects of snow patches are considerable on slopes mantled by debris devoid of vegetation cover. The nival niche backwall retreats 1 to 5 cm per year due mainly to frost action and needle ice. In the lower part of niche bottom sheet wash and rill erosion was observed.

On debris slopes «accumulation niches» are developing in places occupied by snow patches, most often in the apex part of the slope. They are formed due to accreation on de-

bris slope free from snow cover in the vicinity of the patch, when the surface under the snow is protected both from erosion and accumulation. Rates of accreation change from 0,0004 to 0,14 mm per year. This brings about changes in the longitudinal slope profile.

Based on results of the studies in the Tatras the model of nivation on the slopes mantled by and built of debris was constructed.

Mainly qualitative studies of nivation forms and processes were also carried out in the Italian Alps (Ortles-Cevedale Massif) and in northern Sweden (Abisko Mountains and Kebnekaise Massif). Based on their results and published quantitative data models of nivation processes were constructed for both areas.

The mechanism of nivation is similar in all compared areas. Processes connected with microclimatic effetcts of snow patches acting in the upper part of nival niche, those conected with the meltwater change the lower part of niche. But the meltwater is the more important geomorphological factor because processes induced or intensified by it are able to change the relief.

But the set of nivation processes varies in particular mountains. The sheetwash, rill erosion, supranival transport and chemical weathering are the comon processes acting around the snow patches in each considered areas. The solifluction apears around the snow patches in the Alps and in the mountain in subartic zone but not in the Tatras.

In general effects and rate of nivation as well as processes composition of nivation depends on environmental conditions, especially on climatic zone and geoecological belt, the relief, lithology and vegetation cover. The rate of nivation is lowest in the Tatras. Presently the role of nivation there is restricted largly to the transformation of the landforms occupied by snow patches. In the mountains where the nival zone exist (like Alps, Pyreenes etc.) the clear nival forms are developed.

WOICIECH RACZKOWSKI

Rock glaciers in the Martello Valley (Ortles-Cevedale Massif, Italian Alps)

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The field data have been collected during geomorphological studies in the upper part of the Martello Valley. The valley is located in the NW slopes of the Ortles-Cevedale Massif. The relief of the massif is a typical high mountain releif of glacial origin. Moreover, that is one of the most strongly glaciated and simultaneously one of the richest in rock glacier massifs in the Italian Alps (Carton, Dramis, & Smiraglia, 1988)

The rock glaciers occurring in the upper part of the Martello Valley are clustered on the orographically left slopes of the valley, in the side valleys of Madriccio, Peder and Lyfi, which are facing the S and SE. On the N- and NW-facing slopes tongues of ice glaciers occur at similar heights. The character of deglaciation, which was undergoing since the Little Ice Age, and geological structure did not allow for the formation of rock glaciers in this part of the valley. A periglacial realm is found on a large area of the S facing slopes while it is reduced to few hundred meters on the North-facing slopes. Regarding the general character, extent of the vegetation cover (i.e. lichen) and a stage of preservation of a given form the following rock glaciers have been distinguished: 1) relict rock glaciers, 2) inactive rock glaciers, 3) presently active rock glaciers and 4) initial forms.

Relict rock glaciers occur in the lower parts of the valleys, at the heights of 2300 to 2500 m a.s.l. usually at the foot of the N- and NE facing slopes. Conditions favourable for the formation of rock glaciers existed there since the early Holocene. These rock glaciers are assigned to the forms which have been formed of talus materials. There are also found debris rock glaciers (Barsch, 1992). At the heights of 2600 to 2900 m a.s.l. contemporary inactive rock glaciers occur. Some of them have an ice core. Due to a climatic warming the core is gradually melting, and input of talus and debris material is smaller. Such rock glaciers are subject to fossilization.

Rock glaciers found above 2900-3000 m a.s.l. are assigned presently active forms. These rock glaciers occur in cirques, below the S, SE and SW facing slopes. There, ice glaciers and relict firn glaciers were still found in the 1960s (Desio & *alii*, 1967 map). The height limit mentioned above is moving up as climate becomes warmer, especially when temperature increases in summer seasons.

Field and literaure studies lead to conclusion that the observed relationship are typical of the Ortles-Cevedale Massif only. When compared to other regions of the Italian Alps (Carton, Dramis Smiraglia & 1988), the Martello Valley can be assigned to the areas which do not deviate from the average. However the exposition makes the valley unique. There the southern sector predominate in contrast to the overall Italian Alps, where the northern sector predominates and consitutes 46% of all forms. Thus, the Martello Valley is similar only to the areas in the nearest neighbourhood, Val de la Mare, Val dei Foni and Val di Cadec valleys (Gngfeg, 1986, Catasta & Smiraglia, 1991)

Climate, lithology and geological structure as well as the postglacial history of the area are decisive in distribution of rock glaciers in the upper part of the Martello Valley. Formation of fundamental shapes of relief is mainly controlled by geological structure, while the postglacial history (?) is more dependent on the exposition, and thus on a local climate. The postglacial history is as old as at least 9000 BP (Gngfeg, 1986) and differs on the warm (S and Se facing) slopes from that on the cold (N and NW facing slopes). That history is responsible for an extent of the periglacial realm (zone?) on the slopes, i.e. for the size of the area where the rock glaciers could have formed. Probably, the appearance of the S-facing slopes, similar to that known at present, had lasted since the Early Holocene.

LOMBORINCHEN RADNA

Periglacial processes in the territory of Khan-Hentei nature reserve, Mongolia

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The Khan Hentei nature reserve is situated in the north-east part of Mongolia, not far from Ulaanbaatar, near the southern boundary of permafrost of northern hemisphere (fig. 1).

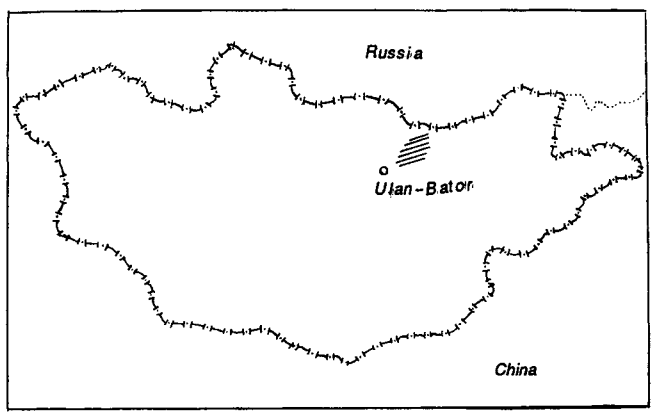

FIG. 1 - Investigated region.

The Hentei - upland is characterized by island, discontinuos permafrost and continuous permafrost. 3/4 of the territory occurs with permafrost. Temperature of permafrost is at an average from O °C to –2 °C. In highland it can be lowered to –10 °C. The average thickness of permafrost is 50-120 m. On high mountains it can reach 500 m. At present the permafrost of this territory is developing in way of aggradation (Sharkhuu, 1995). In the territory of Hentei-upland during the Pleistocene one to two periods of Glaciation occurred. The Hentei- upland was subjected to Glaciation, principally valley cirque glaciers and flat-apex glaciers. In the high Mountains of Hentei-upland are observed evidences of such ancient glaciations as cirques, thoughs and till sheets.

As regards of periglacial processes and phenomena, their spreading is submited to altitudinal zonality. So the territory of Hentei-mountains in consequence of work various investigators is established:

1. The golets zone with mountain tundra (higher 2200 m a.s.l.); 2. Mountain taiga (higher 1400 m a.s.l.); 3. Forest-steppe zone (higher 1100 m a.s.l.); 4. Mountain - steppe zone (to 1100 m a.s.l.).

In the golets zone are strongly developed the systems of cryoplanation terraces. Here with a bigger intensity the processes as frost weathering, frost sorting, solifluction, kurums and so forth are active.

In the mountain taiga are proceeding frost weathering, frost sorting, solifluction, and others, with middle intensity, and icing in a bigger intensity.

In the forest-steppe zone periglacial processes are strongly differenced on the northern and southern slopes. The northern slope of mountains is covered by the forest (larch, cedar), and southern slopes are naked. And therefore the periglacial processes and phenomena are developed in principle on the northern slope (frost weathering, solifluction, frost sorting, icing and others), and swampy bottom of valleys (frost heaving, hummocks, frost cracs, non sorted spots medal lions and so fort). Iu southern slope are observed relict solifluction terraces and clayly-debris solifluction lobes.

The mountain steppe is differed from others with the scanty spreading of periglacial processes. In the rock of mountains it is possible to develope frost weathering, in the bottom of valleys are periglacial processes and phenomena (hummocks, frost cracks and so forth).

R.K. RAI

Impact of coal mining on land and water resource environment in Jaintia Hills, Meghalaya, India

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The Jaintia Hills district of Meghalaya has been selected to study the impact of coal mining on land and water resources. The total area of the coal mining is about seventy five km^2. The coal deposits of this area are mainly of tertiary period. The coal occurrences are scattered throughout the district. Invariably all the coal seams are in general thin.

By and large the exploitation of coal is privately controlled by small scale ventures with impoverished skills and techniques in the state due to the prevailing land tenure/ownership system. Being a tribal dominated district the land belongs to individuals or community of the village.

The various environmental problems noticeable due to large scale mining activity in general are land degradation, soil erosion, surface run-off, increase in sediment load of mine spoils, loss of vegetative cover and disturbance of water bodies and quality of drinking water. Such land transformation as a result of human activity were evident in the study area which contribute to different changes in the land and water resources as observed here. Soil and water samples were collected and analyzed. The major conversion of landuse has been in the transformation of good deciduous forest cover to degraded forest cover. Some recommendations have been made to restore the disturbed land and water bodies.

TERESA RAMÍREZ-HERRERA

Active tectonics on the coast of a convergent margin, Southwest Mexico

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Active tectonics along the coast of the Pacific continental margin of southwest Mexico is related to the subduction of the Cocos and Rivera plates beneath this region. Differences in the geometry of subduction and in the rate of convergence between the Cocos and Rivera plates have been reflected in differences in the rates of observed seismicity. Remote sensing analysis and field evidence show that the coastal morphology across the tectonic boundary of the Mexican convergent margin reflects regional variations in tectonic and seismic activity. The coastal zone of southwest Mexico can be sub-divided on the basis of distinguishing regional morphological characteristics. Six zones are identified: 1) the Jalisco zone, 2) the Colima zone, 3) the Michoacán zone, 4) the Guerrero zone, 5) Oaxaca zone (?), and the 6) Tehuantepec zone. A range of geomorphological evidence, including marine terraces, elevated wave-cut platforms, marine notches and river terraces indicates uplift along the coasts of the Jalisco, Michoacán and Guerrero zones. Differences in geomorphic characteristics between the Jalisco, Colima and Michoacán zones reflect changes in the style of subduction of the Rivera and Cocos plates while variations in the coastal morphology near Tehuantepec accord with transitions in tectonic and seismic characteristics in this area.

JIWAN SINGH RAWAT & GEETA RAWAT

Adverse impact of human activities in geomorphic processes and guidelines for their management in the Central Himalaya, India

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Anthropogenic activities, i.e. poorly managed agriculture and reckless deforestation, and technogenic urban activities, i.e. unplanned building and road constructions in the fragile, geodynamically active, highest and the youngest part of the earth, viz.,the Himalaya, have accelerated geomorphic processes such as sheetwash erosion, channel erosion, (i.e., suspended, dissolved and bed load), overland flow alarmingly resulting in catastrophic floods, frequent prodigal landslides during the monsoon rains; and depletion of groundwater storage, drying up of the natural springs and steadly dwindling of streams base flows during summer. The intensity and pattern of the geomorphic processes in the Himalaya is poorly understood or unexplored. Some recent studies (Rawat & Rawat, 1994 a, b) reveal that the rate of channel erosion has been accelerated five (in deforested land) to nine times (in agricultural land) higher in the anthropogenically disturbed systems in comparision to the erosion rates in the natural system. These studies have also indicated that in the most disturbed agricultural land 60% of the annual runoff occurs in a single month of July-the month of the heaviest rainfall. However, under natural conditions in the oak and pine mixed forest only about 23% of the total annual flow occurs in July. In April, the driest and hottest month measurements indicate that high amounts of runoff (i.e., 308 cubic meter per square kilometer per year) in the natural system while runoff amounts low (108 cubic meter per square meter per year) in the most disturbed agricultural land.
In view of the changing environment of the fragile Himalaya caused by the rapid changing behaviour of the geomorphic processes due to the human activities - a long term research project funded by the Department of Science and Technology, and Department of Forest and Environment, Government of India, was launched in 1990 for the careful monitoring of geomorphic processes and to formulate guidelines and strategies for the sustainable development of water and land resources, in particular and for the regeneration of the entire environment, in general. This paper includes the detail account of the new scientific strategy of the study, instrumentation network of the six permanent field laboratories developed in the micro watersheds to study the geomorphic processes under varied ecological conditions, preliminary results of the project and some major guidelines for the sustainable development of water and land resources of the fragile Himalaya.

BRICE R. REA[1], DAVID J.A. EVANS[2] & DOUGLAS I. BENN[3]

Bedrock quarrying beneath deforming bed glaciers

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Quarrying of bedrock is one of the dominant processes of subglacial erosion. It is traditionally assumed to occur only beneath glaciers with an ice-rock bed. This paper investigates the potential for quarrying beneath a wet-based glacier where a thin or patchy deforming till layer overlies a hard rock bed. This is based upon investigations at con-

temporary (Svalbard/Norway) and ancient (Scotland) glaciated sites where subglacial till has been injected into bedrock fractures and joints.
Joints and stress-induced fractures in bedrock are the key to the erosion of material beneath both ice-rock beds and ice-till-rock beds, because they represent avenues for potential water movement and thus till injection. If fines in the till are abundant they may be carried into the joints and fractures by water movement. Under conditions of over pressuring, hydrofracturing of the bedrock with associated injection of till may occur. This movement of till into the bedrock joints effectively separates a rock fragment from the bed and results in a reduction of its buoyant weight and inertia. Joint cohesion and the coefficient of static friction are also reduced. The removal of the fragment (clast) now requires a much lower shear stress. This maybe applied through stiffening of the till due to water pressure reductions or due to thinning of the till layer with subsequent ice-rock contact occurring. Such water pressure and till layer fluctuations are possible beneath large areas of the glacier bed. We introduce an important new process in subglacial erosion studies. Previously it has been assumed that the presence of a deforming till layer precludes quarrying. However it now appears that quarrying may be very effective in the presence of a thin or patchy deforming till in association with a well jointed/fractured hard rock bed.

A. Rebeiro-Hargrave

Large scale modelling of drainage evolution in tectonically active asymmetric intermontane basins using cellular automata

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In many orogenic regions undergoing compressional and extensional tectonics it is common to find characteristic drainage patterns that appear to be self organised. This is observed in asymmetric intermontane basins where axial drainage pattern is sensitive to regional tilting. Identified as half-graben basins, uplift occurs preferentially at the boundary fault and results in the hanging wall and drainage sloping regionally towards the active fault. There has been limited numerical research in drainage evolution within basins subjected to preferential uplift and corresponding regional tilting. This paper reports the results of cellular automata simulations which indicates how drainage evolution may respond to tectonic stresses under semi-arid climatic forcing regimes. Specifically, it will highlight the difference between large-scale self organisation and small-scale chaotic channel propagation based on regional tilting.
An emergent cellular automata algorithm is routed on various digital terrain models which represents the half-graben morphology at different stages of uplift. The hanging wall tilt ranges from a minimum regional slope 0.5 percent to a maximum slope of 3.2 percent. The local rules are governed by rock strength and permeability parameterized by field measurements taken from the Neogene Guadix Basin , Southern Spain. The density of erosion cells is based on the spatial and temporal distribution of climatic events in semi-arid environment.
After 500 thousand iteration years, results show that with a minimum regional slopes there is an increase of entropy - the tendency for chaotic drainage pattern, whilst for the maximum slope there is a decrease in entropy suggesting self organisation. This is interpreted as low regional slopes characterised with high chaotic drainage density and tectonically inactive, and high regional tilting with self organised long channels and tectonically active. Field observations tend to support this hypothesis with the slowly uplifting regions characterised by short, wide bedrock channels and the opposing tectonically inert sloping pediment with long deeply incised bedrock channels.

Denise J. Reed

Hurricane impacts on microtidal marshes in the subsiding Mississippi Delta Plain: destructive or beneficial?

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The coastal marshes of Louisiana are subjected to high rates of sea-level rise (> 1 cm/yr) because of subsidence of Holocene deltaic sediments. Their microtidal nature means there is little tidal energy to transport sediments into the marshes to offset this subsidence. Several studies have suggested that elevated water levels associated with frontal passage across the coastal zone are more important than daily tides in delivering sediments. Hurricane impacts are of greater magnitude but less frequency than cold fronts and studies of recent hurricanes demonstrate that they can be either beneficial or destructive depending upon the type of coastal marsh impacted.
The salt marshes of the Mississippi Delta Plain require mineral sediment inputs both to keep pace with subsidence and to counter the potentially toxic effects of sulfide build-up within the marsh soils. Evidence from a number of tropical storms and hurricanes confirms that these events can result in significant sediment deposits in the marshes (several cm in thickness) which appear to benefit both vegetative growth and marsh sustainability in the face of sea-level rise. The longevity of the effect, however, seems to be dependent on the nature of the storm passage including its direction at landfall, speed of movement and the amount

of associated rainfall. In optimal circumstances, hurricanes can result in prolonged periods of enhanced sediment deposition on the marsh surface as new sediment introduced into the system is reworked by regular tidal processes.
Fresher and brackish parts of the Mississippi delta plain are characterized by «flotant». These are vegetated organic mats which are buoyant in response to tidal and seasonal changes in water level. The substrate is largely organic and vertical accretionary processes are dominated by organic accumulation. The effect of hurricanes in these systems has often been physical destruction. Rapid changes in water level and associated wave action can tear the organic mat. This may be broken into small pieces which are then exported from the marsh, or piled up in «accordion» fashion against adjacent barriers or levees. Resulting tears in the marsh are persistent landscape features. Mat which is piled up above the level of normal tidal flooding can become colonized by upland species and, although land is not lost, the quality of the habitat is changed.
Differential habitat response to hurricane impact provides a complex context for coastal management planning in Louisiana. The potentially valuable input of sediments to coastal salt marshes needs to be balanced against the protection of fresher marshes and the local population.

ANTONY REEVES, STUART N. LANE & KEITH S. RICHARDS

Development and preliminary assessment of a two-dimensional coupled flow and sediment transport model for gravel-bed rivers

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Recent research has illustrated the potential for using numerical modelling methods in the understanding of river channel dynamics, particularly in relation to the spatial distribution of velocity and shear stress. Fully dynamic models of channel change however require a coupled flow and sediment transport model that allows: evolution of bed texture as sediment transport occurs (especially for gravel-bed rivers); downstream and lateral sediment routing bank erosion and bar formation; and feedback between changes in bed texture and channel topography and flow processes. Previous research has developed one-dimensional models of channel response to discharge and sediment supply regimes that has incorporated these processes. However, they are not able to represent lateral processes effectively, and in certain situations (e.g. zones of flow convergence, meanders etc.) such process may be critical.
This paper presents the first attempt at a fully coupled model of channel change that includes a two-dimensional sediment sorting algorithm in a coupled model for flow and sediment transport. The model allows the detailed simulation of bed sedimentary structures and fractional composition of the bed, as well as channel change, and preliminary results compare well with flume simulations. The next stage of this research will involve application to real rivel channel systems.

HERVÉ REGNAULD[1] & SANDRINE BINOIS[2]

Management of cliff retreat in Saint Brieux Bay, France

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The Bay of Saint Brieuc is located on the southern coast of the English Channel, in Brittany (western France) and is exposed to moderate waves and strong tides (spring tide amplitude = 10 meters). It is 30 km wide and reaches 25 km inland. The coast is composed of gently sloping plateau scarps, mostly made of christalline rocks and covered by periglacial formations such as heads, silts, slope deposits, debris cones. The base of these scarps is eroded by the sea and forms an abrasion platform that may extend two miles offshore. Some small embayments are used as harbours. The main part of this coast line is occupied by touristic resorts, which tend to colonize the cliff top in a very linear way.
Since the middle of the 70 ies, local wind and wave climate has significantly changed, as wind speed and storm frequency have increased . At the same time coastal management regulations have been changed and responsabilities of the coast line have shifted (in some aspects) from the state to the local authorities (laws of 1982 and 1986). These «communes» had to deal with an inccreasing erosion and a lack of funds.
This work presents an inventory of the various morphological types of events that cause cliff erosion and retreat, after continuous field work from 1992 to today. Air photographs have been analysed, the first one dating back WW2. Most of the retreat concerns the cliff cover and not the rocky basement itself. Though, in some place, the rock itself is attacked. The volume of sediment produced by the retreat is calculated and, when possible, the sediment sinks are monitored. If a yearly time step is considered, there appears to be an almost complete decoupling between the cliff erosion and the beach evolution. Some years, a beach may almost desappear, or be reduced to a very thin veneer of sand. If the time step is longer (some years), then some good correlation between beach accretion and sediment input from the cliffs may be calculated.
Management policies have to consider these two time scales and the associated variability. Year to year management

has to ensure the existence of beaches and safe paths to access to the sea. Catastrophic events (rock falls, slides) must be prevented. Some houses are exposed to mass movements. Long term management is different, as it is more concern with a general infill of the harbours and an excess of sediment. One important and badly known point is the actual importance of sea level rise. In this site it approaches 1 mm a year. It may change the sediment cells to such an extend that management policies have to be totally reconsidered.

EMMANUEL REYNARD & LAURENT WENKER

Permafrost mapping in two regions of the western Swiss Alps: Les Diablerets and Verbier

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Two regions have been selected in two different climatic and geomorphologic regions of the western Swiss Alps. The site «Cabane des Diablerets» is situated in the Hautes Alpes Calcaires (Helvetic Nappes) (altitude : 2200-3100 m) and is caracterized by a transitional climate between the wet Prealpes (precipitation = 1500 mm/year at 1000 m) and the central part of Valais (precipitation = 750 mm/year at 1000 m) and a contrasted morphology, with high limestone cliffs alternating with schists. The second site, the «Mont Gelé», is situated in the south part of Valais (altitude : 2200-3000 m) and has dry climatic conditions (precipitation = 800 mm/year at 1000 m) and a relatively opened morphology developped in metamorphic rocks of the Penninic Nappes.
The two sites present the same topographic conditions: a mount with slopes of different orientations with parts affected by permafrost. Some orientations present active periglacial forms as gelifluction lobes and rock glaciers.
Two databases of BTS measurements have been created. The field observations and the permafrost distribution mapped with BTS measurements are compared within a GIS with computer mapping based on an empirical topoclimatic permafrost distribution based on field datas of the Grisons (Eastern Switzerland).

MOHAMMAD HOSSEI REZAEI MOGHADDAM

The alluvial fans evolution at the southern piedemonts of Mishow Dagh Mount, in the NW of Iran

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The southern slope of Mishov Dagh, located at the center of Azarbaijan of Iran, can be considered as a geomorphological laboratory for the study of alluvial fans in a semi arid region. In this region three different kinds of alluvial fans have been recognized on the base field studies. The first kind of these typical forms is paleofans of early Pleistocene. The second is the old fans of late Pleistocene. Finally the third is young alluvial fans which can be classified in two different types: a) the early Holocene fans and, b) the contemporary (historical) alluvial fans.
The paleofans and old alluvial fans were abandoned such as alluvial terraces because of down cutting by the Quaternary streams. The young alluvial fans activities which currently are being formed, may be related to some factors such as climatic factors, human activities, Urumiyeh Lake's fluctuations and neotectonics. The later was found to be the most important and conductive factor. The field observations showed the site changing of alluvial fans due to climatic change and morphotectonics activities. Geological logging from the young alluvial fans confirmed these fluctuation in the Holocene epoch. Theorically, the regression analysis shows the best relationship between the areas of drainage basins and associated alluvial fans with r = 0.99. On the base of this study it can be concluded that morphotectonics and fluctuations of Urumiyeh Lake have important role on the evolution of the alluvial fans of the southern slope of Mishow Dagh.

ADRIANO RIBOLINI

The rock glaciers of the Argentera Crystalline Massif, Italian side, Maritime Alps

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The Italian side of the Crystalline Massif of the Argentera presents numerous examples of periglacial geomorphology, among which the most frequent and significant are the rock glaciers. 37 rock glaciers have been identified, varying in form and position in the alpine morphological context. 23 are on the floor of the cirques and valleys modelled by the Pleistocene and Holocene glaciation. Of this group 14 are at the foot of slopes fed by gravitational and freeze-thaw detritus, influenced by avalanche cone phenomena and debris flows. Morphometric analysis of all the forms identified shows in general how there is no preferential exposure, with the exception of the protalus rock glaciers which show tendentially a position on N-facing slopes. The analysis of the heights of the fronts allowed identification of some groups of values, which suggest that the formation and reactivization of the rock glaciers studied occurred at various times in the Lateglacial. In the Italian Maritime Alps the maximum altitude (July) of thermic zero is 4.190 m. This value attributes total inactivity to the

rock glaciers, the conditions of formation and maintenance of permafrost not having been verified.
There was observation and description of the common compressive and extensive surface fluidal texture, conical pits and areas without flow structures. The surface texture showed how, in some cases, the rock glacier is not the expression of a single state of stress, but is the result of a series of deformational events. A morphological convergence with other alpine forms was observed. It was particularly difficult to distinguish between protalus rock glaciers and protalus ramparts, and also between moraine (valley floor) rock glaciers and ablation morainic complexes. This leads to the consideration that there is, as known from the literature, an evolutionary continuity of form, due to periglacial action, controlled by climatic and topographic conditions between deposits of different origins (protalus ramparts, ablation morainic complexes, talus slopes and debri cones) and rock glaciers. By means of a morphological approach there was estimation, in the field and also on topographical maps, of the slope angles of the rock glaciers and of the detritic slopes behind. From this comparison it emerged that the rock glaciers have, due to their kinematic interior, fronts which are steeper than their supply slopes. The protalus ramparts, where they are not influenced by permafrost phenomena, have external ridges of a steepness similar to that of the back slopes and they are not characterized by surface deformational structures. However, the partial collapse and stabilization of some rock glaciers fronts, at lower altitude, did not allow accurate observations making it impossible to assess their features correctly. The distinction between ablation till and rock glaciers was even more problematic. The criterium used was that of recognizing clear successions of concentric compression ridges, trenches with a variable but more or less continuous tendency and collapse stuctures due to internal ice melt. However, some complex morphological situations were identified in which the rock glaciers had developed both within frontal morainic ridges, partly covering one another, and also starting from these ridges, involving them in their deformational movements. In some cases there was observation of valley bottoms filled with detritic deposits apparently structured in a tight succession of ridges stretching along the valley axis. However there is no correspondence between this apparent extensive fluidal texture and areas characterized by the quite extensive compression ridges found in the frontal part. Therefore these deposits have been interpreted as ablation tills which have conserved structures transferred from the glacial mass that they were covering. The distinctive sedimentological features regarding rock glaciers and protalus ramparts are the general characteristics of the deposit, particularly the presence and distribution of the matrix. Rock glaciers have an open work fabric, with a clast-supported structure consisting of irregular blocks of sizes from a decimeter to a meter and by fine sandy fractions and coarse gravels; these are totally absent on the surfaces of the detritic masses, are found mainly concentrated at deeper levels and can be observed in correspondence with the fronts and the external perimetric slopes distributed in pockets, even if not uniformly. The classic zoned structure of the frontal and lateral slopes of the main lobes can often be found. The protalus ramparts also have a clas-supported structure of angular blocks, but the matrix, compared to that of the rock glaciers, is almost completely absent in the vertical profile and constitutes the filling in the spaces between the biggest blocks.

KEITH S. RICHARDS

Events in fluvial geomorphology; auxiliary hypotheses and the normal science of magnitude and frequency

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The introduction of the magnitude-frequency concept was a significant event in fluvial geomorphology, and the concept has underpinned interpretations of dominant or effective discharge and its relationship to channel morphology since 1960. However, it has been increasingly necessary to bolster its role by a series of *ad hoc* auxiliary hypotheses concerning the significance of flow process events, the controls of sediment transport, and the adjustment of channel form to sediment transport processes. For example:
– The duration and inter-arrival times of flow events (on all time-scales), in addition to the magnitude of that event, all interact to determine the transporting capacity of each event. As a result, the potential effectiveness of flow events cannot be judged solely by the product of their magnitude and frequency.
– The actual effectiveness of a flow event in terms of work done in transporting sediment is dependent as much on sediment supply, both absolute and relative, as on transport capacity.
– The morphology of river channels is a multivariate three-dimensional phenomenon that reflects a wide range of processes that are differentially dependent on flow events of a particular frequency, and the event which has the most lasting visual impact is not of critical importance for all aspects of the morphology.
This paper will address these issues with examples that illustrate the application of the magnitude-frequency concept over a range of space and time scales; from the analysis of turbulent flow structures and their impact on instantaneous sediment transport, through the determination of effective or dominant discharge in relation to time-integrated sediment yield, to the identification of relationships between discharge and equilibrium hydraulic geometry, and the analysis of flow and sediment transport as controls of evolving channel morphology.
The aim will be to consider whether the auxiliary hypotheses now burden the concept to such a degree that it

is no longer possible to maintain it as a viable research tool, as opposed to a convenient organising pedagogic principal.

JOHANNES B. RIES

Monitoring of geomorphodynamics in semi-arid environments by large scale aerial photography taken from a remote controlled blimp

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Geomorphological forms in semi-arid subtropical environments as sheet wash, rills and gullies cannot sufficiently be documented by conventional methods of remote sensing. Spatial resolution of satellite sensors as well as of conventional aerial photography does not correspond to the scale of geomorphodynamic processes. With a specially designed hot air blimp as a sensor platform, large scale aerial photographs can be obtained specifically aimed at the scientific demands (spatial and temporal resolution, normal colour and infrared small format film). The pictures are subsequently being transferred into digital format by electronic scanners in order to enable further processing by digital image processing systems.
In a semi-arid region of the Ebro Basin, key processes of desertification are being investigated. Areas affected by sheet wash, rill erosion and stone pavements as well as patterns of vegetation distribution are differentiated using imagery acquired by this new method. The development of erosion forms can be documented and erosion rates can be evaluated. The combination of these information levels provides insight into interactions of geomorphodynamics and vegetation succession on abandoned fields. Reduced infiltration capacity due to crusts and soil sealing leads to increased run-off and steet erosion followed by the formation of rills and gullies which are the most important sources of suspended sediment.

MASSIMO RINALDI & PAOLO BILLI

Stream-bed degradation and channel instability in Tuscany (Italy)

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Most of the fluvial system of Tuscany has been subjected in the past to numerous human disturbances and modifications. The main rivers of the region, such as Arno River, have been undergoing a number of in-channel engineering works consisting mainly of bank protections (groynes, dikes, revetments, walls), straightenings (including artificial meander cutoffs), resectionings, diversions (as part of flood control systems), weirs (to provide head as a cheap and unpolluted power supply), levees (to prevent flooding of urban areas), sand and gravel extraction (though at a limited extent). The fluvial system evolution has been also largely influenced by interventions at basin level, including deforestation, wide changes in land use and reclamation of large areas (by filling the lowlands with sediment supplied by the rivers). Notwithstanding such extensive control exerted by man, flood plain and in-channel deposition and growth of the delta of the main rivers proceeded until the second half of the past century. During the last 150 years a series of interventions at basin level (construction of weirs,variations in land use), intense instream gravel-mining activity after World War II, and the construction of dams, resulted in widespread channel-bed lowering along the length of many portions of the fluvial system.
Bed-level adjustments of the last century are well documented for some river of the region (Arno, Sieve), on the basis of an analysis of a large number of cross-sections and longitudinal profiles of different years. Comparison of longitudinal profiles indicates that for these rivers degradation is the dominant type of bed-level adjustment, while minor aggradation locally occurs. Degradation is also evident for other rivers of Tuscany, though only qualitative data are available. For instance the Orcia River, a tributary of the Ombrone River (the second largest of Tuscany), has cut through the entire thickness of its alluvium and started to incise the underlaying clayey bedrock. For rivers where cross sections and longitudinal profiles were not available, a field stream reconnaissance has been carried out in order to assess the dominant processes and adjustments and estimate the total bed-level lowering on the basis of morphological and sedimentological evidences.
Differences in channel adjustments compared to other unstable fluvial systems subjected to different human disturbances are observed and discussed. Empirical data from other disturbed stream systems and models of channel evolution in disturbed alluvial channels show aggradation in downstream reaches as degradation migrates upstream, as well as widening following bed-level lowering. In the case of the Arno River and part of its tributaries bed-level adjustments are dominant and channel widening processes result of limited significance mainly because bank protections such as concrete linings, rip rap, and gabions are common. For other streams of the southern part of the tuscan fluvial system, such as Cecina River, lateral activity is at present the dominant channel adjustment after a phase of degradation.
The identification of channel forms and processes and the interpretation of the stage of channel evolution can be used for engineering management, in order to assess the appropriateness of mitigation measures and in the perspective of stream restoration.

MIRELA RIPEANU & IOAN MAC

The evolution of the landscape in the conditions of sudden and successive change of the forms of agricultural exploitation in Romania

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In the frame of the Carpathian - Danubian - Pontic space there existed a succesion of the forms of agricultural exploitation, accordingly to the socio-economic changes, developed during time. Some of those forms of agircultural exploitation changed slowly, others, on the contrary, changed suddenly, causing real «thresholds», in the landscape's dynamics and physiognomy.

The most affected regions in Romania were the plains, the hills and the river meadows and only in the last quarter of the century deep anthropic interventions were traced at the upper limit of the forest toward the level of the alpine meadows.

From the multitude of the sudden changes which ocurred in the forms of agricultural exploitation, having a major impact in the geographical landscape, we focuss on three distinct situations: 1) the period of deforestation and fallowing, which affected large spaces in the Romanian Plain, Moldavian Plain, Transylvanian Plain, Subcarpathians, etc., which has as consequences the change of the initial natural landscapes of grassland and of decidous forests, into agricultural landscape of closed fields or into dispersed landscapes with fruit-trees and vineyards. The excessive exploitation led, sometimes, to states of advanced rhesistasy; 2) the period of land fusion into bigger agricultural surfaces and fields, which led to the change of the initial traditional landscape into a new agricultural landscape of «cooperatist» type, with an emphasized fragility; 3) the period of returning to the system of «lot» exploitation, which had as results the revitalization of the agricultural landscape of the landscape with abandoned lands and «wild» agriculture - without any kind of control, having negative effects in the territorial esthetics.

JOHN B. RITTER

Late Quaternary landscape development in a stable midcontinent setting using adjacent drainage systems with variable geologic controls

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Adjacent watersheds in the glaciated central lowland of southwestern Ohio are used to illustrate the interplay of glacial, geologic, hydrologic, and base-level controls on drainage evolution and graded stream profiles. The area is unique in that it contains a series of gorges formed by streams crossing resistant dolomites of the Silurian Niagaran Series and older bedrock along an outcrop pattern controlled by the Cincinnati Arch. Bedrock is buried by a thin (< 1 m) to thick (> 100 m) veneer of glacial till and outwash. Streams traversing the thinly-veneered escarpment formed by the Niagaran Series dolomites are superposed from overlying glacial deposits onto either the unincised escarpment or buried valleys within the escarpment. The Little Miami and Mad-Great Miami Rivers, originally meltwater streams, are representative of the two conditions respectively. The course of the Little Miami River was established first, confined by the margins of the ice lobes. While outwash was deposited upstream and downstream of the escarpment, the escarpment itself appears to have undergone minimal erosion or deposition by glacial meltwater and outwash. This runs counter to a widely-held belief that the present gorge was eroded by glacial meltwater. A second meltwater stream, the present Mad-Great Miami River, formed parallel to the first but crossing the escarpment along a buried valley associated with the preglacial Teays River. Stream gradients along both systems were initially controlled in the upstream direction by glacial discharge of sediment. Gradients are presently controlled by their regional base level, the Ohio River, and the reaches being studied are approximately equidistant from this base level. Whereas the Mad-Great Miami River is incising sand and gravel deposits within the buried valley and exhibits a smooth, graded longitudinal profile, a resistant unit within the Niagaran Series forms a major knickpoint along the Little Miami River profile, the upper surface of which forms local base level for upstream reaches. Relief on the knickpoint, and therefore between the two river systems, is presently on the order of > 30 m. As a result, former upstream tributaries of the Little Miami River immediately adjacent the Mad-Great Miami River were susceptible to piracy. Terrace remnants, their soil development, and the presence of loess on the highest remnant suggest their piracy occurred during or immediately following establishment of Mad-Great Miami River. Modification of the knickpoint on the Little Miami River longitudinal profile apparently is occurring by both parallel retreat and replacement. Parallel retreat is occurring because of undercutting of the resistant Cedarville Dolomite due to plunge pool scour of the less resistant Springfield Dolomite. Replacement is occurring within the Cedarville Dolomite by vertical and lateral pothole development. Valley walls along the incising reach experience parallel retreat. Implications for equilibrium longitudinal profiles will be discussed; the understanding of gorge development in this area, because of their spatial relation the glacial interlobe area, may also have important implications for estimating meltwater discharge.

FELIPE R. RIVELLI

Les glissements à Volcan (Jujuy, Argentina). Des origins et des posibilités pour sa correction

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La localité de Volcan, située à 20 km au nord de la ville de San Salvador de Jujuy, a été placée sur des sédiments lacustres, dans la rive droite du fleuve Grande.
Ce peuple a, dans ce moments, de graves inconvenients comme conséquence des glissements qui se produisent dans les deux bords du fleuve Grande, ce qui a donné lieu à la perte de maisons et de diverses oeuvres d'infrastructure (d'écoulements, de chemins vicinaux).
Le problème posé montre une évidente tendance à augmenter selon l'observations sur place, menaçant sérieusement non seulement le peuple de Volcan mais aussi la route nationale qui conduit à la Bolivia et la voie ferrée internationale, la quelle dans un tronçons se situe à 10 m de l'actuel ravin.
Malgré la critique situation où se trouve ce peuple et le danger des glissements pour les habitants de la région, de même que pour ses propriétés et d'autres oeuvres, on n'a pas encore fait les travaux nécessaires pour attenuer et, à la fois, empêcher de nouveaux mouvements de terrain.
Les glissements qu'on observe dans les deux rives du fleuve Grande sont une conséquence de l'approfondissement éprouvé par ce cours d'eau, dû à la modification de l'homme dans la trace du lit, en aval de Volcan.
A cause de cette altération, le fleuve se trouve à présent dans une étape d'adaptation dans son nouveau niveau de base, avec un approfondissement accentué de son lit.
Les bordes du fleuve dans le secteur où est situé Volcan répondent d'une façon immédiate à cet approfondissement et les glissements surviennet pour conséquene.
On n'a pas de données qualitatives que permettent d'établir des valueurs exactes de volumes involucrés et precis du recul expérimentés par les bords, regretablement. On a placé les premiers competeurs pendant l'hiver de l'année 1995, ceux qui permettront d'avoir des reinsegnements.
Le comportement du fleuve pendant les derniérs années et le glissements qui se produisent dans ce secteur urbanisé exigent l'urgente realisation des oeuvres néessaries pour empêcher la suite des processus de terrasement, autrement les degâts seront chaque fois plus significative.
C'est pour cela qu'on conseille la construction d'oeuvres flexibles, transversales dans le lit du fleuve pour qu'elles fonctionnent comme des contrôleurs de fond en empêchant son approfondissement.
Au début, on devrait faire trois diques de basse hauteur pour réduire le risque d'être détruites par les crues, et, à la fois, pour son moindre prix, une, située au secteur du fleuve correspondant au peuple de Volcan et les autres deux, en aval.
Pour concrétiser ces oeuvres, on pourrait recourir a deux alteratives; l'emploi de blocs de grand volume (des riches résistantes) minimum d'un m^3, disponibles dans la région; les installer dans le lit, appuyés sur un géotextil de haute densité (600 g/m^2) afin d'empecher l'elimination – par écoulement – du matériau fin qui joue le rôle du support, et par conséquence eviter le déréglement de l'enroulement pour pouvoir accomplir ainsi son onjectif.
L'autre opption d'oeuvre flexibles et économique, c'est le bâtiment d'azuds ave des gabions industrialisés, d'une hauteur maximale de 2 m pour n'engendrer pas de résistance à l'écoulement de l'eau. Ces structures devront être achevées avec un échelonnement en aval et des bassins de dissipation pour éviter le creusement du lit par l'effet de l'eau. Ces oeuvres doivent être aussi appuyées sur géotextil mais de moindre densité, de 150 à 200 gr/m^2.
Les deux choix d'ouvres doivent être contrôlées périodiquement pendant les mois de pluie et selon le comportment du fleuve réaliser les corrections et le travaux complémentaires nécessaires (des nouveaux azuds, des défenses marginales) pour contrôler définitivement le fond du lit et obtenir la stabilisation de ses bords, en empêchant de cette façon de futures glissements.

ROBERT J. ROGERSON

Revisiting glacier re-advance in the Yoho Valley, British Columbia, Canada

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Re-advance of Emerald Glacier in the Yoho Valley of British Columbia was observed between 1978 and 1982 (Rogerson, 1985), and continued for several years afterwards. Around 1990 the re-advance was over and the glacier has retreated, in places almost 30 m from the re-advance moraine. The glacier has been revisited in 1993, 1994 and 1997 to re-establish markers used to quantify advance and retreat. Despite the thinning of the glacier, in parts by as much as 25 m, one section of the terminus has remained in contact with the readvance moraine due to thick supraglacial sediment cover, and will likely become separated from the retreating mass of the glacier in the near future. Both re-advance and recession are examined with reference to climatic conditions, glacier size and response time.

FEDOR ROMANENKO

Modern dynamics of the Arctic seas islands and coasts relief

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Long-term expeditional and stationary (1985-96) researches in various Russian Arctic regions and participation in

Swedish-Russian expedition «Tundra Ecology-94» along all arctic coast of Russia have allowed to find some regularities of spreading of modern geomorphological processes in Arctic tundra and to determine their intensity.
The most characteristics of tundra relief are lakes having essential influence on relief. Study of lake basins structure and dynamics was carried out on the basis of research of loose sediments by a complex geomorphological and paleogeographical methods. Large-scale geomorphological maps of Kara Sea islands (archipelagoes of Izvestiya TsIK, Arctic Institute, Sverdrup and other) and inaccessible places of continental coast are made for the first time. Radiocarbon dating of peats and bone rests of Quaternary mammals was widely applied.
Erosion, abrasion, rockfall and talus processes play the most appreciable role in modern relief transformation of arctic islands. On low-lying sites of coasts are active also eolian processes and suffosion. The most important peculiarity of localization of exogenic processes in Arctic is their high intensity on sites of spreading of underground ice (Central Yamal, Nothern Yakutiya, New Siberian islands). Ground ice slump and the development of thermokar and thermo-cirque play here a fundamental role. They proceed here in so close interaction with erosion and solifluction, that it is expediently to allocate uniform process of thermodenudation in similar regions. Thermokars are the circularitical depressions in coastal breakages. They appeared here as a result of underground ice thawing. Frequently for their appearence amd subsequent transformation in ground ice slump a presence of a few sentimeters of ice layer may be enough (Sverdrup island, Russian island).
Human activity (building and tramsport mainly) raises strongly the intensity of geomorphological processes in natural conditions favorable for their development (ground ice slump - 4 m/year or 50-80 m^3/year and erosion - up to 30 m/year on Central Yamal; thermoerosion - 20-30 m/year on Preobrazhenye island in the Laptev sea).
The obvious tendency of reduction of the area water reservoir comes to light due to overgrowing and descent for the majority of investigated territories. The drain process goes with speed about 0.01 sm^2/year (Central Yamal). The majority of lakes on low (5-45 m) accumulative terraces have a residual origin, the thermokarst role in their formation is insignificant.
The determining factor for geomorphological processes development in high Arctic is the substratum tipe (mainly its ice-cover). The mechanism and speed of erosion, abrasion, slumping and other in a little ice-covered rocks do not differ practically from the same processes in more southern areas without eternal permafrost. The presence of winter rest periods, close dependence of processes speed on weather conditions during the warm period of a particular year, high correlation of processes with each other are characteristic. Because of high ice-cover of loose sediments composing of arctic low land, the general denudation intensity on the nothern plains is more than in mountain regions.
A combination of several favorable conditions is necessary for especially intensive development of processes, that is observed rather seldom, and consequently the high speeds of processes in natural conditions are observed on rather limited sites. Opposite, the acceleration of geomorphological processes near to arctic settlments is an ecological problem now and can completely change the relief aspect of these sites.

GHEORGHE T. ROMANESCU

L'évolution morphohydrographique du delta du Danube pendant le Quaternaire en fonction des oscillations du niveau de la Mer Noire

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En analysant les séries des transgressions et des régressions qui ont influencé le territoire actuel du delta du Danube on a essayé de reconstituer les paléodeltas et les paléorivières qui se sont formés pendant l'intervalle compris entre le Pléistocène inférieur et le Holocène.
On remarque l'existence de deux hauteurs prédeltaïques (Letea et Caraorman) qui ont fonctionné comme barrière pour les sédiments transportés par le Danube. En même temps ces deux témoins d'érosion constituaient une ligne de littoral qui séparait une zone occidentale lagunaire et une autre orientale, marine. Cette ligne du littoral située entre Jibrieni et le promontoire Dunavse présentait sous la forme d'un cordon littoral de type flèche.
En analysant plus de 100 forages qui ont été réalisés dans le cadre du delta du Danube nous avons mis en évidence deux couches de tourbe: la première située à des profondeurs comprises entre 25 m et 35 m, seulement le long du bras Sf. Gheorghe; la deuxième, située à des profondeurs comprises entre 3-10 m, étant présente au long du bras Sf. Gheorghe et aussi au long du bras Sulina.
Les données obtenues confirment le fait que le plus vieux bras du delta du Danube c'est en même temps le plus méridional (Sf. Gheorghe), pendant que Sulina, le bras médian, est le plus récent.
L'évolution du territoire deltaïque est mise en évidence par rapport aux mouvements eustatiques spécifiques pour la mer Noire mais aussi par rapport à ceux de la mer Méditérranée.

NIKOLAI N. ROMANOVSKII

Icing formation and topography in the valleys of the East Siberian Mountains

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The influence of groundwater icings can be traced in the deposits and topography of most valleys of the East Siberian Mountains. Reported annual volume of icing formation in winter, followed by melting in summer, exceeds 19 km^3. As a result, icing formation influences runoff and constitutes a strong topographic forming periglacial process. Under the icing impact, there are oval broadenings (icing glades) and gravel-pebble deposits without matrices (icing alluvium). Continuous permafrost occurs in the East Siberian Mountains, and is found as well beneath the thin cold mountain glaciers. Climate is severe, extreme continental, with a thin snow cover. Intensive tectonic activity and high thermal flux are characteristic of the region. Taliks are linked to the river channels and tectonic faults only. These are the zones of active recharge, runoff and discharge of ground water; surface runoff in winter does not exist. All these are favorable conditions for icing formation at the sites of ground water discharge. Icings and icing glades occur in the same areas.

Icing size, annual duration, and their impact on the topography increase zonally northward. Most large icings in the mountains are associated with the bottoms of tectonic depressions. Upriver, the icing size decreases. Perennial migration due to seismic shocks, modern tectonic movements, and perennial dynamics of geocryological conditions is typical for groundwater icings. As a result, icing glades are much larger than the size of the contemporary icings.

During the cold Pleistocene periods in many parts of the region mountain valley glaciation was developed. Due to the thickness of valley glaciers, subglacial taliks existed serving as groundwater recharge sites. Bottom melting of ice took place to recharge ground water of the mountain massifs with melt water passing through these subglacial taliks. The main discharge of this water was under the glacier edge and directly below where the thickness of permafrost was considerably greater. As a result, large periglacial icings and icing glades formed. At the stage of glacier degradation, icings shifted up valley to form step-like glades. The main part of those icing glades are now relicts and icings are no longer formed within them because of lack of groundwater recharge and the continuity of permafrost.

CARLES ROQUÉ & LLUÍS PALLÍ

Ancient submerged beaches of the Costa Brava (Girona, Spain)

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Some cemented gravel and sand deposits laid in the form of platforms parallel to the coast line were discovered in different places of the Costa Brava under the sea level. Their lateral extension is decametrical and their amplitude is metrical. Their thickness does not exceed 2 m. They always present a slight inclination towards the open sea. Until today, they were found in Platja Fonda (Begur); Tamariu, Llafranc and Calella (Palafrugell); Cap de Planes (Palamós); Platja des Monestri, Cala de la Roca del Paller, Cap Roig and Platja de la Belladona (Calonge); Cala del Pi (Platja d'Aro); Sant Pol (Sant Feliu de Guíxols); Cala Futadera, Cala Giverola and Mar Menuda (Tossa). These platforms had been divided into two groups according to their depths. The first, the most abundant, is the one that integrates all the platforms which are situated at a depth fluctuating between 0 and 2.5 m under the sea level and that we call superficial platforms. The second one is constituted of those encountered between 2 and 5 m under the sea level and that we call deep platforms. The latter is less abundant.

In the locality of Sant Pol (Sant Feliu de Guíxols) one of the platforms had been studied in detail. Three superposed levels were observed: a) The upper level. Its top is situated between 0 and 1.5 m under the sea level, its thickness measures 0.8 - 1 m. It is composed of cemented and very well rounded coarse sand and gravel. It contains eroded fragments of ceramic and bivalve shells. This level corresponds to the group of superficial platforms. b) The intermediate level. Its top is encountered between 1.75 and 2 m under the sea level. Its thickness fluctuates between 0.3 and 0.5 m. It concerns a deposit of carbonated composition, formed by supplements incrusted by coralline algae which wrap wall rounded quartz grains. In this level too ceramic fragments appear but they are less eroded than those in the upper level. c) The lower level. It was observed at a depth of 2-5 m. Its minimun thickness is 0.2 m and its lower part is not visible. It is composed of strongly cemented medium to fine sand. This level is related to the group of deep platforms.

All the studied submerged platforms correspond to ancient beaches deposits, whom compositional and textural characteristics were very similar to those that exist today in this coast. At the moment of its sedimentation the sea level was slightly lower than today's position. As for the composition of the cement that binds those sediments, basically constituted of high magnesium calcite, it points out that its precipitation took place in a marine environment. Thus, the composition of the intermediate level of Sant Pol's Beach indicates some conditions of low energy and without terrigenous supplies. Both sedimentary periods relate, probably, to each relative rising of the sea level.

The age of these beaches was established from the archaeological remains which appear in the platform of Sant Pol and the absolute dating carried out. Thus, the fragments of roman amphora recollected in the intermediate level of Sant Pol date it to a year in-between 40 A.C. to 5 P.C. Given that they are enveloped by incrusting algae and that they are not much eroded, we then consider that these materials are contemporaneous with the formation of this intermediate level that can be dated to the year 0. Besides, a sample of it had been analysed in order to determine its content of C_{14}. The obtained value, of between 112 A.C. to 12 P.C., coincides with the values furnished by the archaeological materials. From the upper level too some

fragments of roman ceramic, which date to the I and II centuries P.C., had been recollected. Given their erosion grade, these materials are slightly prior to the sedimentation of this level and by extension to the remaining superficial platforms.
The intermediate level of Sant Pol Beach, which had deposited during a phase of relative rising of the sea level, correlate chronologically with the warm pulsation of the Roman Era. The upper level seems to have deposited during a phase subsequent to a drop of the sea level. Up to now it couldn't have been possible to precise neither the age of the sedimentation of the lower level or the cementation of the upper level.

MATTI J. ROSSI

Morphology of Postglacial lava flow fields in Iceland

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Volcanism in Iceland is mainly concentrated in the neovolcanic zone where active rifting episodes take place. There are strong indications that lava production rate in the neovolcanic zone was at its highest during the early postglacial period. In the later part of the postglacial period the lava production has decreased. The early peak in lava production after deglaciation can be explained by the rapid isostatic rebound of the thin Icelandic crust that induced magma production and extensional tectonics (Gudmundsson, 1986). Three main types of lava flow fields are recognized: (1) monogenetic shield volcanoes, (2) regional lava flows from volcanic fissures, and (3) lava flows from central volcanoes. Lavas from shield volcanoes and the regional lava flows are dominantly basaltic in composition, whereas lava flows from central volcanoes often vary from basalt to more evolved types.
Monogenetic shield volcanoes were formed mainly in the early Holocene epoch. The cone of a shield volcano forms from successive lava lake overflows which are of highly vesicular shelly-type pahoehoe. A widespread apron surrounding the cone forms from denser, tube-fed pahoehoe. The apron that surrounds the cone is commonly much more thinner than the cone. However, it is often areally more extensive and often more voluminous than the cone. The largest monogenetic shield volcano, Skjaldbreidur, has a volume of approximately 15 km^3. A shield-producing eruption has alternating episodes of lava lake overflows and tube-fed delivery to the distal parts of the flow field. In the late stages of eruption, the cone volume increases in response to the increased amount of rootless outpouring on the cone flanks (Rossi, 1996). Lava-inflation structures, mainly flow-lobe tumuli, are the most prominent features of the lava flow fields of shield volcanoes. Flow-lobe tumuli gradate into lava rises, which are larger inflation structures but both structures have a similar mode of emplacement. Each flow-lobe tumulus is an individual flow-unit that inflates and forms tension cracks in the lava crust. Flow-lobe tumuli are generated by inflation of the lava crust as a result of magmatic overpressure in the associated molten lava core (Rossi & Gudmundsson, 1996).
Regional lava flows erupt from volcanic fissures. Fissures commonly occur in swarms which are 5-10 km wide and 40-80 km long. Regional lava flows typically have aa surface textures and their flow fronts are fed by open lava channels. Eruptions of long duration may develop complex lava flow fields with morphologies varying from tube-fed pahoehoe lavas to aa and blocky lavas with open lava channels. Lava from the Laki fissure eruption is one of the most voluminous regional lava flow with a volume of approximately 12 km^3.
Lava flows at central volcanoes are fed by volcanic vents that are connected to shallow magma chambers. Differentiation of the primary magma is common to these magma chambers. Therefore, many lava flows from central volcanoes possess an evolved chemistry. Generally, evolved magmas have higher viscosities than the primary magmas and the resulting lavas rarely possess pahoehoe morphologies. At Krafla central volcano, however, lava flows in the proximal (near-vent) parts of the flow fields have smooth sheet-flow surfaces. At greater distances the lava flows develop aa and blocky surfaces, and the lava delivery occurs through open lava channels.
Lava surface morphologies are controlled not only by variation in the rheological properties of the lava, but also by supply rate at the vent and the amount of branching of the lava flows. There are strong indications that shield volcanoes were erupted at a relatively low effusion rate. These lavas are dominantly of pahoehoe type. Regional lava flows may have erupted at higher rates. The strong shear forces in lava flows that are supplied at a high rate could be the main reason for the development of broken aa and blocky surfaces.
Open lava channels are common features of regional and central-volcano lava flows. A lava channel supplies lava from the vent area to the middle and distal parts of the flow. Lava flows are non-Newtonian substances and their margins stagnate because lava has a yield strength. In the middle parts of the flow, however, shear stresses exceed the yield stress of the lava and the middle flow region remains active. In theory, the rheological properties of a lava flow can be calculated from the levee and channel dimensions, but several factors complicate that approach. The 1984 open-channel lava flow at Krafla demonstrates that during the lava emplacement several factors, such as varying supply rate at the vent, may lead to overflow from the open channel to the margins of the flow. Thus the initial channel and levee dimensions of a lava flow may change drastically during eruption. If lava continues to flow through a channel at a high rate for a longer time (several days to weeks), a lava channel may become severely eroded and, as a consequence, become much wider than the original lava channel.

MARK E. RUSE & MR. PEART

The spatial variability of fallout Caesium-137 in Hong Kong

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An understanding of hillslope sediment movement is important both to theoretical and to applied geomorphology. The standard approach to its study includes long-term monitoring of sediment yield and erosion rates from drainage basins or controlled erosion-plots. Another technique is to use the fallout radionuclide Caesium-137 (^{137}Cs) as a tracer of sediment movement. This provides useful data aggregated for a period of around 40 years without the need for time-consuming monitoring.

The use of ^{137}Cs in this way depends substantially on a valid assessment of an input reference value. This issue has gained particular importance as recent work suggests the spatial distribution of ^{137}Cs in the landscape is more variable than previously assumed. Consequently there is a need for research into the range of ^{137}Cs values both at input sites and between different sites. Better still would be an improved understanding of the controls on ^{137}Cs behaviour in the landscape and of the influence of differing environmental characteristics.

To these ends the present research has investigated ^{137}Cs tracer input sites in the monsoonal tropics. Hong Kong is a good location to test the variability of ^{137}Cs in the landscape because of the large range of mean rainfall totals (*ca.* 1500 to 3000 mm per annum) within a small area (*ca.* 1000 km^2). As rainfall controls ^{137}Cs fallout from the atmosphere, ^{137}Cs input totals are expected to reflect this pattern. The paucity of ^{137}Cs studies in the tropics coupled with tropical air circulation patterns cast some doubt on the possibility of using ^{137}Cs as a tracer in such areas. Preliminary assessments show that the method is applicable in the Hong Kong environment.

Ten input sites within the Territory have been chosen to reflect different rainfall totals. Qualification of the uneroded status of the input sites was made by assessing a profile of ^{137}Cs totals in 2 cm increments, the form of the profile reflecting the movement of ^{137}Cs in the soil. Results from some other locations confirmed the difficulty of selecting input sites that have experienced no significant sediment movement in the past four decades.

Some basic soil parameters of the profile samples were also evaluated. This permitted a correlation assessment of controls on ^{137}Cs behaviour. This includes the ability of the soil to fix ^{137}Cs and subsequently the ability of natural processes to move it.

Another major component of the research was to assess the variability of ^{137}Cs totals across the input sites. Ten core samples have been taken at each input site to characterise the variability of ^{137}Cs within a small area. This permitted an evaluation of sampling methodology, such as the number of samples needed to make an accurate assessment of input totals. Such data are essential if the technique is to be useful to environmental managers.

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Controls on the geomorphic impact of the November 1996 jökulhlaup, Skeiðarársandur, Iceland

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This paper examines the spectacular geomorphic and sedimentary impact of the November 1996 jökulhlaup on the proximal zone of the Skeiðarársandur, Iceland. Detailed comparison of pre- and post-jökulhlaup river morphology and sedimentology has allowed an assessment of the main controls on the geomorphic effectiveness, of this event in a variety of different ice-marginal and proglacial settings.

A volcanic eruption beneath the Vatnajökull ice cap began on September 29, 1996. Over the next month some 3.2 km^3 of meltwater travelled subglacially into the Grimsvötn caldera, raising the subglacial lake to a critical level. The jökulhlaup began on the most easterly outlet river, the Skeiðara, at 0800h on November 5, and reached a reported peak discharge of 45000 m^{3}s^{-1} within 12 hours. The jökulhlaup also burst from numerous other locations, including single conduit outlets and crevasses up to 2 km in length. Most outlets were in new locations, although some existing outlets were occupied and enlarged. On exiting the glacier, jökulhlaup flows coalesced into four other main outlets, each successively occupied from east to west: namely, Skeiðara, Saeluhusavatn, Gigjukvisl and Sula.

Specific flood powers are estimated to have reached 8000-16000 Wm^{-2} at the moraine constriction on the Gigjukvisl, decreasing to 400-900 Wm^{-2} within 2 km downstream. Flood flows on the Gigjukvisl initially included large debris lobes that surged from the glacier margin at velocities up to 6 ms^{-1}. However, the main flood was dominated by watery, turbulent runoff. At flood peak, 60-100 x 10^{6}m^3 of water was temporarily stored in a backwater lake upstream of the Gigjukvisl moraine constriction. Vast numbers of ice blocks, many over 10m in diameter, were transported by floating, rolling, and sliding, depending on their sediment content and density, many reaching the offshore zone, 24 km downstream. Huge volumes of sediment were transported by the jökulhlaup resulting in all extensive sediment plume offshore of the Skeiðara, although only relatively small sizes were transported, especially in the Gigjukvisl channel.

Grounded ice blocks, especially those forming large clusters on the highest bar surfaces, acted as major sources of resistance to the flows, equivalent in effect to those imposed by boulders of similar dimensions. The backwater zone played a crucial role in (i) delaying and attenuating the flood hydrograph, and thereby reducing peak flow competence; (ii) acting as a sediment trap, thereby releasing mo-

stly fines to the Gigjukvisl outlet river; (iii) providing a temporary flotation storage area for large volumes of ice washed out from the glacier; and (iv) resulting in complex patterns of subaerial and subaqueous deposition at different stages of the flood rising limb, followed by complex patterns of scour and reworking during the waning stages of the flood. The melting of partially and completely buried debris-rich ice blocks will result in a distinctive 'kettled' appearance, perhaps generating «rimmed» or «till-fill» kettles.

This study demonstrates the importance of glacier margin position in relation to proglacial topography as a major control on large-scale erosional patterns and depositional styles, with greatest impact occurring where flows were most severely modified by topographic constraints.

YURY V. RYZHOV

Gully erosion in the south part of East Siberia

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Gullies in forest-steppe and steppe landscapes develop cyclically during quaternary period. A number of modern erosion forms are resulted from ploughing up of land, felling, overgrazing within 100-200 last years. The most large districts of gullies are concentrated in the Minusinsk depression, Irkutsk-Cheremkhovo plain, the Selenga river basin, the South-East Transbaikalia. Areas with density of erosion forms of 1-10/100 km^2 and 11-25/100 km^2 predominate. Maximum (more 50/100 km^2) is found in loess deposits.

Gullying occurs together with other exogenous processes (eolian, criogen) and it has different intensity. In semiarid (dry steppe) conditions of Tuva and Transbaikalia depressions a linear erosion is local process, gullies develop rather intensively. In semihumid (forest-steppe) lanscapes erosin form are of maximum density and growth. Humid (taiga) districts are characterized as well as semiarid, gullies overgrowth intensively.

Gully development in spring (snowmelt period) and during in summer, when rains and dounpours fall. Extremal phenomena (strong rain storms and abundant long rains) determine erosion form development. During these periods gullies in length of 100-1000 m are formed, growth is more than 10-100 m/y. Average for many years rate of erosion form in loess deposits is 2-5 m/y, in sand, sandy loam, loam - 1-3 m/y, in clay, marl, sandstone - 0,2-0,5 m/y.

Development of rills end gullies are consider for forest-steppe (Tunka) and steppe (Barguzin) regions of Pribaikalie in structure of exogenous processes. In Tunka region (depressions and spurs) mean annual precipitations are 350-515 mm, leading geomorphic processes - fluvial, eolian, erosional. Forms of cut spread on 6% of area. In Barguzin region (one depression) fall average 200-327 mm of precipitation, domine fluvial and eolian processes. Erosion is diffuse on 4% of area.

Gully growth in the Tunka region on 1985-1995 yy. were 0,2-55,5 m/y, mean of many years - 1,3-1,5 m/y. For 53 years number of erosin forms became more than in two times. The four types gullies evolution were determined. In Barguzin region erosion forms grown in 1985-1991 yy. on 0,1-69 m/y, in average for many years - 1 m/y. Development and cover gullies are observed. Erosion is local, momentary process and it replace on eolian process.

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Landslides hazard modelling using Gis and logistic multiple regression

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Preliminary field investigations have revealed the existence of many shallow landslides on steep forested areas in the upper headwaters of Traralgon Creek catchment (176 km^2) in Gippsland, Victoria. Multivariate statistical techniques were applied to determine the probability of occurrence (i.e. risk map) of landslides as a function of statistically significant environmental variables. The Geographic Resources Analysis Support System (Gis/Grass) was used to derive 9 digital inputs for the logistic multiple regression model. The independent topographic variables used in this analysis were elevation, aspect (north-south and east-west components) and slope maps, which were derived from a digital elevation model of basin topography at high resolution (25 x 25 m grid cells). Vegetation index and land use maps were classified from multi-thematic Landsat satellite imagery. The Landsat bands (bands 2, 3, 4 and 5) were initially normalised to minimise the shading effects on vegetation classification due to rugged steep terrain in the upper areas of the catchment. A non-Lambertian based backwards radiance correction transformation using Minnaert constant was conducted for topographic normalisation of the four Landsat TM spectral bands. Other independent variables were geology (mainly dominated by sedimentary and volcanic rocks) and proximity to roads and stream lines maps.

Landslides in the catchment were identified from stereoscopic coloured aerial photographs (scale 1:15,000) and site visits for ground truthing. Locations of the landslides (total number of active cells = 131) were determined, mapped and imported to Grass digital database. The resulting landslides map was used as the dependent variable in the regression analysis. The developed logistic regression model determined the probability of occurrence of individual cells based on the values of input variables at both active sites and a set of randomly selected inactive cells. The result is a map of continuous probability values that was discretized into five categories and overlaid with active sites for comparison between observed landslides and model predicted hazard sites. Reasonable agreement between observations and predictions was observed. The model revealed higher risk of landslides at steep forested sites that were located close to road networks and that had a low vegetation index. Most of active shallow landslides were located on brown loams and clays with dark and friable loamy shallow or moderately deep topsoils.

RUDOLF SAILER & HANNS KERSCHNER

Three-dimensional reconstruction of Younger Dryas glacier surfaces with a raster-based Gis

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The Ferwall group is situated at the western margin of the crystalline central Tyrolean Alps. In the central part of the group, there are U-shaped, almost straight valleys (Schoenferwall valley, Fasul valley) with simple topography. During the Egesen Stadial (Younger Dryas), both valleys were occupied by large valley glaciers, which deposited beautifully developed end moraines at their confluence. The extent of the largest Younger Dryas glaciers is well documented by the end moraines and lateral moraines in both valleys. In the Schoenferwall, at least two more morainic systems of later phases of the Egesen Stadial are preserved.

Recent glaciers, the well documented 1850 (Little Ice Age) glacier extent and the well developed Egesen moraines allow the reconstruction of the maximum depression of the Younger Dryas equilibrium line altitude (Ela) in that area (ca. –350 m relative to 1850). The Ela depression correlates well with other areas of the western part of the central Alps. The morphology of the moraines (well preserved, steep slopes, large amount of boulders) is also typical for the Egesen Stadial. Therefore a correlation with the well dated Egesen moraines at Julier pass in Switzerland (Ivy-Ochs & *alii* 1996) is easily possible. From that point of view, the moraines at the confluence of Schoenferwall and Fasul valleys were deposited during the earlier part of the Younger Dryas (ca. 12.000 cal. years B.P.), indicating the glacier's response to the climatic collapse at the beginning of the Younger Dryas.

The simple topography of the valley and the well defined boundaries of the Schoenferwall glacier during the Younger Dryas allow a detailed numeric calculation of its long profile (Nye 1952). Considering the wide range of Geographic Information System Tools available, we will try to marry the complexity of the numerical reconstruction of glacier surfaces with the possibilities of the raster-based Gis module of Arc/Info.

The well defined spatial information on the former glacier margins (lateral and end moraines) as well as the Digital Elevation Model (Dem) are the basis of our Gis-based three-dimensional reconstruction of the Egesen-Maximum of Schoenferwall glacier. With Nye's mathematical model and a Dem with a resolution of 25 meters a sufficient accuracy can be obtained. According to our model the long profile of a glacier can also be calculated if only a lateral moraine were found in an U-shaped valley. Vice versa, if there is an end moraine complex, it should be possible to reconstruct a glacier's surface and its thickness with a high degree of reliability.

Within the context of applied geomorphology, the final aim of the Gis-based modelling of a glacier tongue is to

show areas of potential sediment sources for debris flows or landslides. To verify this hypothesis, a GIS-based geomorphic mapping from air-photographs and in the field is used to map the existing debris flow and landslides and to overlay the results with the reconstructed landsurface as it was covered by the Egesen-Stadial (Younger Dryas) glacier in Schoenferwall valley.

KYOJI SAITO

Formation and evolution of alluvial fans in tropical- and temperate-humid regions

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The effects of climatic conditions upon distribution and sizes of alluvial fans are determined by statistical analyses in temperate humid Japan and Taiwan, and the tropical humid Philippines. Data were collected by use of topographic maps. The results are obtained as follows:

1. Distribution of alluvial fans

The alluvial fans with over 2 km, Qin area are 490 in Japan, 71 in Taiwan, and 129 in the Philippines. Rivers whose drainage basins are larger than 100 km, Qexist 474 in Japan, 50 in Taiwan, and 266 in the Philippines. The ratios of such rivers with fans are 25.9% in Japan, 58.0% in Taiwan, and 12.0% in the Philippines.

2. Relationships between development of mountains and distribution of fans. The development stages of mountains were estimated, based on variations of relief. Among rivers with drainage basins more than 100 km, Q ratios of rivers with fans are 0.0% in the earliest and early stage that is low relief energy, 5.7% in younger-middle one, 22.8% in older-middle one, and 47.6% in later one. Relief ratio is defined as a divided value of a relative height between an altitude of a peak and that of a valley mouth by a drainage-basin length. Relief ratios increase with the advance of the development stage of mountains. Drainage basins with large relief ratios have steeper river-bed gradients, and are apt to make fans to carry larger gravel around valley mouths. The high percentage 58.0% of rivers with fans in Taiwan strongly owe to large relief ratio.

3. Relationships between development of mountains and evolution of fans. Alluvial fan areas increase with the advance of the development stage of mountains, specially from younger-middle to older-middle, and from older-middle to later. Besides, larger fans have been built in the larger drainage basins in the advance of stage. Mountains in the older-middle stage with increases in denudation rates bring existences of fans and larger fans.

4. Relationships between climatic conditions and distribution of fans. Japan, Taiwan and the Philippines have 470 rivers with drainage basins larger than 200 km^2. The effects of five factors upon the existence of fans were calculated by discriminant functions. The five factors are drainage basin area, intermontane basin area, relief ratio, climatic conditions, and sedimentary environments. Based on the great generalized weight and the high frequency in the category of climatic conditions, it is concluded that the dominating factor for the distribution of alluvial fans is the climatic conditions. Sedimentary environments and relief ratios are also important factors. Climatic conditions were estimated to exert the greatest influence on the existence and the distribution.

Ratios of rivers with fans to ones whose drainage basin areas and relief ratios are similar are 12.9% in Hokkaido, or northern Japan, 47.5% in the coast of Japan Sea of Central Japan, 50.0% in the Pacific side of Central Japan, 13.1% in West Japan, 66.7% in Taiwan, 21.7% in the West Philippines, and 3.8% in the East Philippines. Debris supply is rich in Taiwan because of higher precipitation and larger discharge, as compared with Japan. The debris product was abundant in Glacial Age in Central Japan to prevail the periglacial area. Hence, Central Japan had good conditions for fans in those days. On the contrary, debris supply was poor owing to the less precipitation even in Glacial age in Hokkaido, and owing to narrower periglacial area in West Japan. The reasons have made fewer fans in these two regions. The fact that the West Philippines has more suitable conditions than those in Hokkaido and West Japan indicates that the climatic conditions with dry and wet seasons are advantage for fans. The most unfavorable conditions in the East Philippines can be explained in terms of poor coarse-material production under tropical climate and perennial rainfall.

5. Relationships between climatic conditions and evolution of fans. On the basis of equations between drainage basin areas and fan areas, fan areas in the Philippines are 110 to 120% and those in Taiwan are 120 to 160% as large as those in Japan. The fans in the tropical Philippines are small due to poor production of coarse materials as compared with those in Taiwan, but are large owing to abundant precipitation and high discharge in comparison with Japan.

NEIL E. SALISBURY

Seasonal and episodic erosion and mass-wasting in Dakota badlands

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Denudation of the South Dakota badlands involves surface fluvial detachment and transport (erosion), mass-wasting (including piping), solution, and removal of sediments by eolian processes. None of these processes are continuous, either spatially or temporally, within the study area. Rates of erosion and sedimentation were measured on badland slopes and pediments for a period of more than ten years.

Initially these measurements were made each fall and spring, until it was determined through regression analysis that total annual precipitation was a better predictor of erosion than seasonal precipitation. Nevertheless, it was noted that sedimentation, usually in the form of miniature mudflows, was more common in winter and on red clays. Erosion was more likely to be associated with intense summer thunderstorms, and on greenish sediments.
Channel cross-sections on the major stream eroding the wall escarpment were remeasured annually near the mouth of the basin, in mid-basin, and near the head of the surveyed reach. Knickpoints migrated upstream during this period, but with little evidence of overall downcutting. Rather, the channel reflects recurrent episodes of valley-wall collapse, resulting in short-term aggradation or damming of the stream flow; followed by periods of incision and removal of debris from the valley floor.
Thus, both mass-wasting and surface fluvial erosion move sediments downslope and downvalley, where they are stored for periods of time ranging from days to centuries. Episodes of major sediment removal and transport may be related to short-term weather/climate variations, or they may be the result of complex response. Different parts of the badland landscape may be geomorphically hyperactive, active, inactive/stable, or relict at various times. Active and hyperactive episodes tend to be short-lived, and replaced by long periods of inactivity or stability.

GAMAL MAHMOUD SALLOUM

Geomorphologic features controlling the radioactive anomalies in the Egyptian Granites

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Geomorphological study includes the description and analysis of landforms presented in studied areas in an attempt to reveal their geologic, geomorphologic and structural implications as well as their economic aspects.
The work involved relief and drainage analyses to ascertain the economic significance of the obtained results, the quantitative analysis of drainage network of some basins is made using statistical techniques. The drainage patterns give indications about the structural features which are the most convenient reason for thc radioactive anomalies in the Egyptian Granites.

ERGJIN SAMIMI

Albanian recent geomorphological maps

Geographic Studies Centre, Rr «M. Toptani» 11, Tirana, Albania

1. Vertical splitting 1: 500 000
2. Horizontal break 1: 500 000
3. Genetic types 1: 500 000
4. Inclination angle 1: 500 000
5. Tirana district, geomorphological map 1: 500 000
6. Project proposal for 1: 25 000 seaside, aiming to be the basis to build up the infrastructure and to help the agriculture.
7. Thoughts about map keys, mapdata and their analyses, their standardization and updating- such comments and critics over maps.

MARÍA MARTA SAMPIETRO VATTUONE

Geomorphology and archaeology in Tafí Valley (Northwest Argentina)

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The Tafí valley is in the pre-andean region of the Northwest Argentina. It is an intermontane valley were many geomorphological units formed during Late Quaternary can be observed (erosion glacis, cone-glacis, valley glacis, fluvial terraces and alluvial fan).
The development of these geomorphic processes finished about 4,000 BP when actual conditions were established. After that, there where some alternate dry and humid periods.
During prehispanic period it was occupied by the people of Tafí culture (*ca* 2,000 - 1,000 BP). It is included in the general period called Formative that represents the transition between hunter-gatherer economy to sedentary economy.
Several archaeological sites cover the valley on different relict situations. In order to detect geomorphologic evidence in the genesis and evolution of the Tafí settlement pattern a comparison of geomorphic pattern and archaeological sites was carried on.
Aerial photointerpretations in addition with detailed surface surveys and the study of stratigraphic profiles permit the establishment of the relationships between geomorphological units and type of archaeological settlement.
As a conclusion was established that agriculture terraces are related with alluvial fan and cone-glacis geoforms. In erosional paleoforms like erosion glacis and denudative slopes only circular and isolated constructions were detected. It was possible also to recognise the manifestation of occupation impact in the landscape and how this impact is reflected by edaphic profiles taken from prehispanic agricultural terraces.

PAOLO SANSÒ

The ancient landforms of the Apulia region (Southern Italy)

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The Apulia region constitutes the southwestern margin of the Adriatic plate in the central Mediterranean and it is considered to be a poorly tectonized area in the apenninic foreland. The Apulian foreland shows a rather uniform structure with a variscan crystalline basement and an approximately 6 km thick mesozoic carbonate platform sequence. This sequence is overlain by thin discontinuous Tertiary and Quaternary deposits, generally represented by thin carbonate-terrigenous sediments.

The landscape of this region is generally thought to be the result of morphogenetic phases which occurred during the Quaternary period, due mainly to the effects of relative sea level changes, tectonic and karstic processes. Nevertheless, a more careful analysis of the Apulian landscape reveals in several areas the occurrence of landforms developed during theTertiary.

Etchplains are the most common among these landforms as they are recognizable on the Gargano promontory, on the Murge plain and in the Salento peninsula. They formed during a long period of continentality during almost all the Tertiary when deep weathering of Mesozoic limestones was promoted by tropical humid or subtropical climatic conditions. Their evolution was probably interrupted by important Pliocene tectonic phases which broke up the etchplains into several surfaces, each one characterized by a subsequent differing evolution.

A wide etchplain characterizes the top surfaces of Gargano promontory. It is broken by NW-SE, NE-SW and E-W fault scarps, forming several surfaces at different altitude. The main, most elevated surface is located in the central area of Gargano promontory and presently slopes towards the NW between 900 and 450 m of altitude. Its surface lacks any lateritic cover, this having been stripped away by a well-developed drainage network (stripped etchplain); both the etch surface and the valleys are strongly affected by karstic processes which induced the formation of numerous dolines. The density of dolines varies in direct ratio with altitude up to 105 dolines/km^2, probably due to the diachronic removal of the weathering cover. The main surface is bordered to the NE by a lower plain, at about 500 m altitude, which still retains remains of the original lateritic cover. It is characterized by some broad colluvial dolines, generally alligned along main fault lines. On the southern side of Gargano promontory lowered strips of etchplain were smoothed by Pliocene and Pleistocene marine transgressions.

The Murge Alte landscape is represented by a wide stripped etchplain gently sloping NW between 450 and 679 m altitude. It is bordered by fault scarps to the W and SE and by a flight of steps of gently sloping seaward marine surfaces to the N and NE. In detail this plain is marked by isolated areas of high relief and broad depressions. The former usually represent the highest points of low ridges running NW-SE which rise 50-100 m above the surrounding areas, while the latter represent wide, flat endoreic basins elongated NW-SE which retain a Late Pleistocene volcanoclastic cover. The particular morphology of this etchplain is probably due to the presence in the rock body of parallel zones of widely-spaced and closely-spaced joints, associated with bordering faults oriented NW-SE formed in the Lower Pliocene.

On the Salento peninsula, a Tertiary etchplain along with its lateritic mantle was fossilized by Late Miocene calcarenitic deposits. However, on the horst of Serra di Poggiardo the Miocene cover has been eroded so that a small part of this etchplain has been re-exhumed. This surface, placed at about 120 m of altitude, is represented by a rolling plain characterized by broad, wide shallow depressions and showing a lateritic cover of variable thickness.

Along the southeastern coast of the Salento peninsula another impressive pre-Quaternary landform has been recognized. In fact, the general flatness which characterizes the landscape of the Salento peninsula is abruptly broken along its southeastern coast, stretching from Capo d'Otranto to S. Maria di Leuca, by a steep, high slope. Recent geological research suggests that this landform could be the morphological effect of a carbonate platform margin evolution. In fact, from the Late Cretaceous onwards the eastern margin of the Apulia Platform became established roughly along the present coastline of southeastern Salento. On this slope reef depositional systems of Paleogene and Miocene age developed. The shape of the present coastal landscape still reflects the originary Tertiary reef morphology superimposed on the late Caretaceous platform margin notwithstanding the subsequent morphological modifications represented by younger fault scarps and some Middle-Late Pleistocene abrasion platforms.

SUBIR SARKAR

Landslides in Darjiling Himalaya, India

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Landslide is the most pervasive of natural problems that undermine the economic and cultural development of Darjiling Himalaya. The diversity in slope components, geometry, site and situation, micro-regional susceptibility to degradational processes, micro-geology, micro-climate, depth of soil, its physical and chemical properties, vegetation with differential canopy and root system, unplanned growth of settlements and roadssewer systems, imprudent land-use etc. have led to recurring landslides. Record since 1849, show a sharp acceleration in the rate of devastating slide occurrences, leading to great loss of life and heavy damage to land and property. Extensive heedless deforesta-

tion, tea plantation, haphazard construction, inadequate drainage etc. have led to the establishment of vicious cycle of degradation, heavy and concentrated rainfall aggravating the problem further. The situation has deteriorated further in recent times, the last two decades have witnessed the landslides in Darjiling hills. The study reveals that each slide has its own peculiarities and its initiation is not due to any single factor. Of the various factors, water has the most deleterious effect. Some of the slides have admittedly been caused by toe erosion. Many recent landslides are caused due to unscientific and unplanned usages of hill slopes and valleys. Every slide is an individual problem, despite their common initiating principles. The solution to each problem has to be determined for individual site, though the solution may lie in combination of a few well establish methods viz. retaining structure, drainage, afforestation, rock bolt, sheet pile and restriction to settlement and commercialisation of hill slopes.

MOHAMMAD REZA SARVATI

Geomorphology of the Ghom playa (Kawir of Ghom)

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Almost 60 interior basins of the Iranian arid Highland have no outlet for its waters. The run off normally disipated by infiltration in to the ground and evaporation from lakes or swampy areas, for which, if salty, it is called Kawir in Iran (the commen name for playa). The northeastern half of the Ghom Watershed contains Daryache-e-Howz-Soltan and the Kawir of Ghom. This Kawir situated in the eastern part and occupies the lowest part of the Ghom watershed.
Igneous and evaporitic rocks comprise mostly the adjacent northeast and southeast ridges and a large dune field borders its southern margin. The Ghom playa has the general form of an equilateral triangle. The salt crust covers tow-thirds of this playa. This crust is sharply delineated by polygons. There are niether beaches nor beach remnants have so far been reported around the margin of Ghom playa.
This study will attemped to find morphologic and stratigraphic evidence which can indicates the previous periods of erosion and deposition. The author acknowledges Dr. Krisley's work which provides an important source of information and a basis for further studies.

OXANA S. SAVOSKUL

Holocene moraines and rock glaciers in Kamchatka, Russia

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In the mountains of Kamchatka, an area with modern glaciation covering 874 km^2, Holocene glacial landforms of several age generations are recognized. During Holocene numerous volcanoes were active in Kamchatka and the largest eruptions produced about 20 key tephra layers, covering large areas of the peninsula. These tephras identified and dated recently (Braitseva & *alii*, 1995), provide an excellent tool to date the glacial forms. An application of tephrochronology as well as use of historically dated lava flows, and debris avalanches permits also selection of several control surfaces to calibrate the lichen growth curve of *Rhizocarpon geographicum* L. (DC), which can be used to provide more detailed dating of the mid-late Holocene glacial deposits.
From the features of soil development on the moraines and tephra findings, the Holocene glacial forms may be divided into three age groups, i.e. formed prior to 7600-7700 yr BP (Early Holocene); between 6000 and 1400-1500 yr BP (post-Hypsithermal or Neoglacial); and after 1100 yr BP (Little Ice Age, the last prominent phase of the Neoglacial advances). The Early Holocene moraines were deposited during the most extensive Holocene advance (14 moraines). Lichenometry gives an evidence of multiple Neoglacial advances at about 5400-5500 (2 moraines), 3500-4000 (4 rock glaciers), 2300-2700 (3 moraines), 1700-2100 (4 moraines), 1100-1400 (?) (2 moraines) (L) years ago. The first two advances were the most extensive Neoglacial advances nearly at all studied sites. The smaller in magnitude Little Ice Age advances occurred at about 800-1100 (?) (1 moraine), 300-500 (7 moraines) and 100-160 (11 moraines) (L) years ago.
At some sites, Neoglacial deposits are represented by active rock glaciers, related to present glaciers and obviously of glacier origin. However there exist another type of rock glaciers. These are scallop-like ranges attached to the slopes and partly covered by debris from the slope, which could be regarded as debris rock glaciers in terms of Martin & Whalley (1987). From the position and apparent relation to Late Glacial/Early Holocene terminal moraines these rock glaciers can be qualified as rock-glacierized Late Glacial/Early Holocene lateral moraines. Lichenometric dating of the debris on the top of these forms shows that the rock-glacierization occurred in the Neoglacial (Savoskul & Zech, 1997).

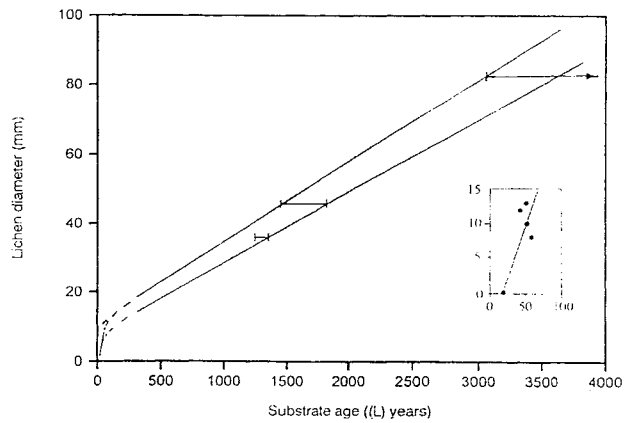

FIG. 1 - *Rhizocarpon geographicum* L. (DC) growth curve (after Savoskul & Zech, 1997).

TAKANOBU SAWAGAKI[1,2] & KAZUOMI HIRAKAWA[1]

Streamlined glacial erosional bedforms along the Soya Coast, East Antarctica

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Drumlin-shaped hills were identified on the ice-free areas along the Soya Coast of Lützow-Holm Bay, East Antarctica (fig. 1). In the ice-free areas along the Soya Coast, distribution of morainic detritus is limited to depressions behind hillocks, and well polished bedrock are widely exposed (fig. 2). The erosional bedforms are found mainly on the gneisses, and are rare on the calcaleous rocks that have been eroded and fluctuated more intensely to not preserve the erosional forms than other rocks. A strong control of the gneissic structure on erosion is revealed by the regional change of the long axis' trend of streamlined bedforms.

Some bedforms in the rock surface are classified into crescentic transverse ridges and tadpole rocks. These bedforms are accompanied by small erosional marks such as mussel-shell-shaped shallow depressions, sickle-shaped marks, comma forms, transverse troughs, stoss-side furrows spindle flutes, cavettos, and furrows (fig. 3). These marks support the interpretation that the bedforms were sculptured by subglacial meltwater.

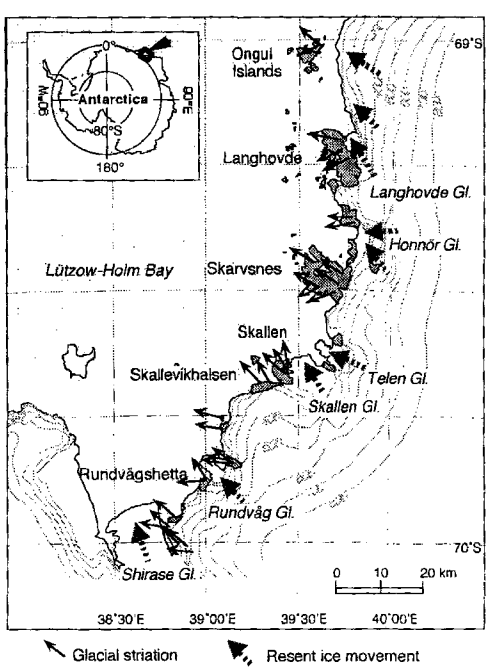

FIG. 1 - Index map of the Soya Coast. The black arrows show the present ice movement.

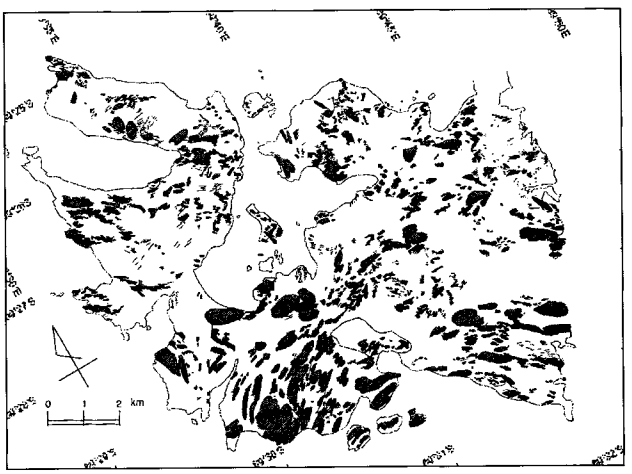

FIG. 2 - Distribution of streamlined bedforms in the Skarvsnes ice-free area.

FIG. 3 - Sculptured erosion bedform in the Soya Coast. Furrows (f) were formed uncontinuously around the obstacle with rat-tail forms (rt) on down side and comma forms on the upper side.

Some tadpole rocks are superimposed on large roches moutonnées, and we interpreted that these two kinds of landforms had different modes of formation.

Concerning the formation of the drumlin-shaped bedforms, a theoretical examination was carried out to estimate the conformity of water flow beneath ice sheet to underlying topography. For this examination, it was assumed that flow of water was controlled by ambient pressure gradients beneath the ice mass, and that the former ice sheet responsible for these bedforms extended to the western edge of the presently ice-free areas along the Soya Coast.

Once a suitable ice surface model is determined by try-and-error, good conformity of hydraulic gradients to the bedform distribution is recognized. Although there is the strong control of bedrock structure to the erosion, it is emphasized that the conformable ice surface represents the former ice sheet that took part in the development of the hills, and the subglacial water flow could be controlled by a single ice mass in short period without significant change of the ice surface profile.

José Manuel Sayago

Geomorphic indicators of present and former environmental changes in the sub-tropical region of Northwestern Argentina

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The perspective of future climatic changes generated by the greenhouse effect have increase the importance of landform as key indicators of the future environmental changes. Present geomorphic processes and the tendencies in relief evolution would be a valuable information on the prediction of the global changes effects.
In this paper an overview of geomorphological processes and its relationship with the future changes in the pre-Andean sub-tropical region of Argentina is presented. Geomorphological indicators are analyzed from different environmental condition: a) Natural region in which anthropogenic influences are incipient allowing the permanence of the primitive landscape organization. b) Regions in which the anthrogenic disturbance is so high (as for instance the agrarian ecosystems) that the primitive landscape structure have been strongly changed, and c) Urban regions in which the geomorphological processes play an important rol on its present and future evolution.
As a conclusion and recommendation some comments are included (based in regional case study) about the perspective (spatial and temporal) in which geomorphological indicators would be integrated into predictive models of the future landscape changes. Finally, a proposal for the inventory of geomorphological indicators and trends in environmental change at regional and macro-regional level is included.

Daniel Schaub, Christoph Wüthrich & Christoph Seiberth

How landscape features influence sediment yields (a comparison of two investigaton areas in North West Switzerland)

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A long-term investigation on nonpoint-source pollution of water courses due to soil erosion has been conducted in two intensively used agricultural areas of north west Switzerland, the loess covered quaternary hill country of the High Rhine valley (Hrv) and the Swiss Jura Plateau (Sjp) with clay-rich soils. Rainfall erosivity is almost equal for both landscapes, and similar crop rotations are practised. The field investigations have been carried out at three scales: the test plot scale, the field scale, and the catchment scale. Soil losses from bounded runoff plots in clean-tilled continuous fallow were in the same range for both areas. On farmer-managed fields, however, the rates were higher in the Hrv. Moreover, the contribution of soil erosion to the sediment yield remains low in the Sjp catchments, whereas in the Hrv a considerable proportion of the eroded soil is removed from the arable land. Thus on the catchment level, there is an even greater difference in the significance of soil erosion processes between the two test regions. The low soil erosion sediment delivery ratio of the Sjp is surprising because here landforms such as thalwegs cause concentrated flow erosion which should result in longer flow distances. Moreover, the low permeability of the underground entails a high natural drainage density. Both factors are supposed to favour a close link between fields and receiving stream. On the other hand the high sediment yield in the Hrv is astonishing because there are no perennial streams.
The explanation of this unexpected behaviour starts from the fact that for single soil loss events the sediment concentration in surface runoff is generally higher in the SJP than in the Hrv because runoff generation is determined by higher thresholds of rainfall intensity, and frequently intact aggregates, i.e. coarser particles, are transported. Decreasing flow velocity due to lower slope steepness causes the exceeding of the transport capacity at the footslope and thus to the deposition of the eroded sediment within the same field. The typical Sjp topography with concave slopes (and thus level footslopes) enhances this effect of short transport distances, compared to the linear slopes in the Hrv. Moreover, the land use pattern in the Sjp contains considerably more elements (grass strips, buffer zones) which impede or intercept runoff. The land use pattern is determined by the extension, shape and areal distribution of single fields, drainage ditches, paved roads, sealed surfaces, and the presence of linear elements such as hedgerows. Based on these results a simple Gis-incorporated model is being developed. It describes sediment and nutrient fluxes in the catchment scale with the help of statistical relationships between weather conditions, geomorphological features, soil properties, as well as land use and sediment retention functions of different landscape elements. In Swiss cultural landscapes which have a long history of human activities, the land use pattern has an important function in determining the range of lateral sediment movement. Changes of the land use pattern thus offer opportunities for erosion control measures. In a recent report of the Swiss government on «Agronomic Policy 2002», direct payments for alternative tillage systems and nature conservation measures have been announced. It is expected that the vast majority of Swiss farmers will have shifted to such programs by the turn of the millennium. The eligibility depends on the observance of several quality aspects, e.g. the reduction of soil erosion. Our model can therefore be used as a planning tool to identify areas at higher risks of water erosion and to select the best locations for the above-mentioned conservation measures, such set-asides, vegetative filter strips or grassed waterways to mitigate effects of runoff and erosion on water quality.

HANS W. SCHENKE[1] & GLEB B. UDINTSEV[2]

Geomorphology of the western continuation of the Norh Weddell Rift

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The North Weddell Rift correspond to the axial zone of the American-Antarctic Ridge, the south-west branch of the mid-oceanic ridge system of the Atlantic Ocean. The western continuation of the rift have been studied during the 21 cruise of R/V «Akademik Boris Petrov» in 1995. The multi-beam echosounding were made in three areas of the rift: to the south of the southern end of the South Sandvich Island Arc, on the South Scotia Ridge between South Orkney Islands and South Shetland Islands and in the western tip of the Bransfild Strait between South Shetland Islands and Antarctic Peninsula. The data obtained demonstrate a chain of rifted valleys, correspoinding to punctiform propagation of the rift into the body of the continental massive of the West Antarctic. The propagation of the rift is accompanied with emergence of the crustral blocks near the western tip of it (up to 2 km) in the Bransfild Strait and with submergence of blocks in the eastern part of the rift (down to 2 km), and with development of volcanic cones in the western part of the rift along the Bransfild Strait.

ASHER P. SCHICK, JUDITH LEKACH & TAMIR GRODEK

The Nahal Yael research catchment, Negev desert, Israel: a third of a century of observations on floods

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Nahal Yael, a small arid catchment located in the mountains near Eilat, has been instrumented for research purposes in 1965; its full operation programme started in 1967 and has continued, with varying immediate goals, to date. It represents the oldest and most complete hydrological record in the hyperarid (mean annual rainfall <100 mm) worldwide. Measurements available include rainfall (and associated meteorlogical parameters such as wind and evaporation), terrain and channel infiltration, runoff and streamflow, sediment sampling, bedload tracing, and reservoir sedimentation. Associated studies were made on aspects of runoff generation, flood routing and extinction, sediment transport, fluvial sedimentology and geomorphology, plant-floodwaters relationships, quarternary climatic impact, and dambreak simulation. The presentation summarizes the observations collected, provides a long-term view on the behaviour of desert floods, and stresses the application of some of the results to the management of the flooding problems in extremely arid environments.

ASHER P. SCHICK[1], M.G. WOLMAN[2], & TAMIR GRODEK[1]

Observations on hydrologic processes and geomorphic constraints on urbanization of arid alluvial fans

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The natural array of processes conveying water and sediment from arid mountain catchments, thorugh alluvial fans, into the baselevel below is nowadays affected by human intervention to an extent unknown until a few years ago. Previously permeable fan terrain has now been replaced by paved, impermeable surfaces whose drainage becomes problematic along with the growth of the town and of its building density, particularly vis a vis the smaller catchments. The high sediment yields with typically predominant bed material components that are supplied by steep catchments create situations difficult to manage in terms of effective, economical and environmentally sensitive criteria. Within the context of the general inadequacy of structural attempts to fully control the floods emanating onto an alluvial fan, a case can be made for exercising the option of local, low-key engineering intervention in protecting fan settlements.
Several aspects of the considerations involved are illustrated by examples trom the town of Eilat, Southern Negev Desert, Israel, and dynamically developing international tourist resort.
Geomorphic principles applied to various engineering solutions at the up-fan boundary of the town, at its lateral boundaries, and in its fan toe areas are discussed, along with observations and possible guidelines as to the internal planning of the town.

KEVIN M. SCHMIDT & DAVID R. MONTGOMERY

Relief limits, deep-seated landsliding, and mountain scale strength properties

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Controls on the size of mountains and the stability of bedrock slopes are poorly constrained, but provide potentially important limits to the development of local topographic relief. Natural slopes rarely attain heights close

to the theoretical maximum predicted by intact rock strengths because pervasive discontinuities such as faults, joints, and bedding planes weaken rock masses. Thus, determining representative strength properties of a mountain is difficult because such properties integrate both material and structural discontinuities and may also be time dependent. Here we investigate bedrock slope stability and quantify material strength by 1) comparing hillslope profiles at the landscape scale in areas exhibiting widespread bedrock landsliding with the use of a model for the maximum size of stable hillslopes and 2) by estimating rock mass strength (Rms) values for individual discontinuities at the outcrop scale.

We hypothesize that in a threshold landscape integrated rock strength properties limit local relief development and effectively bound the size of stable hillslopes for mountain drainage basins in a given lithologic, climatic, and tectonic regime. In the absence of external forces, such as extreme pore-water pressures or earthquakes, bedrock landslides occur where relief development produces topographically induced stresses that exceed rock strength. A model for bedrock landsliding provides a framework for predicting the maximum size of stable hillslopes or mountain fronts and thereby for the evaluation of the influence of material properties on relief development. Integrative rock strength properties back-calculated from the upper limit to hillslope relief and gradient (limit to topographic development, Ltd) in the Chuckanut Formation, an alternating sequence of coarse and fine-grained alluvial strata, of the northern Cascade Range, Washington, U.S.A are a friction angle of 21° and cohesion of 150 kPa. Back-calculated values for the suite of sedimentary rocks in the Santa Cruz Mountains, California, U.S.A. have a friction angle of 20° and cohesion of 60 kPa. Laboratory experiments on fractured shale recovered from drill cores through landslide slip-surfaces in the Santa Cruz Mountains (friction angle = 20±6° and cohesion = 69±32 kPa) corroborate material strengths determined from the Ltd. The close agreement between strength parameters back-calculated from the Ltd method and those obtained through field and conventional laboratory measurements on the weakest members of each rock formation supports the idea that large-scale rock strength controls the limit to relief.

While material properties back-calculated from observed hillslope profiles provide an estimate of rock strength at the landscape scale, rock mass strength (Rms) values determined for joint surfaces and bedding planes provide quantitative measures of outcrop-scale strength encompassing the spatial variability, character, and frequency of discontinuities in a rock mass, features impossible to evaluate via conventional laboratory analysis. Strength quantification of the Chuckanut Formation using bedding planes from 61 hillslopes, including 17 rockslides, reveals distinct populations of data for stable hillslopes and rockslides, with the latter exhibiting Rms values below 69 (possible total of 100). In contrast, Rms values obtained from joint surfaces in the study area do not correlate with deep-seated landslide susceptibility in the Chuckanut Formation. Analysis of the seven weighted variables in the Rms scheme indicates that bedding plane orientation relative to hillslope orientation, together with intact rock strength, serve as the primary controls on deep-seated rocksliding within the Chuckanut Formation. The association of low Rms values with sites of bedrock landsliding highlights the influence of spatial variations in material strength on landscape evolution. Heterogeneities in mountain-scale rock strength, however, should impart significant spatial variability to the maximum stable relief, and hence to the rate and depth of channel network incision. As large rivers carve into bedrock, rock mass strength regulates the magnitude of local ridge relief through the mass transfer provided by bedrock landsliding. Moreover, as exhumation of a landscape proceeds, the spatial locus of bedrock landsliding may concentrate where rock uplift exposes units with relatively low mountain-scale material properties. Thus, if mountain-scale material strength limits the stable relief in a given geologic unit, the Ltd approach estimates material properties for the entire geologic unit while the Rms approach identifies those localized portions of the landscape most prone to bedrock landsliding.

SUSANNE SCHNABEL & ANTONIO CEBALLOS

Gully erosion and temporal variability of discharge in a small watershed in semi-arid Spain

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Gully erosion is studied as part of a research project about the erosional and hydrological processes operating in areas of open evergreen woodland under silvo-pastoral landuse in Spain. Investigations are carried out in a catchment of 35.6 ha since 1990. Gullying is observed in the valley bottoms filled with sediments of 1.5 metre depth, which contrast with the shallow soils on the hillslopes. The amount of gully erosion is estimated by repeated monitoring of transverse sections. Discharge production and rainfall is measured with a time resolution of five minutes. Furthermore, soil erosion and runoff on hillslopes is determined on an event basis. Mean gully erosion for the six year period amounted to 12.3 $m^3 a^{-1}$.

Temporal variability of gullying is high and can be attributed to rainfall variations. However, the results indicate that high sediment losses are either caused by intensive rainstorms of short duration and moderate frequency, or by continuous rainfall of long duration. In the first case overland flow in the basin is exclusivley of the Hortonian type and discharge in the channel is rapidly produced with peak flows occurring 5 to 10 minutes after the rainfall peak. In the second case large amounts of precipitation produce water saturation of the whole catchment giving rise to saturation overland flow on footslopes and in the valley bottoms. This situation was observed during winter of 1995-

96, when approximately 500 mm of precipitation was registered during three winter months. Channel flow lasted for several months. Analysis of long-term data (1907-95) from a meteorological station nearby show that only on three occasions the rainfall total registered during a 3-month interval exceeded the observed one.
The contrasting rainfall characteristics (i.e. high intensity, short-term rainstorms versus continuous rainfall) produce a complex catchment hydrology, which in term is responsible of the highly variable sediment losses in the channel. A simple relationship between rainfall, discharge and gullying does not exist in the study area. The dominant process is assumed to be surface erosion produced by running water (pipes do not exist) as indicated by active headcut retreat and lateral incision with subsequent bank collapses. However, the importance of sediment humidity can not be excluded.

BERNT SCHRÖDER

Human impact in Late Quaternary rift basin geomorphology of W-Anatolia (Turkey), B. Menderes valley

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The fluvial systems of the Aegean coast in Turkey have been operating since the Late Pliocene/Quaternary time. The high influence of the west Anatolian rivers in shaping the coastal configuration is due to the W-E-running horst/graben tectonics at the eastern rim of Aegean Sea, influencing both the direction and size of the catchment areas as well as their high amount of easily erodable Neogene sediments within the graben structures along the river courses.
Intensive Late Holocene delta progradation is fairly well known from some W-Anatolian rivers between Troy in the N and Kaunos in the S. The former «Latmian Gulf» in the lower course of the B. Menderes valley is an area of extremely rapid coastal change during the Late Holocene.
The human impact on the landscape in this area can be traced and quantified by interdisciplinary field work and in intimate contact with archaeologists. The increasing growth of the «younger alluvial fan generation» as well as that of the alluvial cones can be traced and dated by ceramics. The data fit to stages of delta progradation.
i) Delta progradation since 5 ka
The flooding of the original marine embayment during the Holocene sea level rise might have reached 60 km inland from the present delta front.
The original contours of the Late Holocene Latmian Gulf are under investigation. Data from water drillings indicate Holocene marine strata below the fluvial delta plain reaching 50 km inland. The stages of the delta progradation can be roughly reconstructed using archaeological data.
About 50 km^3 of suspended load have been accumulated during Late Holocene time in the marine embayment this giving rise to a prograding delta into its present position. The onset of delta progradation seems to be intimately connected with increasing human settlement since the midth of the 4th millenium B.C..
The Holocene time-averaged fluvial sediment load is about one tenth of that of Archaic to Early Byzantine time. At present it is four times higher than «normal» and equals rivers from areas of very high relief of low latitudes. The time-averaged rate of mechanical erosion within the catchment area (25.000 km^2) is about 0.5 m during the last 5 kyr.
ii) Late Holocene fan and slope deposits
The steep flanks of the Samsun Mts. at the northern rim of the rift basin are bordered by many alluvial fans, some of them coalescing. The main growth stages of these fans go at least back to the last glacial marine lowstand. Afterwards stream channels became entrenched into the fans. The channels have been partly backfilled during the Holocene. The thickness of alluvial fill in these young cones may reach up to 6 m since Archaic time.
At the «normal» slopes of the smoother southern rim of the rift basin late Holocene sheet flow deposits accumulated in gently dipping alluvial cones from the Chalcolithic period onward, reaching downfan thicknesses up to 6 m. Gullying of slopes can be traced back to the Archaic period. Intense slope wash and valley fills (up to 5 m) can be older or even younger than Roman aqueducts.
iii) Environmental aspects
The early stages of deforestation and destruction/erosion of soils in the area of Milet go back to the midth of the 4th millenium B.C.. The most intensive human impact on the landscape started during the Archaic period and lasted till the Early Byzantine period.

LOTHAR SCHROTT

Water storage of permafrost in the semiarid Andes

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In many catchments of the semiarid subtropical Andes of Argentina rock glaciers, as the visible expression of mountain permafrost, are a widespread cryogenic phenomena covering larger areas than glaciers do. Based on airphotograph interpretation, geomorphological mapping and field measurements (soil temperature, seismic soundings, discharge measurements) the extent and hydrological significance of high mountain permafrost is demonstrated.
Different approaches are applied in order to estimate quantitatively the potential water store of permafrost bodies and glaciers and to show how much meltwater they constitute throughout the ablation period. On the basis of an inventory, taking account of surface and thickness, the potential ice content of glaciers and rock glaciers was cal-

culated. Even without considering the other areas underlain by permafrost, the water volume of the active rock glaciers corresponds to about 70% of the estimated water volume of the glacier. Using the discharge rate of a large rock glacier as a minimum value and taking into account the meltwater supplied by all the other existing active rock glaciers in the catchment, the estimated discharge would constitute as much as about 13% of the mean overall streamflow during the summer months. Moreover, this does not include other potential water sources in the permafrost areas. Changes in the streamflow between the glacier tongue, situated at the head of the catchment, and 9 km further downstream confirm that the melting of frozen ground contributes an important part to the basin discharge. That means that after snowmelt water released from the active layer and seasonally-frozen ground produces an increase of about 30% in discharge between the glacier tongue and the gauging station. For the whole ablation period 1990/91, melting of frozen ground constitutes about 20% of the total discharge. This simple estimation shows that the water storage of permafrost and the water supply due to melting processes play an important role in the water balance of semiarid mountain regions.
Due to the fact that permafrost areas are highly sensitive to climatic change (e.g. global warming), there is a possibility of permafrost degradation and, as a consequence, a shift of the lower limit of mountain permafrost due to a rise in its temperature. The loss of water resources and the potential destabilization of slopes which were previously frozen will create a variety of dangers (e.g. mass movements).

BRIGITTA SCHÜTT

Holocene climatic change at in Central Spain: reconstruction of holocene palaeoenvironments by sedimentological investigation of endorheic basins

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Along a northwest-southeast striking transsect through the Iberian Peninsula core drillings were taken in 23 endorheic basins. Location and genesis of the endorheic basin vary from dolines and solution hollows in the central Ebro basin and the La Mancha area, to a fault-block depression in the Cordillera Iberica (Laguna de Gallocanta) up to maars in the area of the Campo de Calatrava (Lamura Manchega). By geochemical and mineralogical analysis of the basin's sediments local palaeoenvironmental and palaeoclimatic conditions during the Holocene have been reconstructed. The different morphogenetic and lithological environments of the areas investigated allow to calibrate such information.
Most of the investigated endorheic basins are characterized by soluble carbonate or gypseous bedrock side by side to silicate rock (Paleozoic quarzites, eruptives or raña topsets). In these areas landscape budget and morphological processes show standardized reactions to changes of climate and water-budget:
1. during humid phases aquaeous solutions, mostly characterized by carbonates or sulphates, were brought into the endorheic basins by subsurface flow and have been precipitated there;
2. during arid phases subsurface flow and input of aqaeous solutions into the endorheic basins were reduced, while erosional processes were intensified because of decreasing vegetation cover;
3. the increasing human impact since Neolithic Age caused an increasing ecosystem degradation which in many cases results in a geomorphological response that effects a sedimental structure which is simliar to that deposited during phases of arid environmental conditions.
The results of geochemical and mineralogical analysis of sediments indicates that in the whole area of the Iberian Peninsula the climatic conditions governing sedimentation during the Holocene changed from humid and sub-humid to the present sub-arid conditions, but was interrupted by, with local varying intensity and frequency, phases of increased humidity. Especially the relation of sediments originated from precipitation (halite, gypsum, calcite) to detritical sediments (silicates) gives information about the conditions of water-budget during sedimentation. These understanding on geochemical composition of lake-sediments were supplemented by mineralogical analysis, because in several cases solutes were precipitated secondary by aqaeous solutions which immigrated into the sediment's interspace after sedimentation.

ANDREI SELIVANOV

Coastal morphological changes under the various rates of sea-level changes: Late Pleistocene and Holocene examples from the Russian seas

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Examples from the depositional sand coasts of the White Sea and the Sea of Japan provide valuable information regarding the importance of sediment budget and the direction and rates of sea-level change for patterns of coastal evolution. These examples demonstrate a limited applicability of the Bruun Rule and its modifications to the prediction of shoreline movement under the sea-level change. A moderate underwater coastal slope and an excessive or insufficient sediment supply may result in the prevalence of deposition during sea-level rise and erosion during its fall. In general, the faster sea-level rise, the higher the possibility of burial, drowning, or destruction of the coastal

depositional body. The faster the sea-level fall, the more probable the preservation of depositional bodies above the retreating sea, e.g. in the form of beach ridges and coastal dunes. An analysis supports similar results obtained on the coasts of the Caspian Sea, an interior water body with the extreme annual water-level fluctuations.

As a first approximation, a model of coastal development under accelerating sea-level rise is established for the conditions of excessive and insufficient sediment supply on sand coasts. Under the former a moderate acceleration of sea-level rise causes the change from mobilization of sediments at a beachface and formation of a beach ridge to the landward translation of the coastal depositional body and, then, to its transformation. An extreme acceleration causes burial of the coastal depositional body by a transgressive sedimentary sequence. Under the latter mobilization of existing scarce sediments turns to a landward movement of a depositional body, erosion of its seaward slope, drowning, and partial destruction. The extreme acceleration may bring, in some cases, the total grading of the coastal zone profile. The series of responses can be interpreted in terms of a turn from quasi-equilibrium to disequilibrium evolutionary patterns.

Sediment budget of a coastal segment may be the dominant factor in coastal evolution under sea-level changes, notably in cases where there is either heavily excessive or insufficient supply of sediment. Both situations may result in a dominantly landward movement of sediments. Moderate inclination of the undervater coastal slope is possibly another precondition for such a response.

YOURI SELIVERSTOV

Genesis of exerational relief

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Glacial erosion or exeration is not an effective process; the majority of exerational forming has another origin, like denudational, crumbling etc. The proof of this observation can be carried out in the mountains of central Asia, the Altai, the Sayansk mountains, Tyan-Shan etc., where the cirques and crust are not exerational forming. We can say even more nowadays glaciers don't destroy, but bury some friable forming different genesis, which happened to be there. Under the glaciers which are going away appear some friable forming of different crust of weathering. Moraine and especially boulder material are only transported by glaciers. They appear because of first of all denudational processes. All these points allow us to estimate the meaning of glacial regions in another way, for example by seeking for some minerals.

PROBHAT KUMAR SEN

Gemorphology of the Lower Ganga Basin, West Bengal, India

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Ganga basin, one of the largest deltas of the world, has only 1/3 of its Western section in West Bengal, India. The river Ganga at present flows only for a small length from the NW to SE in West Bengal before flowing down to Bangladesh Ganga (Padma) delta.

The genetic classification of the delta as moribund, mature and active deltas portray some remarkable hydrographic features, palaeo-geomorphic and present-day geomorphic forms and processes which can be recognised after careful study of its evolution, micro-relief, lithologs and riparion features.

Ganga delta, a composite one, is formed by the coalescence of a number of deltas built up by its tributaries and distributaries of which one group are those flowing down the Himalays and the others from the Chotanagpur plateau. The surface topographic forms do not provide a ready clue to the demarcation of each of them unless lithology and palaeo-geomorphic investigations are carried out.

The moribund delta in the north, formed of older alluvium manifest higher relief and distinct pedogenic processes of leaching and hydrographic features of dying channels, vulnerable to floods, spill channels, meander scars, cut-offs, chuts etc. The mature delta is formed of newer alluvium, bearing the imprints of oscillating channels, extreme sinuosity,meander scars, backswamos, cut-offs etc. With vehement bank-side erosion and innundation creating hazards. The southernmost part facing the sea front, south of Calcutta is the active delta zone experiencing tidal phenomena through the creeks and anastomostic drainage. Salinity and siltation are serious problems

In this paper the different aspects of the delta geomorphology and problems have been discussed.

MATTI SEPPÄLÄ

Geomorphological aspects of road construction in cold environments, Finland

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The traditional concepts of roads were chosen to follow easy landscapes and suitable landforms. When the traffic and the size and weight of vehicles increased and higher speeds were used it required more straight roads. That meant that the easy going relief could not always be fol-

lowed any more and problems arose. New cross-country connections between settlements were needed and old natural corridors did not provide these roads. Road constructors could save a lot in building and maintenance costs if the geomorphic facts were considered. The examples in this presentation are from Finland where road construction is very expensive because the severe winters need well-based roads In Finland we have more roads crossing the Arctic Circle than the whole North America and they are paved. This paper gives examples of geomorphic elements effecting on road construction in cold environments: eskers, drumlins, late and postglacial glaciolacustrine and marine sediment plains, mires, steep rock cliffs, river channels and ice-darns, fluvial erosion, palsas, and how to solve problems in these connections. Frost sensible materials have to be removed and replaced by more favorable sediments because road surfaces are kept snowfee in the winter time and their bodies are therefore exposed for deep freezing The maintenance of roads can be supported with some solutions affecting on snow drift and icing problems and avoiding the geomorphic factors causing the problems and using the natural processes to help people. At the end shall be given some examples how the road constructions are affected the geomorphic processes and vice versa. For example bridges dam moving river ice and road banks cause in special occasions icing.

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Moraines of mountain glaciers: results of integrated glaciomorphological and glaciosedimentological investigations

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The integrated glaciomorphological and glaciosedimentological approach stimulates the analysis of mechanisms of moraine formation as a result of interaction between glacier and its bed. Much attention is given to the estimation of possibilities displayed by glaciological interpretation of the quantitative analytical data about moraine composition and structure (morphometry, morphoscopy, grain size analysis, stone and mineral counts, X-rays analysis) . Proceeding from this keystone position, the sources of debris supplied to glacier systems are identified and the mechanisms of sediment mobilization and transportation as well as accumulation processes are thoroughly studied.
The development of actual models of moraine formation is proposed for several glacial mountain regions (Central Caucasus, Central Tien Shan, Spitsbergen). As a result some classical ideas on the moraine formation in mountains were revised. Marginal moraines are formed during glacier advances and consist mainly of plucking and attrition products of glacier bed. Very often it is possible to distinguish also assimilated till materials of the former stages of glacier evolution as well as incorporated pockets of fluvioglacial sediments.
Lateral moraines are complex polygenetic landforms created predominantly during glacier advances and parageneticaly connected with stadial marginal moraines. They consist usually of the same products eroded and transported from glacier bed. During glacier retreat stages the supply of such sediments weakens and slope materials are accumulated in lateral moraines.
Special reference is devoted to the superficial moraines of mountain glaciers. Different types of these forms are analysed. All of them have small thickness and are attached to uppermost parts of glaciers. They have a subordinate importance in the structure of glacial morphosculpture of mountain regions. Taken as a whole, the structure of mountain glacial formation looks like a result of active impact of glaciers upon their beds.

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Periglacial landforms and permafrost distribution in the South Shetland Islands

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Periglacial landforms occupy a little area in the South Shetland Islands due to the large ice coverage (>90%). Although periglacial landforms are only present in the 3% of the archipelago's area, they represent about 30-50% of the ice-free terrains, and correspond to some of the richest and most varied ecosystems from the South Shetland Islands. The periglacial landscape is overprinted on the existing glacial landforms and on the raised beaches and marine erosive platforms at different altitudes, where permafrost is also common. The periglacial landforms and processes are conditioned by the cold and humid climate of the maritime Antarctica, that facilitates a wide availability of liquid water during summer time, when average temperatures are higher than 0°C.
The distribution of the periglacial landforms and processes has been studied by means of geomorphological mapping in nine of the larger and more significant ice-free areas of the archipelago. The places and scales of the geomorphological maps are: Deception Island (E. 1:25.000); Byers Peninsula (E. 1:25.000), Hurd Peninsula (E. 1:5,000 to 1:25.000), Williams Point (E. 1:10.000), Renier Point (E. 1:10.000) and Barnard Point (E. 1:10.000) in Livingston Island; Half Moon Island (E. 1:10.000); Coppermine Peninsula (E. 1:10.000) in Robert Island and Fildes Peninsula (E. 1:15.000) in King George Island. These maps have allowed the inventory and the surface and altitude distribu-

tion analyse of the periglacial landforms in a representative part of the South Shetland Islands.
Finally, 26 types of periglacial landforms have been inventoried: Slope landforms: debris slopes, talus and cones, protalus ramparts, rock glaciers, stone stripes (coarse and fine), terraced debris lobes, ploughing blocks, gelifluction lobes, debris lobes; landforms associated with permafrost: patterned ground (stone rings, poligonal ground), fussion hollows, stone fields, cryoplanation terraces, gelifluction sheets; nivation landforms: debris flows, mudflows, nivation niches, nivation pavements, flat-floored valleys, assymetrical valleys, sandur; weathering of the bedrock: laminated cracking, tors.
Most of the landforms are active at present, specially those above 10 m a.s.l. However, an attenuation of the periglacial activity in relation to previous periods has been pointed out, being signalated by the presence of inactive landforms colonized by lychens, that denote recent environmental changes. At the present time, crionival processes and in second place those associated to the active layer are dominant. The permafrost has been studied by means of surface temperature measurements (Deception Island), seismic and geoelectric sounding (Caleta Española, Hurd Peninsula), shallow coring (Deception Island and Byers Peninsula) and, in general, by landforms analyse and study of periglacial morphosequences. Depths of the active layer have been reconnaised at 10-96 cm below the surface, always at altitudes of more than 10 m a.s.l. except in Deception Island.
The distribution of the periglacial landforms in altitude shows that 8% of these landforms are located at altitudes between 0 and 20 m a.s.l., being most of them above 10 m and associated to slope processes. The greatest presence of periglacial landforms is between 20 and 50 m, being stone fields and patterned ground the most common. Same types of landforms are also present between 50 and 100 m, but in less quantity. Above 100m slope landforms are again dominant.

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Sediment delivery in a small, agricultural catchment, Devon, UK

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Agricultural non-point pollution in the UK has increased significantly in recent years owing to the intensification of farming practices. Accelerated soil erosion and soil degradation lead to a loss of productivity on-farm and to an increase in suspended sediment transported by rivers. Sediment acts as both a pollutant and as a vector for nutrient and chemical contaminants. Spatial and temporal discontinuities exist between on-site erosion and downstream sediment yield. An improved understanding of the complex nature of sediment delivery is therefore required to design effective pollution control strategies. The findings of an intensive, spatially-distributed study of a small, agricultural catchment, Devon, UK, are presented. Several techniques were employed to elucidate the sediment delivery dynamics of the basin at a range of spatial and temporal scales. The relative contribution of suspended sediment sources to sediment yield was established using the fingerprinting technique. Medium-term rates of soil erosion and deposition were estimated using ^{137}Cs. Various measurements of contemporary erosion, transport and deposition were taken over a two-year period. Linear elements in the landscape including tractor wheelings, rills and ditches were found to be important zones for the erosion and conveyance of sediment. Grass and woodland buffer areas showed significant levels of sediment storage. Sediment budgets were developed on both the catchment and subcatchment scale. The paper highlights the importance of an integrated, basin-scale approach to the study of sediment delivery and its controls.

JULIE SHANNON & JOHN B. THORNES

A probabilistic approach to modelling of ephemeral channel flow and sediment transport

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In ephemeral channels the flow is intermittent and asynchronous, the channel bed and boundaries are highly mobile and very irregular and waves of sediment occur in the channel. Transmission losses to the bed and the presence of both vegetation and anthropogenic features , such as excavation hollows and check dams, mean that conventional routing techniques are inapplicable either for technical or conceptual reasons, except when the channel is behaving more like a perennial river i.e. in extremely rare events. On these occasions the strongly unsteady nature of the flow in any case precludes the use of many standard methods. Under these circumstances the adoption of a probabilistic methodology seems especially appropriate. Todorovic & Woolhiser (1962) already attempted to provide a general sediment transport model for such conditions that consisted of obtaining a multi-dimensional aggregate probabilistic distribution of flow events upon which the sediment transport was piggy-backed. Others have attempted to build a sediment rating onto a probabilistic flow routing, while yet other (Smith, 1972) attempted to develop an analytical solution to the forward propagation of the wave front across a dry bed using the dam-burst modelling approach.
In this paper we describe the conceptual basis, theoretical, laboratory and field investigations and preliminary results of investigations to model these phenomena. By analogy

with flow through the soil, we recognize five major flow stages of increasing discharge. In the first stage (detention) flood plain hollows are disconnected; in the second (Darcian) the connections are built up and flow occurs between cells. In the third stage (macropore) connected flow through the reach occurs, with one or several channels having faster flow than with poorly connected flow and at the fourth stage, flow is sufficient to occupy the entire channel but is entirely within the boundary layer. Finally the channel is filled beyond the boundary layer and can conform to the usual assumptions of unsteady flow in perennial channels. Some or all of these conditions may occur in any flow and the hydraulic conditions are different at each flow stage. Effort is concentrated at this stage in defining the behavior of flows in the first three stages.

Our approach comprises supplying water at the upper boundary of the plot as a hydrograph (from a basin model) that is distributed by channel cross section depths (after Baird, Watts & Thornes, 1992), with the flows generating random walks through the topography. From this the distribution of mean first passage times, boundary impacts, network characteristics and similar flow response variables are derived from theoretical and digital simulation models and validated against scale model hardware simulations. The discrete random walks are developed first on a finite difference mesh, using local channel slope as the direction criterion and the path frequency per cell as a method of generating flow depths and velocities and therefore is somewhat similar to hillslope flow algorithms and to Murray & Paola, 1994. The results comprise a set of output hydrographs from both hypothetical and actual channel reaches, with characteristic bed configurations, and for the actual channels we compare the results with finite element modelling of the flow equations. In a second formulation we consider the process as a continuous Markov process with varying time steps, though this work is still in its infancy and will be reported on at the meeting.

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Shear velocity – saltation layer interactions

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For equilibrium saltation in aeolian systems, the vertical distribution of mass flux should be dependent upon shear velocity, and sediment size. It is widely recognized that mass flux in the saltation layer is distributed in a semi-logarithmic manner, with most of the sediment transport occurring within a relatively short distance above the surface. Further, the presence of saltating grains modifies the distribution of wind speeds above the surface, resulting in an apparently increased roughness length.

Owen (1964) was the first to express the implicit relationship between the shear stress and surface roughness parameter for a saltating system. He developed an expression relating mean saltation height, h, to shear velocity: $h = 0.82\ u_*^2/g$, where g is the gravitational constant. During saltation Owen hypothesized that the saltation layer and boundary roughness are intrinsically related whereby «the saltation layer behaves, so far as the flow outside it is concerned, as an aerodynamic roughness whose height is proportional to the thickness of the layer» (Owen 1964, p. 226). His analysis was dynamically similar to that of Charnock (1955) in his examination of fully developed turbulent air flows over water. Charnock suggested that $z_0=\alpha u_*^2/g$, where z_0 is the surface roughness length, and a is the Charnock constant. For aeolian saltation Sherman (1992) modified Charnock's equation and described the equilibrium relationship between shear velocity and an apparent roughness length.

This study builds from these investigations. Specifically, we demonstrate that field experiments suggest that mean saltation height is relatively insensitive to changes in shear velocity, at least over ranges of transport conditions typical to beaches. Most sand transport occurs below about 0.05 m above the surface. We also examine 10 data sets (both laboratory and field based) in the context of the modified Charnock equation, and demonstrate that the empirical constant is substantially and significantly larger for field data than for the laboratory data. This suggests that basic physical relationships may not be readily transferable from the lab to the field.

HIROSHI SHIMAZU

Catastrophic debris transport along the japanese mountain river

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The Upper Tedori river basin, central Japan experienced catastrophic debris transport in July 11, 1934. This event were triggered by a rainstorm with a cumulative two days rainfall of approximately 466 mm. Since this event there have been many huge blocks on the river bed. The largest one is more than 10 meters in b-axis. Debris flows, which consist of huge blocks and which do not triggered by a large landslide, generally deposit along the river with about 8% in channel slope. But in this event the blocks were transported more than several kilometers along the river whose channel slope is as small as 3%. To examine the origin of the blocks and the cause of the debris transport the author investigates morphology and sediments in the upper Tedori river basin.

The upper Tedori basin has an area of about 140 square kilometers and an elevation range of 500 to 2702 meters. This basin is underlain by sedimentary rocks and lava of the Hakusan volcano, and is largely covered with the alpine and subalpine vegetation and the forest of *Fagus*. Along this river and its tributaries several levels of terraces are di-

stributed. The lower terraces show good continuity standing 2 to 20 meters above the present river bed. *Salix* and/or *Alnus* younger than 60 years on these terraces indicates that the valley filling occurred in this event.
The size of blocks is about 2.5 meters and the downstream change of it is small in the headwater of the Tedori river. It abruptly increases at about 1 kilometer downstream from the confluence of the Miyadani river which is one of the tributaries of the upper Tedori river. From there it decreases downstream along the river. Many landslides occurred during the two days rainstorm. The Miyadani river basin also experienced many landslides. The deposits of a landslide, which locates about 4 kilometers upstream from the junction of the upper Tedori river, consist of many huge blocks larger than 2 meters. These deposits are distributed both sides of the river and there are sorted fluvial sediments upstream behind the deposits. These indicate that the landslide dammed up the Miyadani river and that the destruction of the dam caused the event. The large hydraulic bore washed away the blocks, from which the landslide dam had been made and which were picked up from the river bed. Thus, these were transported along the Miyadani river and the upper Tedori river by debris flow of dam failure origin. The landslide dam was estimated about 30 meters in height and about 60 meters in width based on the valley morphology and distribution of deposits. Because there were no lake formed by landslide dams in the upper Tedori river basin after the event, immediately after the dam forming the dam was destroyed. On the higher terraces along the upper Tedori river, which was formed before this event, there are huge blocks larger than 5 meters. The slope of this terrace surface is as same as the present river bed. This suggests that the debris transport caused by the debris flow of the dam failure origin were repeated along the upper Tedori river.
Some other Japanese mountain rivers have also experienced such catastrophic debris transport caused by failure of landslide dams. This type of debris transport process is very important along the Japanese mountain rivers.

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Morphometry and genetic-age features of glacial landformes: problems of interrelation

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The territory of the Republic of Belarus presents an example of classical forms of the glacial landforms. The use of the morphometric method enables one to identify its genetic, age features and hence to determine the duration of landformes tramsformations under the effect of later processes.
The differences in morphology of the landform types in Belarus are quite obvious. To illustrate, marginal glacial formations are characterized by maximum absolute points, by considerable variations in relative heights (mainly 20-35 m), slope steepness of 10-20° and more, predominance of ridge-undulating landforms. On the contrary, lacustrine-alluvial and alluvial plains are very weakly dissected: dissection depth of 2-5 m/km^2; dissection density up to 0,5 km/km^2; slope steepness of 1-3°. These plain and rolling plain sites are occasionally complicated by eolian hills. In a quantitative sense, moraine, outwash amd lacustrine-glacial types of landforms hold an intermediate position between marginal landforms and alluvial plains.
As a result of previous investigations, it has been found that 5 glaciations had covered the whole territory of Belarus, and the greatest effect on the land surface was exerted by the Dnieper (240,000 years ago), Sozh (140,000 years ago) and the Lake Region (70,000 years ago) glaciations. It should be noted that the landforms within each zone of glaciation are distinguished quantitatively. Glacial forms of the Sozh Ice Age are caracterized by the greatest absolute and relative height, rather long (up to 500-800 m) slopes. The landforms of the Lake-Region Ice Age are distinguished for intensive manifestations of denudation processes, for considerable steepness, short slopes, high extent of hilliness. The landforms of the Dnieper Ice Age are heavily denuded and exhibit a wide-undulating character of the spatial manifestations. The like patterns of morphometric parameters distribution are revealed within the glaciation stages as well. The quantitative differences therewith demonstrate that at every subsequent stage of its development the glacier is less active than at the previous one. Thus, the Pleistocene inland ice retreation after from the territory of Belarus, various glacial, stadial and phasal formations were left behind which differ in their morphometric characteristics.

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Quantitative reconstructions of variations of karst denudation rates during the last 1 Myrs

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We used the quantitative theory of solubility of karst rocks (Shopov & *alii*, 1989,1991) in dependence of the tempera-

ture and other thermodynamic parameters to make reconstructions of past karstification rates. For this purpose we obtained several paleotemperature records from Duhlata cave, Bosnek karst region, Bulgaria. They are covering last 1 Myr with resolution of about 10 years for most of the the time span. Paleoclimatic records has been derived from speleothem luminescence, calibrated by actual climatic records from near climatic stations. We estimated the precipitation residues and the size of karst aquifer. The sample was dated by 6 mass spectroscopy U/Th and 9 Tams radiocarbon dates.

In result we obtained first quantitative reconstruction of karst denudation in the past (during last 1 Myr). Obtained data are important for estimations of the significance of the contribution of karst denudation to global CO_2 amount and cycle.

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Nanga Parbat Himalaya: tectonics and denudation

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Assessments of relationships between extraordinarily rapid tectonics and denudation of the Nanga Parbat massif in the western Himalaya require detailed geomorphologic mapping, ^{14}C and cosmogenic radionuclide dating of landforms, and interpretation of stratigraphy and structure to elucidate uplift and erosional history in the Quaternary period. Establishment of the rich Quaternary history of denudation of the Nanga Parbat Himalaya provides control for the understanding of suspected associations with deep crustal processes, including decompression melting through rapid unroofing of the orogen, and concommitant injection of young leucogranites and high-grade metamorphism. Studies of such hypothesized unusual feedback mechanisms between surficial and deep-Earth processes have the potential for important new understandings of crustal dynamics.

Two of the oldest glacial deposits in the Nanga Parbat Himalaya, the Jalipur and Gorikot tillites, are preserved along the Raikot and Stak faults between which the rapid uplift of the Nanga Parbat massif (8125 m) is taking place. The Jalipur units have been known from the 1930's but understood unequivocally as glacial only recently. The dominance in the Jalipur tillite of mafic-rich clasts from the Kohistan island arc, to the exclusion of Nanga Parbat gneisses, is thought to show glacial unroofing of the rising massif in which the uppermost mafics were removed first. The Jalipur valley-fill cover sediments directly overlying the mafic-rich Jalipur tillite contain the first Nanga Parbat gneiss clasts, thus recording the initial unroofing event. Preservation of the Jalipur tillite in the Indus river trench at the base of Nanga Parbat is thought to be the result of protection in part by down faulting, but especially by the thick cover sediments derived from rapid erosion of the massif. The newly discovered Gorikot glacial tillites and other related deposits upstream from the Stak fault in Astor valley contain Nanga Parbat lithologies so the nearby glacial unroofing at this time had progressed sufficiently to expose the gneisses from beneath the island arc lithologies. Perservation of the Gorikot units on the downthrown side of the fault was facilitated by the Nanga Parbat massif rising across the Astor river valley, forcing deposition of thick cover sediments over the Gorikot and hindering deep erosion that would have removed the older units. Downstream within the massif, all evidence of Gorikot ice has been eroded.

Cosmogenic radionuclide dating of high moraines at about 4300 m shows that at ~55,000 yr an eight-fold ice expansion from the condition of the present allowed ice to descend from the north Raikot face of Nanga Parbat to fill the Indus valley to a depth of 3 km. Catastrophic flood flushing of sediment from such huge ice dams has been recognized as a significant denudation agent. Some of the Punjab erratics and other deposits in the Peshawar basin in the Himalayan foothills are now known to be products of these glacier breakout floods. Emplacement of Last Glacial Maximum (Lgm) moraines on NangaParbat was at about 17,000 yr B.P. Since Lgm time the prime denudational processes have been slope failures, glaciers and rivers, which we recognize are episodic, differential, scale-dependant, and generally high magnitude and moderate to high frequency compared to less active landscapes. Slope failure is strongly controlled by bedrock geology, especially along the plate terrane boundary near the Raikot fault, altough climatic and seismic controls are important as well. Several major events have recurred at the same sites. Measurements of basin volumes, fan volumes, and recurrence interval of debris flows from dendrogeomorphic assessments allow reconstruction of denudational process rates associated with some alpine fans. Assessment of glacier debris loads and velocities enables sediment discharge denudation calculations. Bankfull river discharge and sediment load estimates similarly enable calculation of basin denudation rates. Numerous catastrophic breakout floods from slope failure and small glacier dams have now been identified and used to calculate denudation as well.

In these multiple assessments of past and present process rates, a comprehensive investigation of the complex relations between tectonics and denudation of the Nanga Parbat massif is being made in the interdisciplinary Nanga Parbat project. Access to new high-resolution satellite imagery, state-of-the-art digital elevation models, and computer-generated terrain-evolution models are providing sound bases for geomorphological mapping where prior topographic map control is deficient. This collaboration between tectonicists and geomorphologists is proving to be a highly fruitful and mutually rewarding enterprise.

YURII D. SHUISKY

Geomorphology and dynamics of the abrasive coastal zone of the World Ocean

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At present the World Ocean shores have stabilized in their development after the end of Holocenic transgression. As a result rather stable correlation between abrasive and accumulative shores of both separate seas and the World Ocean as a whole has been formed. Abrasive and accumulative processes have formed in general and the greatest short-term changes are connected with climatic factors influencing biogenetic, termafrost-abrasive, corralline, shelly, mangrove shores.

Abrasive shores whose regime of development has global importance are of particular interest. These shores are considered in the sphere of coastal zone structure, correspondingly their above-water (cliffs) and under-water (submarine) parts are genetically inseparable. They develop under the impact of one and the same energy source, closely interact with each other, are connected with other elements of coastal zone by substance flows of the same type.

On the maps of middle scale the length of measured World Ocean shores constitutes about 780,000 km, or 47.5%. Within separate seas the part of abrasive destroyed cliffs turned out to be equal from 20.9% up to 67.2% of the general one, and the bench length was 10-40% greater than these values. Approximately the same correlation is within separate states adjoining seas and oceans as well. Active benches are spread along 445,000 km of the coastal line. Taking into account that 80% of accumulative forms length are subjected to retreat (~ 200,000 km), about 73.2% (~ 570,700 km) are retreating and destructive at the modern stage of the World Ocean development.

Guessing that spreading of destructive shores prevails some authors explain this global phenomenon by equally global general rise of the water level. However, the level relative rise is not global, and in natural conditions no dependence of cliff rate retreat on the Ocean level rise rates has been found.

In connection with wide spreading of abrasive shores lithodynamical significance of their development is of particular interest. All variety of active cliffs can be represented as three main groups: abrasive-collapsive, abrasive-landsliding and abrasive-danudative. The rates of their abrasion are different. In the average during a long-term period about 5.7×10^9 t/year of sedimentary materials of various composition are shedding off from them to seas. All variety of abrasive nearshore bottom is devided into 5 groups, about 9.0×10^9 t/year of sedimentary materials are shedding off from them. It is approximatelly 15% less than river sediment flow into the boundaries of mouth areas. Under the impact of processes of physic-mechanical desintegration and wave differentiation 4.3×10^9 t/year of beach-forming fractions, or 11.7 t/year per 1 m of shoreline length remain in the coastal zone. To extinguish wave energy and protect cliffs against abrasion the amount of beach-forming fractions coming to the coastal zone must be an order greater. Besides they are not retained near abrasive shores but move to the accretion sites in the conveyor of alongshore drift flows. This phenomenon constantly supports active wave influence on cliffs and their destruction.

As a result the following conclusions can be represent:

- modern spreading of abrasive forms of relief and processes is not zonal in the Ocean coastal zone in total;
- abrasion of cliffs and benches is the main source of beach-forming fractions (most often coarser than 0.1 mm) for the coastal zone and bottom sediments of the World Ocean in general; and this must made one reconsider theoretical diagrams of marine sedimentation and exogenous relief-formation;
- wide spreading of abrasive and retreating shores testifies to such stage of the World Ocean evolution during which summary drifting of sedimentary material decreased from the land to the sea;
- rates of cliff and bench abrasion depend in general on three global reasons: *a)* strength of rocks and deposits, *b)* wave energy potential of the coastal zone, *c)* sediment volume (content) in the coastal zone; their correlation determines the numerical value of rates;
- abrasive destruction of shores takes place because at the current stage of the World Ocean development the coastal zone is subjected to acute deficit of beach-forming sediments and irregular impulsive impact of stormy waves against the background of higher energetic potential of the coastal zone;
- direction and intensity of development of abrasive relief forms mainly do not depend on the rate and signs of long-term relative change of the World Ocean level.

ALEKSEY SIDORCHUK

The hierarchical system of river bed relief

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The interaction between the flow and movable bed in the self-organizing dynamic system «stream flow-channel bed» leads to quasi-periodic flow structure formation and fluvial relief development. The hierarchical system of the macroturbulent structures in the river flow can have a wide range of size from depth order to meander length order. The river channel relief is also hierarchical system of dunelike features with the same range of size.

The quantitative basement for description of stream flow - channel bed interaction is the analysis of the initial instability of the wave-like structures of the flow and channel bottom relief. Stability analysis of 3-D equations of momentum and conservation in curvilinear coordinates leads to

solutions that predict the continuos (both in longitudinal and lateral directions) spectrum of amplitude growth of unstable in time channel bed waves. The topography of this continuos spectrum is complex, five types of channel forms were defined: 1) 2- and 3-D ultramicroforms with the length of depth order, 2) 3-D isometric in plane microforms; 3) 3-D elongate mesoforms; 4) 3-D macroforms, 5) long (up to 100 channel width) and narrow megaforms.
These unstable waves have their analogy in the relief of the river channel. The hierarchy of the channel relief forms in the rivers and experimental flumes usually consists of six to eight levels. The experimental data on ripples and antidunes in flumes and megaripples in river channels satisfactorily fit the field of ultramicroforms in the theoretical spectrum. 2- and 3-D megaripples usually coexist in the channel and form wavy bands stretched across the channel. The length of 2-D megaripples increase with depth D_0 and Froude number $Fr = U / \sqrt{gD_0}$ (U is mean flow velocity) and can be calculated with use of the formula: $L_x = 5.4D_0Fr$. The length of 3-D megaripples is usually 1.2-2.0 times larger than those of 2-D ones.
The dunes of the first and second orders correspond to the field of microforms. These bed forms are most common in large river channels with sandy alluvium. They form a well-defined maximum on the spectrum of natural channel bottom elevations.
The dunes of the third order and the bars of the second order, and (partly) of the order one, correspond to the field of mesoforms. The boundary between dunes (bed forms) and bars (which determine the channel morphology during the period of low flow) is rather indefinite in natural channels with changing discharge and depth. The boundary between microforms and mesoforms on the theoretical spectrum is also not clear. This raises some classification problems, because the length of small mesoforms and of microforms (which can be both dunes and bars) increases with the Froude number, and the length of large mesoforms (which can also be dunes and bars) decreases with Froude number. As the first approximation the boundary between microforms and mesoforms is situated at the field of wave-lengths $L_x = 8.2D_0\exp(2.0Fr)$.
The field of macroforms corresponds to large bars, islands and channel meanders. The local maximum of the rate of amplitudes growth exists in the field of macroforms on the theoretical spectrum. The lengths of these forms increase with depth and as Froude number and bottom resistance λ decrease: $L_x = 6.28D_0\lambda^{-1}Fr^{-1}$ when $0.1 < Fr < 0.5$ and $L_x = 62.8D_0\lambda^{-1}\exp(-3.1Fr)$ when $Fr > 0.5$.
Well-defined maxima on the spectrum of natural channel bottom elevations also corresponds to these forms, but it is usually shifted to a smaller wavelength. The main reason for this phenomenon is secondary effects (for example, helical flow), which become very important as the amplitude of the channel forms grows. When the width of the long unstable wave is less than two widths of the channel, the influence of this wave on the bank erosion is small. When the width of the long unstable wave (the initial bar) becomes more, than two widths of the channel, bank erosion takes place around this bar. The alluvial form often stops its movement down the channel, being stabilized by vegetation and thin floodplain alluvium, and therefore effects a general channel pattern, forming an island or a meander. As a result, two shallow riffles appear on each meander in the zones of channel curvature change, and these secondary waves of the bottom elevation have the same length, as the initial undulations that cause the meander formation. The most frequent value of length/width ratio for macroforms is about four , so the length of developed meanders L_m must be about eight widths of the channel W_0
There had been relatively little investigation of very long and narrow forms of channel relief (megaforms). Coupled lateral vortices with the horizontal axis along the channel were studied in flumes. In the natural river channels the braids, which are following parallel courses for a long distance, are known. Parallel braiding may be the natural analogue of the theoretical megaforms.

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Morphostructure of floor of the Japan Sea

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A number of maps disclosing by leaers nonhomojous leaers' block structure of the earth crust and upper mantle basin the Sea of Japan basin is composed on the base of geomorphological, geological and geophysical on syntosis of date. Maps being quasi-static models are the basis of morphostructural analyses and voluashen of mutual connection of upper surfaces form and deep structure.
Different forms of relationship of surface structure and deep structures have been specified in different morphostructural zones - continent and island scarps, deep depression, submarine rises, deep-sea basins etc. Three bathymetric steps are distinguished in the sea floor topography: 0-160, 500-1000 and 2500-3500 m. The steps determine the position of upper edges of morphostructures and coincide in space with zones of deep fractures bounding blocks of different types of the earth's crust.
Sedimentary bodies in the sedimentary cover within morphostructural zones are characterized by a set of indications, e.x. formation, seismic complex, facies conditions. Their separation surfaces form conformed, reversed and complicated forms.
The relief of the acoustic basement surface reveals consequences of endogenic processes such as subsidences, uplifts, horizontal movements, volcanic activity.
The most contrasting are continental and island scarps, the difference in their depths reaches 8000 m which evidences the relationship between the step and deep fractures. Acoustic basement is represented by sialic, mafic and in-

termediate complexes of rocks. The development of the sialic complex began in Archeozoic - Early Proterozoic and finished in Cenozoic. The development of the mafic complex is connected with the destructive reconstruction of the sialic crust of Asia in Paleogene-Neogene. The Moho discontinuity relief is characterized by difference of depth reaching 18000 m and corresponds to its (Moho discontinuity) dome-shaped rise in the place of the Central Basin.

CARLA SEMIRAMIS SILVEIRA & ANA L. COELHO NETTO

Hydrogeochemical basin responses to rainfall inputs in a tropical mountainous rainforest environment: Rio de Janeiro, Brazil

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The spatial and temporal pathways of water reflect the interactions between climate, biota, soil, relief and weathering processes under distinct bedrock. Detailed studies on the solute fluxes of hydrological processes aim to provide basic informations of the evolution of weathering. The study area is a small catchment (3.5km^2) located in the southern slopes of Tijuca massif, Rio de Janeiro. The secondary rainforest (Tijuca Forest National Reserve) is still preserved despite a strong urban pressure in the surrounding. Previous work at this basin provides knowledge of the internal operation of hydrological processes. Block escarpments are seen as important recharge zone to feed subsurface flow due to percolation in the joint system, besides overland flow. The soils were derived from colluvial deposits and precambrian bedrock (biotite gneiss, plagioclase-microcline gneiss and microcline granitoid) showing low cation exchange capacity.

Precipitation and discharge measurements were conducted at the basin outlet. Rainfall, throughfall and water below the litter cover were collected to evaluate the chemical input. Six points were selected to monitor streamwater based on hydrological behavior and lithological differences. Water was analyzed for Ca^{2+}, Mg^{2+} (atomic absorption spectrophotometry); Na^+, K^+ (flame emission spectroscopy) and Cl^-, SiO_2 (colorimetry). Water samples were taken weekly for eight months and continuously during seven rainfall events to analyze the relationship between stormflow discharge and solute fluxes.

The results show that chemical input by rain water is lower than streamwater output for all elements. Throughfall's composition is higher for all elements and pH, demonstrating the effect of neutralization exerted by vegetation. Litterflows incorporate Ca^{2+} and K^+ but were considered negligible to stormflow. Output at the stream was characterized by an increase in all elements (except for K^+) in relation to throughfall demonstrating that it is an important nutrient uptake by vegetation.

Spatial variations show a good correlation between lithology and streamwater chemistry. Biotite gneiss proved to be a source area of Mg^{2+} to streamwater, while microcline granitoid was responsible for higher concentrations of K^+.

The basin showed a quick hydrological and geochemical response to rainfall inputs. Different contributing areas result in a chemical lagtime between monitored points and the outlet of the basin. The concentration of all elements decreases during the rising limb of the hydrograph. This dilution is attributed to overland flow. The subsurface stormflow was characterized by high concentrations of all elements. However when groundwater seems to prevail the composition is marked mainly by SiO_2 and Na^+.

BRAS RAS K. SINHA

Interference of human resources in geomorphic systems

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Human resources and geomorphic phenomena are the two important aspects of geography and the roots of these two date back to the postulates like physical vs. human or determinism vs. possibilism in geography. Human resources and geomorphic processes and features of geomorphic systems are the components of human and physical geography respectively. Both are interwoven and the effects of these two are seen on one another.

Human resources are the sum total of knowledge, skills, talents, strength, energies and other qualities actually or potentially available in all people of a region which they exercise or may exercise in performing their activities. Human resources both in quantitative and qualitative terms are considered as an active anthropogenic agent. Human beings applying their vigour and technological devices with the aid, advice and consent of the nature alter and modify the shape, size, nature and forms of several types of geomorphic landforms/ features and interfere the landforms processes of alluvial, aeolian, glacial, coastal and karst systems for preparing cultural means to satisfy the needs of the people in the society.

However, while doing so human resources sometimes became inactive in its action after some certain limits of geomorphic constraints and create some geomorphic hazards which affect adversely the human society.

In this way human resources by interfering the natural state of geomorphic systems create both the positive and negative impacts at large scale on the earth's surface.

Since the above theme has not received much attention of the scientists including geographers, the present paper focuses attention on the types of human resources and their activities such as agricultural, mining and quarrying, industrial, construction, commercial, transport and communication etc. and their possible interference in the geomorphic systems and impacts on the geomorphic processes

and features of various types, size, nature and forms. The paper also lays emphasis on management of resources, physical and human, to obtain a balanced and integrated approach. The paper is exclusively descriptive and is supported by the conceptual model of the above theme.

MICHAEL C. SLATTERY & PAUL A. GARES

Runoff and sediment production in a small coastal plain watershed during tropical rainfall

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Recent research has shown that soil erosion on the Atlantic coastal plain is more rapid and extensive than was long believed to be the case, but little is known about erosion processes in the region or about the transport, storage, and ultimate fate of eroded soil. A three-year project is currently underway in a small agricultural basin at Clayroot, North Carolina, the overall objective of which is to elucidate the erosion processes and sediment delivery systems operating within coastal plain catchments. The study combines extensive field measurements of contemporary erosion and sediment transport processes with examination of geomorphic indicators of long-term erosion and deposition, and includes water erosion, fluvial sediment transport and storage, and aeolian erosion and transport. This paper reports the results of measurements conducted during the summer of 1996 during four tropical storm systems, namely Tropical Storm's Arthur and Josephine and Hurricane's Bertha and Fran. The data, though preliminary, indicate rapid soil loss, both from individual fields and the basin as a whole, during the storm events. Considerable erosion occurred on fields planted with cotton. Serious erosion on, and runoff from, fields of cotton is of interest because these are relatively new crops in the region but the area under cultivation is increasing. The fact that significant erosion was recorded in several fields in an area where topography and soils suggest a low erosion risk, casts doubt on some assessments of the coastal plain as being a stable, non-eroding landscape.

OLAV SLAYMAKER

Geomorphology and global environmental change

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In recent statements in the United States (Nrc 1993) and in Canada (Canadian Geoscience Council, 1996) the role of geomorphology in global environmental change has been identified as a growing priority among earth and environmental scientists. Nrc (1993) recognises the following high priority research areas (not in order of priority):

1. Constructing models of the interaction between biogeochemical and rock cycles through time
2. Fluid flow in sedimentary basins
3. Landform response to climatic, tectonic and hydrologic events
4. Improving the monitoring and assessment of the nation's water quantity and quality
5. Defining and characterising regions of seismic hazard
6. Defining and characterising potential volcanic hazards
7. Minimising and adjusting to the impacts of global environmental change.

The Canadian Geoscience Council (1996) identified four priority areas in the «earth environmental sciences»:

1. Natural geological hazards
2. Water supply and quality
3. Society related activities
4. Environmental and global change.

From the perspective of geomorphology these reports are both encouraging and threatening. Encouraging in the sense that the greatly increased profile of geomorphology is acknowledged; threatening in the sense that the specific contributions of geomorphologists are rarely made explicit. There is a need for the International Association of Geomorphologists to be more proactive in advertising its own perception of the role of geomorphology in the earth and environmental sciences.

JOHAN LUDVIG SOLLID, IVAR BERTHLING, BERND ETZELMÜLLER & STINE SAETRE

The rockglaciers on Prins Karls Forland, Western Svalbard

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Rockglaciers are defined as creeping permafrost bodies, partly super-saturated with ice. In contrast to most dynamic ice-bodies, rockglaciers have low mass fluxes, leading to build-up time spans of thousands of years. This makes the forms as indicators for long-term subaerial exposed periglacial areas. However, knowledge of the mass input onto the glacier, its dynamics and the mass flux through the glacier are important for substantial conclusions of build-up time and response to changing climatic boundary conditions.

On the northwestern tip of Prins Karls Forland, western Spitsbergen (78°50'N 10°30'E), a series of 20 rockglaciers build a ten kilometres long continuos transition between mountain cliffs and the strandflat area. The fronts of the rockglaciers are up to 60 m in height and 500 m in width.

All forms show a more or less distinguished depression at the break in slope between the talus area and the rock glacier. The study site lies in an area where the glacier history such as the maximum extend of the Weichselian icesheet is strongly discussed among geoscientists. An intensive field and laboratory measurement program was therefore launched on this site with the objectives to: i) calculate volumes of the rockglaciers in relation to the mass-contributing rock-cliff area, ii) study the velocity field of the rockglaciers, iii) study the differences in ice-content in relation to rockglacier size, location and contributing area.
The aim of the program is to model mass flux and development time of the forms. This is important for understanding the processes both in relation to the origin of the form and to their particular geometry. The time-scale is important for the time the area was subaerial exposed.
Contributing area and mass transfere were estimated using high-resolution digital elevation models of all rockglaciers. The forms were parameterised with respect to topographic and geometric characteristics. The dynamics of four selected rockglaciers were measured in detail applying traditional surveying and photogrammetric techniques. Rockglacier thickness and estimations of icecontent were gained by DC-electrical resistivity measurements on five rockglaciers. The paper will present results especially concerning the analysis and interpretation of the digital elevation models and the DC-electrical soundings.

LINHUA SONG[1] & FUCHANG WANG[2]

Pinnacle karst and shilin karst in tropical and subtropical climatic zones in China

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The pinnacle karst and shilin karst all developed in the present tropical and subtropical zones or the paleo-tropical and subtropical zones, so they might be defined as one of tropical-subtropical karst landscape. The typical pinnacle karst in China develops in Xiean area, Baoding County, Hainan Province. It covers about 0.4 km^2. The annual mean temperature reaches up to 22°C and precipitation 1700-2000 mm. The pinnacle karst developed in the Sirian thick and pure limestone mostly covered by the rainforest. The limestone has been eroded as the shapes of niddle, sward, bamboo titch, pig tail etc. The 60% of pinnacles reach 5-15 m high, and 40% are 15-30 m high. All the pinnacles and ridges if the solutional potts are very sharp like the knife. There is no any deposits in the solutional pits and depressions on the pinnacle hills. The pits are connected with the horizontal caves with few deposits and speleothem.
The shilin (stone forest) landscape have been discovered in more than 20 regions in tropical and subtropical areas in China. The magic shilin landscape is in Lunan County, Yunnan Province.
The Lunan shilin distributes in an area of 970 km^2, of which 350 km^2 of shilin is defined as the protected area and the national park of China. It belongs to the subtropical climatic zone, the annual average temperature is 15°C and precipitation 936 mm, Geograpphically, it is situated in 24°40'-24°05' N and 103°10'-103°30' E. The national park includes 12 shilin subregions. The shilin landscape developed in the Lower Permian pure and block (over 30 m thick) limestone with gentle dipping. The columns are 10-30 m high, max. 48 m. Generally, the columns may divided into 4 parts: (1) buried column, (2) smooth and white column just out from soil, (3) columns with normal karstic features, and (4) the pinnacle features on the top of columns. In the most area in Lunan shilin, the E-N red deposits and P basalt covered on the shilin features and depressions or filled in the fissures of limestone. Under the shilin landscape, the drainage system and cave system with rich speleothems well developed.
The conclusion may be drawn as follows: the pinnacle karst developed in the tropical zone, rainwater erosion is its main origin, the origination rather simple and short evolution processes; the Lunan shilin karst mainly developed in the tropical and subtropical zones, the main origination is subsoil erosion and reformed by the rainwater, it formed and developed since Permian, it experienced the processes of denudation and deposit for several times, that means its evolution processes are very complicated.

ASUNCIÓN SORIANO, ANGEL L. CORTÉS, ADOLFO MAESTRO & ANTONIO M. CASAS

Origin of the satellite lineaments in the Neogene rocks of the Almazán Basin (N Spain)

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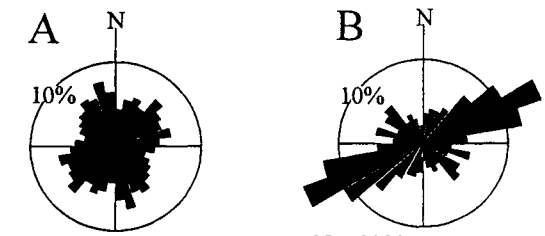
The Almazán Basin is located within the NW part of the Iberian Chain. It is limited by the Cameros Massif to the north, the Aragonian Branch to the east and the Castilian Branch to the south. The basin was filled by Paleogene and Neogene age deposits. The Neogene sediments (conglomerates, sandstones, lutites and carbonates) correspond to alluvial fans and lacustrine facies. Folds and thrusts in Palaeozoic to Paleogene rocks of the Cameros Massif and Aragonian Branch show an arcuate shape with trends varying between ENE and NW-SE. Neogene beds lie unconformably on older rocks and are horizontal in most

part of the basin. These deposits are divided into three chronological units (Miocene to Pliocene in age) covering an area of about 4000 km^2. There is an important fracturing at the outcrop scale, with several maxima, not very well defined, striking 020-030, 040-050, 060-070, 140-150 and 160-170 (Fig. A).

We utilised a satellite image to determine the fracture pattern of the Neogene rocks at medium scale. To perform this study, we use an image (200-31) from the Landsat 5 satellite with Thematic Mapper sensor taken in September of 1984 at sun time 10.02. With the selected area we try different combinations of three bands and the best visual quality was obtained with a false colour image utilising the bands 2, 4 and 5 (in blue, green and red, respectively). Because of the big size of the image we decided to make 24 subscenes (4 rows and 6 columns) for an easiest and more detailed manipulation. After doing a linear contrast stretch of the subscenes a visual study was made and 2.547 lineaments were mapped. The high number of lineaments that we found conditioned the use of an automatic exploration program to determine the following parameters for each one of the lines obtained: the X and Y coordinates from the first and last pixel, its length in pixels, the slope of each line and the goodness of the fitting to a straight with the same slope. From this file the length and orientations of the studied fractures are represented and statistical analysis of this data can be carried about. The knowledge of the X and Y coordinates of the first and last point of each line allows the differentiation in areas or domains to be studied and analysed independently and consequently to establish comparisons among them.

Lineaments are distributed throughout the studied area. Its absolute orientation maximum strikes 060-070, and several relative maxima strike 100-110 and 120-140 (Fig. B). Its maximum density is found in units 1 (Lower to Middle Miocene) and 2 (Upper Miocene to Lower Pliocene). The third unit (Pliocene in age) shows a lower density of lineaments. The density and orientation of lineaments do not depend on the lithology of sedimentary units. Some spatial variations in their orientation can be observed: near the eastern border of the basin the NW-SE (parallel to the trend of main structures) set is dominant, whereas in the northwestern part the NW-SE and WSW-ESE sets coexist with the main ENE set. In practically all the central part of the basin, the ENE trending lines are the most representative.

Most lineaments found in the Neogene rocks of the Almazán Basin correspond to fractures with little of no-offset. Some of the orientations found (namely NW-SE and WNW-ESE) could be inherited from Paleogene structures. The main set of lineaments, ENE, must be neoformed structures, possibly controlled by the recent stress field. The latter is characterised by a NE-SW compression and NW-SE extension. The ENE fractures could be left lateral shear joints associated to NE-SW compression. The conjugate set of joints within this system (NNE-SSW) is much less developed probably due to border conditions, the overall brittle deformation being NNE-SSW contraction and WNW-ENE extension.



N = 2343
Class Interval = 10 degrees

N = 2332
Class Interval = 10 degrees

MATTHEW SOWTER[1], PETER TALLING[1],
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The use of digital elevation models in quantitative topographic analyses within orogenic mountain belts

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Long-term theories and models of macro-scale geomorphological processes within orogenic mountain belts require information regarding the spatial distribution of different erosional processes. Such data must be both statistically reliable and available on the broad spatial scales being examined by the models. Digital elevation models (Dems) offer the potential to satisfy both these criteria and have broad implications for modeling geomorphological change. The Italian Dem covers the entire state and was assembled by a joint Cnr/Usgs project using data from the Mean Heights Archive. It has a ground resolution of 230 m, comparing well with other national Dems; for example, the US national Dem, which has a ground resolution of 805 m. This presentation develops the work of Guzzetti and Reichenbach [1], and illustrates the potential uses of such a Dem in the quantitative analysis of mountain belt topography.

The Apennine mountains in Italy form part of a mountain chain running from the Po Plain through to Sicily. They represent an orogenic mountain belt whose morphology is affected by local tectonic and lithologic patterns. The region is tectonically active, with numerous thrust sheets and transverse faults, whilst dominant lithologies are marine sediments. Even at a national scale, the Italian Dem shows abrupt changes in morphology throughout the Apennines, which, upon initial inspection would appear to be related to lithological variations. At a local scale, the northern Apennines around Bologna demonstrate a noticeable variation in topographic form from rounded hillslopes of low relief to sharply crested linear ridges, even on relatively small spatial scales of a few kilometres. It is suggested that such linear crests represent the result of debris flow erosion, whilst rounded topographic forms are generated by

more diffusional erosional processes, such as creep. Furthermore, river channels demonstrate transitions from bedrock to loose-bed conditions in areas of linear and rounded topography respectively. It is therefore important to gather morphometric data on the mountain belt, and to incorporate these quantitative Dem data with qualitative field observations in order to assess the spatial distribution of erosional processes within the orogen.

Quantitative analyses of Dems may be operated through the various algorithms existing within the Arc/Info Grid package in which data are recorded in a series of rectangular grids. Grid allows for the rapid, relatively easy computation of numerous quantitative topographic variables from Dem data. Such variables include slope angle (topographic gradient), convexity (rate of change of slope), slope reversal, aspect and the elevation-relief ratio. The latter may be used as a quantitative measure of the degree of dissection of a landscape, as in this case, to compare the morphology of rounded and linear ridge topography. These morphometric variables in turn allow for the definition of drainage courses and divides, which may then be utilised in modeling hydrological and geomorphic processes.

Examination of the Italian Dem therefore provides a macro-scale representation of an active orogen from which the spatial distribution of different erosional processes may be modeled. Analysis at a finer resolution than previous work [1] allows for the incorporation of field data, and the assessment of the relative roles played by lithology and tectonics in determining orogenic surface morphology. A similar methodology may also be applied to Dem data for other active orogenic belts, such as the Southern Alps. By examining mountain belts other than the Apennines, the apparent coupling of tectonic and erosional processes demonstrated for the Italian orogen may be tested under different structural, lithological and climatic conditions.

TOMAS SPENCER[1], J.R. FRENCH[2], A.W. TUDHOPE[3] & T.P. SCOFFIN[3]

Ocean dynamics and sealevel change from coral micro-atolls, Tongareva Atoll, Northern Cook Islands

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Sealevel change on low-lying, often heavily-populated, oceanic islands is a major environmental concern for the late twentieth and early twenty first centuries. However, estimates of the magnitude and rates of future sea-level rise, and thus the evaluation of their significance, need to be set in the context of the natural variability of ocean water levels. In some areas, inter-annual changes, associated with large scale oceanographic processes, can be considerable and can mask longer-term trends.

In the absence of long mid-ocean tidegauge records, it is necessary to find a sensitive indicator of palaeo sea-level to extend the instrumented record back in time. Intertidal corals have potential as recorders of historical sealevel change. Flat-topped coral colonies up to several meters in diameter, or «microatolls», growing to an upper limit related to low spring tide level can be used to reconstruct sea-level histories over 1-100 year timescales. At Tongareva Atoll, South Central Pacific Ocean, a micro-atoll based sea level record for the last 60 years has been constructed from i) detailed (2 cm spacing) transects of micro-atoll surface micro-topography and ii) X-ray photographs of annual skeletal density bands in coral slabs recovered from coherent coral wedges sawn from selected micro-atolls.

The concentric ring structure of the micro-atoll surfaces shows i) a general rise in sea level (1.51mm a^{-1} 1949-1979 (comparable to the 1.81mm a^{-1} recorded by the tidegauge at Pago Pago, American Samoa, 1500km to the southwest)) and ii) substantial sea level variations on inter-annual timescales related to Enso (El Nino Southern Oscillation) driven sea level fluctuations. Warm-phase Enso events in the West-Central Pacific Ocean are characterised by sealevel fall; this results in die-back of the micro-atoll growth surface on subaerial exposure followed by recovery growth back to sealevel. Thus low sealevels interrupt the usual relationship between microatoll surface height and sealevel, with the magnitude of this interruption being related to the strength of the warm phase event. Enso chronology suggests that the Tongarevan microatolls have experienced nine warm phases of varying severity over the period of their growth history; internal microatoll growth structures indicate that «moderate» Enso events interrupt the record by 3-14 years but that reef recovery from the «severe» 1982-83 Enso event is unlikely to be completed before 2003. Whilst microatolls have potential for filling in the gaps of the sealevel record, both over space and time, such records need to be treated with caution at some localities.

BARBARA SPONHOLZ

The South-German Muschelkalk-Karst and its impact on the landscape system

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In the South-German Muschelkalk region (Triassic marine limestones with some clayey and marly strata and salt/gypsum in the middle part) different karst areas have developed. Aside from a number of caves in the lower and upper Muschelkalk most of the karst phenomena are sinkholes, uvalas and dry valleys. Their formation has often been ini-

tiated by salt dissolution in the middle Muschelkalk. The karst forms are mostly oriented parallel to rivers or related to tectonic faults with higher ground-water mobility. The intensity of karstification depends on the general landscape development since mid-Tertiary times.
The oldest evidence of karstification is related to the Late Tertiary fluvial incision of the Main River valley. However, all the karst fillings preserved belong to the (Upper) Pleistocene succession of warm-temperate and cold/periglacial periods, mostly consisting of reworked soil sediments and loess derivatives.
Older fillings could not be found. This may be regarded as evidence of several periods of «flushing» during the lower and Middle Pleistocene interglacials. There is also evidence of recent and presently continuing karstification: frequent formation of sinkholes by collapse during the last decades; very effective evacuation of suspended load through karst systems; high content of dissolved carbonates and gypsum in ground water throughout the region; fluvial geomorphic elements of the dry valleys fully in agreement with those of the principal valleys.
As compared to other karst regions such as the adjacent Franconian or Swabian Alb, the South-German Muschelkalk-Karst is less spectacular and therefore less studied. However, the karst has an important impact on the regional groundwater hydrology and in many cases surface and subsurface drainage areas differ considerably. As almost the whole region is under cultivation, the risk of groundwater contamination is one of its biggest problems. Ongoing or reactivated karstification of the South-German Muschelkalk also causes civil-engineering risks in built-up areas, as in the city of Würzburg.

MARLEEN H. STAM

Edimentation in the Geul River System (the Netherlands): the effects of land use changes, mining activities and climate variability

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Recent flooding of the Meuse river (1993, 1995) has resulted in an increased awareness of the importance of understanding the response of the Meuse to external changes, such as climate and land use. In order to assess the relative importance of land use changes and climate change, a study is being performed on a tributary of the Meuse: the Geul river, located in the loess area in Limburg, Southern Netherlands. For this study sedimentological and trace metal analyses of fine grained flood sediments will be compared with a catchment history of mining activities, land use changes and precipitation variations over the last 200 years. The fieldwork is performed in 1996 and results are still forthcoming.
Locally, the Geul river has deposited up to 2.5 m of fine grained flood sediments in abandoned channel sections and point bar edges, over the past 50-200 years. These recent deposits are frequently exposed in cut bank sections and can be distinguished from older sediments by their coarser texture, discernible lamination, organic material content and, in the top, the incorporation of various anthropogenic waste materials (i.e. plastic, candy wraps) in the deposited sediments.
Several sections were sampled in 5 cm intervals. Changes in trace metal concentrations within the vertically accreted alluvium can be linked to 19th century mining activities in the Belgian part of the Geul river catchment and thus be used to date depositions from this period. The ^{210}Pb dating technique is being used for dating more recent sediments and a few ^{14}C samples have been taken from the bottom of the fine grained overbank deposits, which are expected to pre-date the industrial mining period. Sampled sections are then compared to define changes in depositional characteristics over the past two hundred years, which is subsequently compared with the history of land use changes, climate change and mining activities. Land use changes are derived from the analysis of several historic maps dating from 1806, 1837 and from 1920 onwards. For more recent developments the use of different farming techniques (which are known to have led to wide spread soil erosion in this area) are also considered. Climate change is regarded as variations in precipitation on the scale of decades, which have been reconstructed for different parts of the Netherlands.
Finally, an attempt will be made to incorporate these data in a physically-based rainfall-runoff model to assess the relative importance of land use change and climate change for streamflow regime in this catchment.

MILOŠ STANKOVIANSKY

Geomorphic effects of collectivization in farming: a case study

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The aim of this contribution is to characterize the geomorphic effects of collectivization in farming in hilly regions of Slovakia on the example of the Jablonka Catchment (163 km^2) situated in the Western Slovakia in the contact zone of the Inner and Outer Western Carpathians and built predominantly of flysch-like, marlaceous and conglomeratic rocks. Under geomorphic effects we understand on one hand the changes of operation of geomorphic processes triggered by surface runoff (i.e. changes of their spatial distribution and intensity as well as of the leading role of the particular partial process) influenced by land use changes an on the other hand the geometric changes of

land forms conditioned by these processes since the beginning of collectivization untill the present time.
Collectivization in farming was realized in the area under study in 1949-1975, while it was accompanied by large-scale land use changes, out of them the most inconvenient were above all the merging the former small plots in large cooperative fields and drastic terrain adjustments, namely the levelling of the step-like character of slopes in portions with the formerly terraced plots. A negative phenomenon intensifying the mentioned processes was also an introduction of crop pattern inadequate for the hilly topography.
Anthropic interventions associated with the collectivization resulted in extension of spatial distribution of processes from the original plots with up and down cultivation (where intense erosion operated also before collectivization) in fact on all slope portions with new cooperative fields as well as in their intensifying. Predominant partial process during long-term landscape evolution leading to land use typical for the period before collectivization, was linear erosion that resulted in dense network of deep, V-shaped gullies. After stabilization of these gullies by forestation, the linear erosion has taken place above all along the unmetalled field roads. For new, postcollectivization land use, the combination of areal erosion (sheet wash, rill and interrill erosion) occuring on all types of cultivated slopes and linear, concentrated erosion, taking place along the dell bottoms and slope gradient depressions of both natural and anthrophic origin, resulting in the creation of shallow, ephemeral gullies, is typical.
Operation of geomorphic processes triggered by surface runoff within the last almost five decades led to such geometric land form changes, as the lowering of slopes and raising of bottoms of dells and dell-like valleys as well as of colluvial bodies at the valley floor margins. There were distinguished three different types of geomorphic evolution of linear deepened land forms (i.e. of valleys, dell-like valleys and dells) within this period. Maximum accumulation was proved in the bottom of the dell-like valley near the village Krajné (the lokality Luskovica) where in total 105 cm thick bed of eroded material was deposited after 1961. Nine layers of sediments were identified here, corresponding to nine erosion-accumulation events.

LESZEK STARKEL

Role of events, phases and main climatic stages in the quaternary evolution of landscape

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The main stages of the Middle and Upper Quaternary are well reflected in the evolution of the valley floors and slopes. Therefore in most geomorphological reconstructions this level of consideration is present although the lower range elements related to substages or phases are visible too. In reality the transformation of forms is realized either by low magnitude and high frequency events (wash, creep, solifluction etc.) or on the contrary by low frequency and high magnitude events when the intensity of processes is very high and the equilibrium of slope or channel shape is passed. Of special importance are the phases with high frequency of extreme events recognized during transitional phases as well as during the Holocene, when the clustering of debris flows or flood causes the chain of changes leading to a new tendency in the slope or valley floor evolution.
The reaction of slope and fluvial systems to external forcings may be synchronous or metachronous in time. It happens too that one subsystem is active and the another is passive or vice versa not only during a single event but also during relatively long period (whole climatic stage). Therefore there may exist side by side newly created forms and inherited ones, both exposed to active processes of various magnitude and frequency.

LESZEK STARKEL

Spatial and time scales in Geomorphology

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The surface of Earth is a complex product of various forces including solar energy, gravitation and tectonic forces. On the other hand in regional and local scales the energy exchange and the circulation of matter in space and time are controlled by the relief of this surface. The unic character of relief in the global system is based on the fact that the geomorphic features, separating various spheres are visible, may be measured, described and are one of the most slowly changeable elements.
Studing the origin and evolution of landscape we use various scales, both in the space and in time. By moving from the mega-forms upto the microscale usually we assume that the forms of higher order (larger) were formed earlier and longer, that the smaller ones.
Considering the evolution of forms we start from geological time units of millions and thousands of years and go down to the circulation of solids reflected in microforms, changing during minutes and seconds. Analysing the transformation of Earth's surface in time, we distinguish time of creation and time of forming. The first initial stage is frequently combined with passing of tresholds caused by climatic or tectonic forces. This passing may be either gradual or combined with extreme event or with clustering of events. A simultaneous crossing of several boundary conditions creates poligenic forms, one among them may play the initial role.

The prevailing part of greater forms is created by endogenic processes. Their ornamentation is mainly controlled by the different distribution of energy flows in space. A leading role in various processes of energy exchange is played by gravitational forces, which regulate the transfer of water and matter on the continents, in ice sheets and oceans.
On the continents dominate the system of converged and directed transfer of water and solids. Its two subsystems: slopes and river channels act in a close cooperation but it does not means, that they respond simultaneously. Lot of varieties in the landscape evolution depend on their metachronous reaction to external factors or intrinsic thresholds.
Observing the landscape evolution through time we conclude, that the assumption about positive correlation between the size of forms and the length of their formation in many cases is not valid. In the tectonically active areas the large neotectonics horsts and fault-scarps carry on their backs the assemblages of smaller forms belonging to old, Tertiary mature landscapes. Over the low resistant rocks it follows a continuous rejuvenation by badlands or landslides. The structure-controlled relief may be either the coproduct of long planation or may develop simultaneously with the orogenic system, starting with the emerging of land from the ocean.
The rhytmic climatic fluctuations and tectonic reactivations, both so typical for the Quaternary, cause the rejuvenation of inherited relief and create either the sequence of *Piedmonttreppen* or policyclic forms. Under such conditions the exact separation of the role of single cold or warm stage in the relief may be problematic.
The existing landscape of the earth incorporate the forms of various size, origin and age. All of them underwent a continuous adaptation to the new conditions. Among them the slopes are characterised by the adaptation rate changeable in space and time, depending on climate and lithology. On the contrary the fluvial, features, channels and floodplains are the most unstable components of the runoff-denudation systems. The microforms on the channel floor react to every change in the stream pover. The rate of relief transformation also depends on the relations between effectiveness of extreme and saecular processes.
In geomorphology we classify processes and forms, we try to reconstruct the sequence of events and stages of evolution, we are searching for modern or paleo-analogs. But not every form follows the commandments of geomorphology.
The nature impose new questions and challenges, leads to unexpected junctions of factors on small territory as well as to concentration in a very short time or on the contrary to almost total omission of some territories by the main exogenic and endogenic forcing factors during long units of time. One cataclysmic event may destroy the old construction, the enclave of senility. This great diversity of the Earth surface reflects the perpetual spatial and temporal variations in energy exchange and transfer of matter, in their acceleration or in delay, in continuous destruction and creation.

VOLODYMYR V. STETSYUK

Relief as ecological-geomorphological factor: questions of hierarchy

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Categories of relief, suitable becoming a field of action of development of unfavourable reliefforming processes in the conditions of the intensive anthropogenic loading, firstly, themselves influence on the various components of the environment, secondly, are surroundings, where go off various reactions of adaptation on anthropogenic pressure and changing of other components of environment. In connection with this, relief and reliefforming processes, which create it as an ecological factor «surrounding of rise» diserve consideration as object of ecological-geomorphological map-making.
That is why, for the principle «from partial to general», one can discern such classificational categories of relief.
1. Elementary surfaces type elementary interflews-slopes-bottoms) as elements of limited ways of migration substance in the process of morphogenes.
2. Morpholitogenetical systems, which reasonable to divide on: a) genetically homogenous surfaces, created by predominate reliefforming processes (such happen very rarely, but must be take into account); b) genetical types of relief (or composite genetically homogenous surfaces), which created by complex of genetically similar reliefforming processes, among which one is the main.
3. Complex genetics systems, among which it is necessary to mention: a) nivational geomorphological-climatic systems ,with distinct influence of arctic climats on the processes of the exogenic reliefforming); b) cryogenic litoclimatic systems, in which influence of the extremal climatic situation on reliefforming realize through the specific of reaction of permafrost ; c) fluvial basin systems with predominant influence of lasting many years balance of warmth and moisture on reliefforming hydrological factor; d) glacial paleogeomorphological-climatic systems (complex of superimposed morphosculptures-witness of influence of paleoclimate mainly of anthropogenic period; e) erosion orographic-climatic systems, created by combination of peculiar climatic situations of the present day steppes with areas of spreading lightlyeroded loess rocks and availability of number of hills-Peredkarpatska, Volyno-Podilska, Serednyoruska (south part), Donetska, Stavropilska, Ergenei, Pryvolzhska and so on.; f) eolian (arid) litoclimatic systems, where the role of extremal climatic conditions express by the forming of the specific wrakege rocks and in totality with certain processes create composite (or compount), but genetically homogenous morphosculptures; g) eluvial rainforest litosystems, where the variety of different reliefforming processes have general base-powerful crust of weathering .
4. Morphoclimatic zones of dry lands, that is, prominent areas of land surface, within the limits of which various cli-

matic conditions (global regularities of balance of warmth and moisture), and that's why exogenic reliefforming processes created equivalent systems of geomorphological landscape.
We guess, that conception of morphoclimatic zones with similar reactions of adaptation in the period of intensification of influence of anthropogenic factor on the environment (and on relief), will caused further interest of investigators in the field of ecological geomorphology. In lecture I am going to expound the results of the investigations in the field of evaluation of engineering-geomorphological and ecologic-geomorphological conditions of two large regions of Eastern-European plain-cryological-litological zone (Arkhangelsk region of Russia) and zone of dry steppes of Ukraine.

ERICH STOCKER

Area distribution, development and interdependencies of erosion and periglacial features on slopes in the Alpine zone, Kreuzeckgruppe, Austria

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Evaluations of a basal geomorphological map (1:10.000) from a section of the Kreuzeckgruppe, Carinthia, show a specific distribution of features of accelerated slope erosion in the investigated alpine periglacial zone above the tree line. The erosional features are characterised by the absence of turf. Generally their boundaries in the upper parts are abrupt and complicated, primarily caused by needle ice activity. The areas without turf («Plaiken») are affected by surface wash and gelifluction. The size and distribution of these forms of slope erosion depend on various parameters such as altitude, slope angles, availability of material and geomorphological processes in their environment.
The statistical analysis of the features of accelerated slope erosion is based on geomorphological mapping in the field and air photo interpretation. On the one hand the resulting basal geomorphological map may give an inventory of erosional forms, their sizes, their area distributions and boundaries. On the other hand the geomorphological map includes both the wide ranges of periglacial phenomena (recent and relict) and relief forms resulting from gravitation and also glacial relief forms showing various interdependencies.
To obtain exact data concerning the interactions between periglacial and erosion processes in a small study area, statistical analyses of both were conducted. The results of statistical analysis of erosional features corresponding to their phases of evolution, indicate the optimal environmental conditions for the development of slope erosion, their altitudinal zonation and their relationships to periglacial forms and processes. The relatively high density of forms that underlie erosional processes in an altitudinal zone higher than 1950 m shows the importance of these features for denudation on steep alpine slopes. Accelerated slope erosion may also play an important part on material transfers into the ravines with predominantly episodic mass movements due to debris flows or fluvial transports.
The statistical analysis is supported by evaluations of patterns of erosional features and it serves also for explaining their location and development. The detailed studies of the patterns lead furthermore to an interpretation of external influences (gelifluction, gravitational processes, processes due to running water, snow avalanches). Additionally the microrelief-patterns of the boundaries of erosional features are mainly caused by the human impact such as alpine pasture favouring the extension of the erosional areas.
Advanced stages of slope erosion occur generally in combination with ravines. In recent times most of the steep slopes of cirques with parallel ravines are only partially active. Nevertheless the basal relict rock glaciers indicate an intensive late glacial debris production under strong periglacial conditions which finally led to extended slope erosion. The effectiveness of combined periglacial and erosional processes are favoured by the instability and weakness of the phyllitic rocks.

ARJEN P. STROEVEN & JOHAN KLEMAN

Importance of relief in models of the East Antarctic and Fennoscandian Ice Sheets

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The pattern of glacial erosion that we mapped in the Kebnekaise region of northern Sweden is linked to three specific modes of glaciation known to have existed at various times during the last 2.57 million years: cirque glaciation, mountain ice sheets, and Fennoscandian ice sheets. Based on the distribution of preglacial surface remnants we conclude that the average subglacial thermal regime of both ice sheet types was frozen on uplands and melting in the main valleys, where outlet glaciers and ice-streams formed. Cirque glaciers eroded most of the terrain they covered, but were apparently restricted to elevations that were only slightly lower than those experienced today. Hence, the preglacial landscape is best preserved on interfluves between cirques and at intermediate elevations, low enough not to be covered by cirque glaciers, and apparently high enough not to have experienced melted-bed conditions and subglacial erosion during ice sheet overriding events (Kleman & Stroeven, 1997).
The preservation of the preglacial surface remnants allows us to demonstrate the spatial and temporal robustness of the topographically-induced basal thermal zonation. The

preservation of these remnants is primarily a function of preglacial relief, and not as much a function of climate and glacial configuration.

Till sheets and till patches occur in a pronounced pattern across the mountain range. Generally, till sheets are extensive east of the mountain range, and their thickness and extent taper out westwards and approach zero at the mountain range elevation axis and in the western part of the mountain range (Norway). This pattern reflects the basal thermal zonation and is complementary to the pattern of glacial erosion. Where glacial erosion rates were high (at low elevations and in the western sections of the mountain range), till deposition was limited in space and time. Where glacial erosion rates were low (intermediate elevations in the eastern part of the mountain range, and east thereof), till deposition dominated. Where the mountain ice sheets and Fennoscandian ice sheets were frozen to their substrates (highest elevations in the mountains), erosion and deposition were negligible.

The setting of the Transantarctic Mountains is similar to that of the Scandinavian mountains during the ice ages. In both regions, ice sheets expanded over an inland depression (Wilkes and Pensacola basins, Gulf of Bothnia) and expanded through, or overtopped, mountain ranges along the coast. In contrast, evidence for glacial erosion and till deposition is present throughout the 4000 m of relief in the Transantarctic Mountains. At the highest elevations (along the mountain range elevation axis), consolidated tills mapped as the Sirius Group crop out (*e.g.,* Stroeven, 1997). Some of these deposits are of local alpine glacier origin. However, most of these deposits are considered to be of East Antarctic Ice Sheet origin (*e.g.,* Webb & *alii,* 1984).

We identify the following problems in the East Antarctic Ice Sheet interpretation of the high-elevation Sirius Group. For example, at Mount Feather, Dry Valleys, Transantarctic Mountains, the Sirius Group rests on an interfluve separating a >1000 m ice free relief from the Ferrar Glacier trough of >1000 m relief. However, an interfluve in a high-relief landscape is the least likely location for till deposition. Also, given the present relief, we exclude the possibility that the East Antarctic Ice Sheet deposited the Mt Feather Sirius Group (and tills in similar morphological positions).

We identify another problem, which concerns an assumed late Pliocene age of deposition (*e.g.,* Webb & *alii,* 1984). We regard it as impossible that the high-elevation Sirius Group on Mt Feather is of Middle Miocene or younger age. This is because the >1000 m topography surrounding the Sirius Group was in existence in the Late Pliocene based on (i) $^{40}Ar/^{39}Ar$ dated *in situ* ashes in the ice free valleys of Early Pliocene through Middle Miocene age (*e.g.,* Marchant & *alii,* 1993), and (ii) the Oligocene-to-present age of the Ferrar Glacier trough (implying that there has probably been a topographical depression of significance since the Middle Miocene). Given that >1000 m of relief was present in the Middle Miocene, ice would have been the thinnest, coldest, and least erosive on the interfluves, and thickest, warmest, and most erosive in the valleys. This model cannot explain glacial erosion of the interfluve and deposition of the Sirius Group on top of it, *and* a preservation of fragile morphology in adjacent Middle Miocene-or-older ice free valleys. Because the subglacial temperature zonation is robust with relief, but probably uncoupled to the absolute elevation of that relief, inferring that the Transantarctic Mountains were lower in the past offers no support. Instead, deposition must have occurred on reduced relief. The implication is that the Sirius Group on Mt Feather, and probably other units of this group in similar morphological positions, are older than Middle Miocene in age.

KURT STÜWE

Constraints on the geomorphological evolution of the Eastern Alps

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Questions concerning the heat budget of Alpine metamorphism, the shape of metamorphic PT paths and a large range of geodynamic questions depend critically on the thickness geometry of crust and mantle part of the lithosphere. One data set that is useful to constrain these parameters independently is the paleotopography. Two more parameters are necessary: 1. An appropriate isostatic model and 2. knowledge of lateral tectonic motions. These two latter parameters are reasonably well known for the eastern Alps (e.g. Molnar & Lyon-Caen, 1988 1 Ratschbacher & *alii*, 1991), but the paleotopography is still very ill-constrained (although see e.g.: Winkler-Hermaden, 1957; Sakaguchy, 1973; Stüwe & Sandiford, 1994)

In this contribution, the first results of a current project are presented in which we attempt to constrain first order features of the paleotopography of the Eastern Alps since the Cretaceous. The project aims at interpreting the following key observations: (i) the strong correlation of topography with depth of exhumation; (ii) the strong correlation of topography with tectonic units; (iii) the strong correlation of the drainage systems with the first order geological boundaries; (iv) the interesting «L-shaped» pattern of drainages including the rivers Rhein, Inn, Salzach and Enns in the north (Stüwe & Sandiford, 1994). All these drainages flow eastward before turning abruptly northward (for the significance of this pattern see: Braun & Sambridge, 1996). Following datasets are used for our integrated interpretative approach: (i) the distribution of depth of exhumation through time as known from geochronology, geobarometry and the sedimentological record of the Molasse basins; (ii) digital elevation models describing the current topography and (iii) the current denudation rates as derived from stream sediment data (Stüwe & Fabel, 1995).

Our project attempts to model the topographic evolution backward as well as forward in time. First results indicate that the initial topography rose abruptly at the time (and location) of Alpine metamorphism in the mid Tertiary. Subsequent tectonic uplift appears to be largely balanced by denudation resulting in limited change of the topography. Slow eastward spreading of the topography accompanies the eastwards lateral extrusion since the mid Tertiary.

TOSHIHIKO SUGAI

River valley development by concurrent fluvial processes and climatic changes

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River terraces are important landforms to understand the interplay of climatic changes with fluvial processes of incision and sediment deposition. The Usui River is a tributary of the Tone River that is the largest river in Japan. The Usui River has a drainage basin area of 287 km^2 with the maximum altitude of 1603 m a.s.l. Along the Usui River, three well-developed terrace levels are observed. Each terrace is subdivided into two segments: a filltop terrace along the upper reach and a strath terrace along the lower one. Three valley fillings with coarse gravel beds in the upper reach correspond to the last three glacial ages of oxygen-isotope stage 2, 6 and 8 based on the ages of marker tephras. The positions of these valley fills migrated upstream from the older terrace to the younger one.
To clarify the response of fluvial systems to climatic change, terrace sediments were interpreted from the viewpoint of paleohydraulics. Using the grain diameter of terrace sediments, paleo-tractive forces were evaluated based on the correlation between tractive force and grain diameter of the sediment on the present river bed. The valley filling was caused by the diminution in tractive force related to the decrease in heavy rain produced by typhoons during the glacial ages. During the interglacial ages, the reverse responses occurred due to the increased incidence of typhoons. The curvatures of the longitudinal profile of the river channels of the glacial ages were decreased by the aggradational processes, resulting in migration of the front of the valley filling area. In contrast, the curvatures during the interglacial ages increased by the degradational processes.
From another aspect of the development of river landforms, the positions of the valley fills during the glacial ages migrated upstream. Due to the increase in curvature of the longitudinal profile of the preceding interglacial ages, the positions of the segment where the tractive force can transport coarse gravels migrated upstream during the following glacial ages.

VIRGIL SURDEANU

Grands glissements de terrain dans l'espace montagneux de la Roumanie

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Le travail présent a comme point de départ l'acception qu'un glissement de terrain entraénant plus de 1 x 10^6 m^3 de matériel peut s'inscrire parmi les grands processus de mouvement en masse. Par conséquent, on s'adonne (l'analyse de tels phénoménes produits dans l'aire des mouvements orogéniques de la Roumanie, en particulier, dans les montagnes cristallines et dans celles du flysch.
L'étude entreprise vise en premier lieu, les causes qui les ont déclenchés : facteurs climatiques, tremblements de terre, interventions antropiques sur l'environnement. Selon nous, l'intrusion des activités humaines dans l'espace montagneux constitue la cause principale des grands désastres.
Dans le cas des glissements contemporains on en analyse la dynamique en rapport étroit avec l'évolution des éléments cause. Les aspects morphologiques et morphometriques eu sont soumis é l'investigation en corrélation avec le substratum, le relief et aussi avec les surfaces affectées, pendant des cycles antérieurs, par des processus identiques. La réinstauration de l'équilibre s'est produite apres 10-15 ans. Ayant à la base l'évaluation des dégàts anregistrés à l'occasions, nous proposons une prognose possible du processus, tout en mettant en évidence les risques qu'il présuppose ou entraîne. Les analyses statistiques realisées concernant surtout les montagnes du flysch nous autorisent à avancer cette idée qu'à la fin du millénaire, il est bien possible qu'on enregistre une récrudescence majeure de ces processus.

NICOLA SURIAN

Channel changes of a regulated river: the case of the Piave River (Eastern Alps)

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In the last century the Piave River (Eastern Alps) has been strongly regulated for production of electric power and for irrigation purposes. The presence in the drainage basin and along the main stem of many hydroelectric reservoirs and diversions has significantly changed the river flows and the sediment transport. Remarkable channel changes are the river response to this regulation. The aim of this research is to describe these channel changes trying to understand the causes and the mechanisms of the changes. A better understanding of the river dynamics in the past is important both to improve regulation strategies and for the management of the river in relation to floods.

The Piave River is an alpine stream 222 km long and with a drainage basin of 3,899 km^2. In this study a reach about 100 km long has been examined and in this reach the Piave River is a braided gravel bed stream.
Channel river changes in the last century have been studied using historical maps and aerial photos. The oldest IGM maps at 1:25,000 scale were drawn between 1890 and 1910, and so they give a picture of the river when it was in natural conditions. Because of the width of the river, generally some hundred meters, and of the map scales; 1:25,000 and 1:10,000, not only a qualitative analysis of changes but also some measurements and a quantitative analysis were possible. In the last century narrowing and incision of the river channel have been the main processes. By measuring on the maps and on the aerial photos the river width at about 100 sites along the studied reach some average rates of narrowing of the stream during different periods of time can be evaluated. In the last century the river has reduced to a half its width. The average of the channel widths measured at the different sites on the oldest maps (1890-1910) is about 600 m, whereas it is about 300 m on the more recent maps (1980-1983). In absence of cross sections, maps and aerial photos can give some qualitative informations about the degradation of the bed. These informations allows to compare the average rate of incision of the river during the Holocene (natural evolution) and during the last decades (man-induced evolution). The average incision during the Holocene is few millimeters per years (0.001-0.004 m/year, considering terrace heights in the Vallone Bellunese), whereas the average degradation of the river bed in the last decades is some centimeters per year (for example 0.06 m/year at Ponte nelle Alpi). In the last case the highest values of bed degradation are in the reaches below the dams.
Another issue developed in this study is the identification of the river corridor. The river corridor is defined by those areas next to the active channel which, from the hydraulic, geomorphological, and ecological point of view, are influenced by river dynamics. The historical analysis, together with the study of the river terraces, has allowed to achieve a geomorphological definition of the river corridor of the study reach and the mapping of the corridor.
From this historical analysis it can be argued that the channel changes of the Piave River in the last decades are mainly man-induced. The channel narrowing and the bed degradation are the river response to the flow regulation and to the reduction of sediment supply. Anyway, though a general understandig of processes has been achieved, the mechanisms of changes of the river need to be explained in more detailed. For example, it is still not clear the relation between flows, and particularly of channel forming discharges, and the observed channel changes.
This study confirms that there are some specific contributions that fluvial geomorphology can provide for river management. The value of the geomorphological approach in river studies is that it considers time and spatial scales that are generally neglected in engineering approaches. In the case of the Piave River, the study of the river in the historical times and during the Late glacial-Holocene allows to determine the rate and the magnitude of channel changes and a better understanding of man effects on the fluvial system.

GRACIELA M. SUVIRES, JORGE A. SISTERNA
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Geomorphological models of an arid region of a southeastern sector of San Juan Province, Argentina

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This work shows in a three dimensional shape the relief variations related with neotectonic activity of this arid region. The area analysed correspond to the N23 line of Instituto Geogràfico Militar, of the Argentine Republic. This line cross differents geomorphological environments with many structurals styles such as: intermountain tectonic depression of Tulum Valley, Pic de Palo Range (included into the Western Pampean Range System), the Rio Bermejo Valley Depression and the Valle Fertil-La Huerta Range. The 1977 earthquake (M=7,3 Richter) had as epicenter the Pic de Palo Range producing cortical superficial deformations, registered in the temporal models computer generated. The relief increased about 100 cm in the post seismc period (1978-1980). After that the relief decreased slowly until the present.

HIROSHI SUWA[1] & TAKAO YAMAKOSHI[2]

Sediment discharge by storm runoff at volcanic torrents affected by eruption

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Mount Unzen began to erupt in November 1990 and continued erupting until March 1995. After several phreatic eruption, debris flow began to occur at the mid of May 1991 when the first rainy season started. Frequency of debris flows has been kept very high due to frequent occurrence of pyroclastic flow and ash fall. Erosion rate of the drainage area of Mizunashi river reached 175 mm/year. We estimated that one major cause for this high erosion rate is brought about from a significant increase in runoff coefficient of hillslope which is the result of the decrease in infiltration capacity due to new tephra and pyroclastic deposits by eruption.

Observation of debris flows and sediment discharge were executed at three volcanoes: Mount Unzen, Mount Yakedake in Japan and Mount Merapi in Indonesia where the lava composition of volcano is similar and the main process of sediment discharge is the occurrence of boulderly type debris flow, in order to clarify the effectiveness of eruption to sediment discharge from volcanic drainage slope. We found that the rate of sediment discharge and the frequency of debris flow were different from each other, being affected by the time after eruption. Geomorphological factors and hydrological factors are summarized in Table 1.
Comparing the specific amount of sediment transport, a general relationship is expected in which specific amount of sediment transport would decrease exponentially with the time after the last eruption of the volcano. Consideration of the result in Table and erosion rates in other studies (Swanson & *alii*, 1983; Chinen, 1986; Collins et al., 1986; Shimokawa & *alii*, 1987) gives a general expectation, where the erosion rate of volcanic slope, initially very high immediately after the eruption, decreases from the magnitude 10^1- 10^2mm/yr, to 10^1mm/yr in less than several years, and finally approaches 10^0mm/yr in less than a few decades. This fact recommends us to make response against potential debris-flow hazard as fast as possible just with the beginning of a volcanic eruption.

TABLE 1 - Condition of sediment discharge at three volcanic torrents from 1991 through 1994

	Mt. Yakedake Kamikamihori G.	Mt. Merapi Bebeng R	Mt. Unzen Mizunashi R.
Drainage area for the observation site (km^2)	0.83	5	12
Mean of annual precipitation (mm)	2,600	4,500	3,100
Year of the last activity of effective eruption	1962	1984	1990-1995
Time after the last effective eruption (years)	32	10	0
Permeability of the slope (cm/sec)	$10^{-2}10^{-3}$	$10^{-2}10^{-3}$	$10^{-1}10^{-3}$
Frequency of debris flow (/year)	0.7	5	23
Total volume of sediment discharge (10^4m^3/year)	0.5	20	210
Erosion rate (mm/year)	6	40	175

LAFOS SZABÓ [1], T. SURÁNYI K. [2] & ADÁM KERTÉSZ [3]

The effect of crop pattern change on erosion processes of hillslopes in Hungary

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2.3 million hectares are eroded to different extent in Hungary representing ca. 25% of the surface of the country. Mountainous areas underwent a more serious erosion. The erosion risk is, however, greater in the hilly countries because of the agricultural activity there. The hills are mostly covered by brown forest soils developed on loess, loess-like sediments and sand. The area of the original forest has been continuously diminishing as a consequence of agricultural activity leading to increasing erosion accompanied by the degradation of humus manifested in the thickness of the humus layer, in the quality of humus and in humus content. As it is well known the best way of combatting these phenomena is reforestration as a natural biological tool. Reforestration will also reduce the accumulation of toxic materials.
The Gödöllő-Monor hilly country was chosen as a test area to study the above phenomena and to show the possibilities of concervation and improvement. Our research was supported by the «Foundation for soil concervation». This support is acknowledged here.

ZOLTÁN SZALAI

Human impacts on a floodplain ecosystem: the case of Háros Island, Budapest

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The Háros Island is a peninsula in the Danube section at Budapest, near Budatétény. Since the 1950's it has been closed to the public because of the military barracks established there. Thus, in the recent past direct human influence was kept at a moderate level but the impacts of the nearby industrial and previous forestry activities are still felt today. The question arises whether there is any relationship between the microrelief and the soil/vegetation pattern and how it is manifested in the species composition of indicator plants under natural and disturbed conditions.
In the Háros Island three subtypes of alluvial soil occur. In the high-floodplain oxbows calcareous humic alluvial soil and calcareous humic alluvial soil with double humic horizon arc found. One metre higher, on the high floodplain surface there is meadow alluvial soil, indicating transition from alluvial soils to meadow soils.
The vegetation of the herbaceous and shrub levels displays similarities to the soil pattern. This is especially clear in the springtime aspect (in places not affectal by forestry in the past). In the higher areas youthful deciduous forest prevails as far as species composition is concerned. In the high floodplain oxbows plants typical ot high or low floodplain and of weed associations are present. Affected by forestry species of willow and weed associations advanced to the higher areas. In the summer aspect the variation between the different areas remains but reduces compared to the early spring aspect. This can be explained by the decrease in the number of species. The share of the indicator species showing degradation is higher in the high floodplain oxbows than on the high floodplain surface as far as cover and species composition are concerned during the whole vegetation period.

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Thermo-infrared images of sandstone blocks used for a masonry bridge piers in the coastal spray zone

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Yayoi Bridge, connecting Aoshima island with Kyusyu main island in Japan, is supported by four piers whose surface is composed of sandstone blocks. The four side walls of the piers, have a height of 3 m and a slope of 70°, and face approximately east, south, west and north. The bases of the piers are situated at Mean Tide Level (mean tidal range: 1.6 m). Each sandstone block has developed a dish- or bowl-like depression due to weathering and erosion. The greatest depth of each depression in all blocks was measured in 1971 and 1989 corresponding to 20 and 38 years, respectively, since the construction of the bridge.
The erosion data indicate that the rate of erosion is not linear function of time but an exponential function such as $D = A (1 - \exp(-bt))$, where D is the erosion depth, t is the time, and A and b are constants. The erosion features are summarized: (1) the erosion depth is the largest on the south-facing wall (maximum value is about 15 cm during 38 years), and gradually becomes smaller on the west- and east-facing wall, and is smallest (about 5 cm) on the north-facing wall, i.e. the erosion depth and the amount of insolation accepted are positively related; (2) altitude of maximum erosion is situated at just High Tide Level on the south-facing wall, and at 3 m above Mtl on the north-facing wall where the sea spray zone, i.e. wetting zone, is located higher due to prevailing waves. These findings suggest that the difference in the depth of depressions according to aspect and altitude is due to the combined effect of insolation and sea water spray.
The joints between the sandstone blocks are filled with mortar. The surface of the mortar joints protrudes from the surface of the sandstone blocks except in the lower part of each pier. The resistant sandstone (64-100 MPa in compressive strength) is eroded to form the depressions, whereas the less-resistant mortar (50 MPa) is nowhere eroded, irrespective of aspect and altitude. This indicates that (1) these depression never form on fresh (unweathered) sandstone, and (2) they form only after the surface layers of sandstone blocks have suffered some loss of strength due to physical weathering. The deepening of the depression is, therefore, weathering-controlled erosion.
The field evidence shows that (1) the depth of the depressions is controlled by the frequency and intensity of both wetting by the supply of sea water spray and drying (evaporation) by insolation and (2) the shape of some depressions is similar to «tafoni» and the sand grains produced by disaggregation are found on the surface of depressions. Tafoni have recently been suggested to be formed by salt weathering. These findings indicate that the salt weathering in superficial part of the sandstone blocks plays the most important role in the strength reduction and resulting formation of the depressions.
The formation and deepening of these depressions is caused by the sequential process of granular disintegra- tion and removal of the detached sand grains and weakened sub-surface layer of sandstone through the action of such external agents as wind and waves.
In order to elucidate the weathering processes mentioned above, the measurement of the temporal changes in water content of the surface layer of sandstone blocks was tried. There is, however, no instruments for non-destructive in situ rock moisture monitoring. Then, the rock surface temperature, which reflects water content, was measured with a thermo-infrared image tracer. The images of the piers taken with two hour interval indicates that the blocks with high changes in rock surface temperature, i.e., high changes in rock moisture, have a large depth of the depression.

PETER TALLING & MATTHEW SOWTER

Erosion, deposition, and stream power in large alluvial basins

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The boundary between the relative flat depositional parts of alluvial basins, and the adjacent rugged areas from which sediment is eroded is often very abrupt. This observation is particularly striking in areas of active tectonic deformation. Alluvial sediment underlying these depositional areas may be up to several kilometers in thickness. A key question is what controls the position of this boundary, and by what processes can such large thicknesses of sediment accumulate over geological (> 10 ka) time scales. Previously, such large thicknesses of sediment have been attributed to the filling of a subsiding «hole» initially caused by tectonic deformation of the lithosphere. However, such an explanation does not provide a link to the physical processes which act on actual sediment particles in alluvial systems.
This presentation aims to illustrate a striking coincidence between large-scale patterns of erosion and deposition in the present-day Po Basin of northern Italy, and downstream changes in stream power. Stream power is measured in this study as the product of channel gradient and upstream drainage area (typically proportional to mean annual discharge). Relatively rapid downstream decreases in stream power are found to occur only along the reaches of rivers which have deposited sediment during the last 5-25 ka. (Patterns of man-induced erosion or deposition occurring during the last two centuries have been excluded from this study). Such rapid decreases in stream power are pro-

duced by rapid downstream decreases in channel gradient (Fig. 1), which cannot be compensated for downstream increases in drainage area (i.e. discharge).

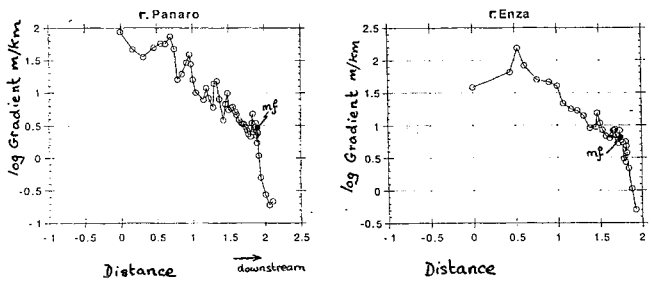

FIG. 1. Logarthmic plot of distance downstream and channel gradient. The increased slope of the best fit line indicates a more rapid decrease in channel gradient below the mountain front (mf).

Empirical data from flume experiments and short term measurements have indicated that bedload transport rates increase as stream power increases above a critical value. Such observations support a broad correlation between downstream changes in bedload transport rates (and hence erosion or deposition) and downstream changes in stream power.

Further work is needed to see if downstream changes in stream power coincide with the large-scale patterns of erosion and deposition in other modern alluvial basins. The impact of pronounced downstream fining of channel material on bedload transport rates also needs to be assessed using quantitative data from the Po basin. However, the measurements from the Po basin suggest that downstream changes in stream power may determine where large-thicknesses of alluvial sediment will accumulate over geological time scales. It is proposed that stream power represents a parameter, that is measurable across large modern alluvial basins, which links tectonic subsidence (i.e. deformation of channel profiles) and the physical processes which affect sediment transport in alluvial basins.

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Effects of runoff characteristics on the frequency of slope failure in Soya hill, Northern Japan

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The authors examined the effects of runoff characteristics on the frequency of slope failure in Soya hill, Northern Japan. Soya hills are underlain by Neogene or Lower Quaternary sedimentary rocks, which are divided into 4 rock types: i.e., Miocene hard shale (Wk), Miocene-Pliocene massive siltstone(Kt), Pliocene unconsolidated fine-grained sandstone(Yt) and Pleistocene unconsolidated medium-grained sandstone(Sa). These rocks have different values of mechanical strength(*S*) and permeability(*K*): i.e., Wk: large *S*, high *K*; Kt: medium *S*, low *K*; Yt: small *S*, low *K*; Sa: small *S*, high *K*. These rocks form clear differential erosional topography: i.e., such as drainage relief, stream length and drainage density. Drainage density of second or third order stream of Wk and Kt hills shows the small value (about 9 km/km^2), whereas that of Sa and Yt shows the large one (about 15 km/km^2)(Suzuki & *alii*, 1985). Gully erosion dominates on the trail of Sa and Yt hills, while no gullies is found in the case of Wk and Kt hills. The frequencies of slope failure in Wk and Kt hills are larger than those in Sa and Yt.

However, these differences in hillmorphology have not been resolved from the hillslope-hydrological point of view sufficiently. Therefore, the authors made a hydrological observation in experimental drainage basins and a hydrological analysis for data obtained from observation. Experimental drainage basins, which have almost equivalent drainage basin area (about 0.5 km^2), were chosen for each 4 rock types.

The results of observations revealed that recession rate of discharge of Wk and Kt is smaller than that of Sa and Yt, and second peak of discharge is often recognized in Wk and Kt basins. Filter separation and AR method (Hino & Hasebe, 1984) indicated that Wk and Kt basins have interflow dominated characteristics, while in Sa and Yt basins, quickflow component more dominant than the case of Wk and Kt. Penetration test and observation at outcrops revealed that the thickness of soils is less than 20 cm for 4 rock types. Therefore, the difference in runoff characteristics is caused not by the difference of soil structure but by the rock type variety.

These results show that most rainfall-derived water runs as subsurface flow which path through regolith or basement rocks in Wk and Kt basins. Therefore, the subsurface flow saturates the slope surface, such as regolith, this would induce the slope failures in Wk and Kt hills. This large frequency of slope failures indicates erosion is active at the present in Wk and Kt hills. Whereas surface flow occurs in Sa and Yt hills, this would generate gully erosion under the condition of no vegetation. However, the most of hill slopes in the study area is covered with vegetation. Therefore, erosional actions such as slope failure and gully erosion are not active in the Sa and Yt hills under the present condition.

It can be deduced that the difference in the periods of active erosion caused the differences in drainage density between Wk•Kt hills and Sa•Yt hills; i.e. in the past periods when no vegetation was found, erosional actions mainly caused by gully erosion would be active in Sa and Yt hills, this generated large drainage density. While no gully erosion would be found at this time, but large frequent slope failures are found at the present in Wk and Kt hills. This provides the variety of drainage density between Wk•Kt and Sa•Yt.

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Landslides from the February 3, 1996, Lijiang earthquake in China

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A strong earthquake occurred on 3 February 1996 with its epicenter located 40 km north of Lijiang City in Yunnan Province, southwestern China. The magnitude of 7.0 on the Richter-scale placed this event among the strongest that have occurred in densely populated areas in China during the 1990's. 385 people were killed by the earthquake. The epicenter was determined to be at 27.18 N and 100.13 E, where is located the seismically active region of the Hengduan Mountains, which belong to the Alpine-Himalaya seismic belt. The earthquake triggered more than 140 small to moderate-scale landslides (less than 10,000 m^3) and 96 large-scale landslides throughout an area of 12,000 km^2 based on an intensive field investigation taken a few days after the earthquake. The mass movements induced by this earthquake caused extensive damage to settlements and farmlands; blocked or destroyed roads and bridges; isolated the city of Lijiang and other towns; and hampered rescue and relief efforts. The investigation has been made for mapping the distribution of landslides triggered by this earthquake and for determining the mechanisms of their formation in order to lend technical assisstance to Yunnan Government in assessing the future hazard to people and property in areas where apparent landslide hazards remain. Because of the widespread landslides distribution, the 1996 Lijiang earthquake has provided a great deal of information and insight regarding seismically induced landslides. This study lead us to the following generalization:

1. The earthquake triggered-landslides were concentrated south-southeast of the epicenter of the main shock, adjacent to the area of tectonic rupture at the surface and within the area of principal aftershock. The regional distribution of landslides has a coincidence with seismic intensity. The landslides distributed mostly within the modified Mercalli intensity VI.
2. The predominant types of landslides induced by this earthquake were rockfalls, debris slides, and slumps (classification after Varnes,1978). Rockfalls were commen on steep-walled canyon faces cut in well-fractured basement rock, easpecially along major dainages-Baishui and Hutiao Canyons. Debris slides occurred mainly at the free face of recent stream terrace deposits and intensely weathered sedimentary rock. Slumping was found largely on reactivated, preexisting landslides. Incipient slumps were also numerous.
3. Topography was a key factor in controlling the location and extent of landslides in all affected areas. Rockfalls occurred on very steep (steeper than 60°) canyon slopes and ridges, and largely initiated in the upper parts of slopes. Debris slides and slumps occurred on gentler (approximately 25°-45°) slopes. Topographic amplification of seismic ground motion appears to have been another important factor influencing on the distribution of landslides.
4. The presence of preearthquake landslides also contribute to slope instability during the 1996 earthquake, which showed obviously reactivation, in the sence that they were generally characterized by many new open cracks or fissures.
5. Most incipient and reactivated landslides have the potential for further failure if they receive sufficient rainfall in the affected areas. Widespread ground fracturing throughout much of the area is closely related to landsliding. This fracturing appears to be most pronounced along ridge tops and road cut slopes, where, given sufficient moisure, the highly fractured surficial mass rock may give rise to as many as or even more landslides as were triggered during the earthquake.

KHALID E. TANRYVERDIYEV & A.S. SAFAROV

Development of relief of the Lowerkür depression (Azerbaijan) in connection with neotectonics

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The latest tectonic movements beginning from the Early Pliocene (age of productive rock mass) predetermined in large way the plan of development and formation of present appearance of the relief adjoining to the Caspian of the Lowerkur oil-gas bearing depression. At that time the mentioned territory was subjected to the greatest depression (Kargalin sinclinal - more than 4,200 m, Alat, Kharamin, Kürovdag and oth. anticlinals - up to 1,600-2,200 m). The beginning of foldness which later caused the formation of morphostructure is clearly see. The beginning of formation of Alat, Kharamin, Mishovdag, Kürovdag and other folds refer to this time. The intensive depression, sedimentation and fold formation taking place in the early pliocene illustrate the inseparable link between them. Beside that, connected with neotectonics of transgression and regression of sea basins exerted a great influence on the development of relief of the given territory which experienced mainly submarine development. In Akchagyl period all mentioned territory was covered by sea water which was experienced relatively weak latest movements (maximum thickness up to 600-700 m). The increase of folds slowed down at this time. In Absheron, especially at its end, the neotectonic movements intensified, which immediately exerted influence on the development of relief of the territory at that time. Ihe Kargalin and Navagin depressions began to take shape in their present boundaries. The formation of the present morphostructural plan is connected mainly with Pleistocene. At the beginning of the Bakuian age the relief of the territory was partly experienced the constant continental development, covering the

island lands, answering the top part of the most actively growing morphostructures (Alat and Mishovdag ridges, Kharamin range and oth.). These island lands were later experienced mainly the horizontal and vertical development, not being covered by sea. The relief becomes complicated. The mud volcanism and corresponding forms of relief develop. The tectonic deformation becomes revived and formed newly. Beginning from Late Khvalin the relief of the territory gains the present outlines and peculiarities and it is very interesting that even the sinclinal basins are covered by sea alternately. It did not happen before. The sea left the limits of mentioned territory only during the deep regression which occured several times (between in Türkanian time and before). The change of situation took place repeatedly during 20 thousand years there which it is impossible not to be affected on the development of relief of the mentioned territory. A great help in reestablishment the quantitative indecies of quaternary movements exerted the sea terraces (about 14 levels). Palaeotectono-geomorphological course of development of the territory shows the succession and mobility the display of the latest and present movements and development of relief.

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Geomorphology and sediments of the Wahiba sand sea, Sultanate of Oman

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Geomorphological, geochemical and mineralogical analyses of terrestrial sediment samples and aerosol dust were undertaken in an effort to understand the geomorphology and cycling of sediment through the Wahiba sand sea (erg) in northeastern Oman. Sediment transport in the region is associated with the geomorphic development of the erg and the production, transport, and flux of desert dust material from the Oman desert into the Arabian sea. The Wahiba erg covers over 12,000 km^2 along the northeastern coast of Oman. It is bordered by mountains on the north, wadis on the west and east, and the Arabian Sea along the southeast. Most of the erg is comprised of a linear, north-south trending draa system. The remaining areas are covered by transverse dunes, barchanoid dunes, sand ridges, and nabkha fields. Terrestrial sample collection included surface sediment samples from the Wahiba erg, surrounding wadis and sabkhas, and bedrock material. Aerosol dust was collected on paper filters from a ship-borne platform over the Arabian Sea for a semi-continuous one year period. Sediment samples and aerosol filters were analyzed for major and trace elements using elemental neutron activation analysis. Both short and long irradiation times were used to quantify a wide range of elements. Mineralogy was obtained with a combination of optical microscopy and wavelength dispersive x-ray spectrometry.
The geochemistry and mineralogy of dune samples were compared with those of wadi sediments and bedrock outcrops in an attempt to define ultimate and proximate provenance for the Wahiba sediments. This analysis suggested that sediment sources for the erg came from multiply provenances of varying lithologies contributed sediment to the erg. Landsat Thematic Mapper (TM) imagery was used to further extend the boundaries of the mineralogic sample sites beyond the sample points. Regions where the composition of sediments was determined from in situ chemical data were linked to specific pixel regions on the imagery. A combination of classification and band ratio techniques, designed to enhance contrasts inherent in the spectral responses of different mineral types, was employed to locate axes of variability in the spectral signatures and identify mineralogical boundaries as well as transport pathways.
Geochemical signatures from Wahiba samples were also compared with those of aeolian dust samples. This comparison was an attempt to determine the relative contribution of Wahiba sediments to the regions atmospheric dust concentration. These data are also important factors in the understanding of global climate variability. This is because aerosols with a significant atmospheric residence time may impact radiation budgets. Also, the flux of mineral matter is a potentially important factor in the biological productivity of the Arabian Sea.

BELAY TEGENE

Soil-geomorphic units on piedmont slopes of Wurgo valley, Welo Highlands, Ethiopia

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An investigation of soil distribution in a piedmont valley of a mountainous cathchment in the Welo highlands led to the identification of clearly defined soil-geomorphic units.
Luvic Phaoezems are associated to divergent footslopes, while Haplic Phaoezems occupied convergent footslopes, and Eutric Vertisols mantled alluvial toeslopes.
The main characteristics of divergent footslopes-Luvic Phaoezems consociation were concave slopes, saprolite parent materials, truncated soils with stony surfaces and Ap/Bt/Cr horizon arrangements.
The convergent footslopes-Haplic Phaoezems consociation is marked by gentler slopes, colluvial parent materials, deep young soils and A/Bw/Bb horizon sequences.
The alluvial toeslope-Vertisols consociation is characterized by gentle to near level surfaces, alluvial parent materials, deep uniform A horizons, cracking clays and A/AC/Cr or A/AC/Bb horizon arrangements.

REMO TERRANOVA

The great landslide of Mount Ciapa Liscia in the Aveto Valley (Ligurian-Emilian Apennines)

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The great landslide of Mt. Ciapa Liscia is situated in the western side of Maggiorasca-Groppo Rosso mountains, which is located on the right slope of the middle Aveto Valley, in the Ligurian-Emilian Apennines. The geological structure consists of five superposed tectonic units which appear from the top to the base of the enclosed geological section.

The landslide occupies an area of 3,378,750 m^2, in which 205,625 m^2 at the head are formed by a large curved surface of fault, with antiapennines direction, showing basalts and polygenic breccias, and 3,173,125 m^2 are occupied by the body of landslide. Other parameters interesting the geometry of landslide are: maximum length of the area of landslide = 3,250 m; maximum length of the body of landslide = 2,950; maximum width of the body of landslide = 1.400 m; difference in altitude between the top of the head of landslide (1,658 m) and the base of the body of landslide (715 m) = 943 m; difference in altitude between the top of the head of landslide and the top of the body of landslide = 300 m; supposed maximum thickness of the body of landslide = 135 m; volume of the body of landslide = several ten millions of m^3.

The Torrio village has been settled on the body of landslide since ancient times. It is formed of a main centre at 1065 m of altitude, a minor centre at 1050 m, and some spread houses, said Cascinelle, at the same altitude. The secular movements of the body of landslide have caused fractures, accidents and slope failures. Failures of the structure of buildings were so deeply that, at the end of XVII century, a new village Torrio was constructed around the new church, in an area at north out of the body of landslide, on compact and stable rocky slope, formed by sequence of marly limestones, claystones and clayey marls (M. Penice unit). Gradually the old village was abandoned and today the construction of new buildings is forbidden by low.

Some different geomorphologic units are present in the landslide area: the upper sector of the body of landslide is formed by an enormous pile of great blocks, often colossal, of pillows basalts, basaltic and polygenic breccias, corresponding to a great part of Mt. Groppe (several millions of m^3), ruined for rock falls; the medium part is formed of boulders of basalts, arkosic and ophiolitic sandstones and shales; the lower part down the old village Torrio is mainly constituted of clasts of sandstones, limestones, marls, claystones, included in a clayey and earthy matrix.

The fall of the western part of Mt. Groppe, favoured by the great fault of Ciapa Liscia, had an important role, among the determinant causes. The enormous volume of rocks fallen has mobilised the lower detrital bodies, causing also translations, rotational movements and falls in the below sedimentary units.

Today the body of landslide is active, favoured by the great volume of water which impregnates it (probably several millions of m^3) and accelerated by the two perimetric rivers which continuously erode it flowing together to the base of the body of landslide. It is more and more detached from the head of the area of landslide (Ciapa Liscia), from which masses of altered basalts and breccias fall. Large slumpings, debris slides are active in the medium-lower parts of the body of landslide, showing depressions in the ground, uphill facing slopes and several large marshy and boggy esplanades which represent the remains of old little lakes.

A great amount of mud and detritus is removed every year from the body of landslide and transported by the Remorano Torrent in the lower Aveto River, causing the progressive filling of the Boschi artificial lake.

REMO TERRANOVA[1], PIERLUIGI BRANDOLINI[2], MARIO FEDOLINO[3], GIUSEPPE CANEPA[3] & AGOSTINO RAMELLA[4]

Morphological change of Genoa west coast following the creation of a new «container» port (Liguria, Italy)

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The new port area is situated along the coast between Pegli and Voltri, wich extends rectilinearly for 5 km. It has been built in a pre-existing morphologic and environmental context represented by a narrow alluvial plain, wilh widths ranging from under a hundred metres to 1 km max. and lined by stretches of beaches, situated at the base of ophiolitic slopes, part of the alpine chain of western-central Liguria.

Small rills, draining little basins with area of a few km^2, provide the main sediments supply of the Quaternary coastal-fluvial plain. Alluvial covers, as has emerged from many soundings, are mainly composed of sands, gravels, and less frequently of silt-clay levels, with maximum thickness rates of up to 10-20 m, on a Tertiary/ophiolitic bedrock (gabbros, prasinites, serpentines and cale-schists).

Since 1970, in order to satisfy new port demand, a large embankment on the sea with a surface of approximately 700,000 m^2 has been built. Today port facilities are at an advanced stage of construction and in use as container handling areas. This reclaimed area has been protected by means of a southern sea dam 2,200 m long, of an eastern breakwater 1200 m long and of a pier 600 m long for the shelter of the western gateway of the port. It has been fil-

led with debris material of various origins, for a total volume of approximately 15,000,000 m^3. along the seabed down to the 15 m bathymetric line.
The main effects on the morphologic and dynamic features of the studied area, deriving from the creation of the new harbour could be synthetized in the following way:
– artificial progression (reclaimed area) of the shoreline of aup to 800 m in front of the urban settlement of Prà, where seaside resort and shipyards were formerly located;
– progression of Voltri beach (50/80 m), to the west of the harbour area, and consequently the raising of the scabed in this area, due to the prevailing long shore downdrift from west to east;
– recession of Pegli beach on the west side of the Varenna Stream mouth (to the east of the arbour area) and progression on the eastern side;
– landfill of residual chanell between the embankement and the former Prà shoreline by the sediment supply of some small rills.

MAME DEMBA THIAM

Cinématique des flèches sableuses de bordures lagunaires: cas des lagunes de Joal et de Mbodiène (Petite Côte, Sénégal)

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Le Sénégal compte trois systèmes lagunaires exclusivement situés dans la partie méridionale de la zone côtière appelée Petite Côte. Seules celles de Joal [14° 05' 30" N - 16° 48' 00" W] et de Mbodiène [14° 15' 00" N - 16° 52' 20" W] sont bordées par des cordons sableux qui sont d'importance assez inégale.
Le suivi de la dynamique de ces unités géomorphologiques permet de comprendre les changements qui affectent cette partie basse et sableuse du littoral sénégalais. La démarche employée met en exergue, de manière comparative, le comportement de deux environnements lagunaires qui ne sont pas soumis au même régime hydrologique. En effet, il existe des différences quant aux facteurs - agents qui commandent les modifications. Il s'agit des points d'attache rocheux, des apports d'amont, de la configuration côtière par rapport à la dérive littorale, des actions éoliennes et anthropiques, etc
A l'aide de divers documents iconiques, (cartes anciennes, photographies aériennes et images satellitaires), la cartographie des situations a permis de restituer des valeurs qui montrent des comportements faciles à comparer.
Un suivi sur le terrain durant quelques mois aide aussi à la validation des constats qui résultent du suivi à distance. Ce qui confirme que cete méthode, peu coûteuse peut servir à renforcer la disponibilité de l'information utile aux décideurs, en vue d'une meilleure politique d'aménagement du milieu littoral

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Morphogenesis in lowland equatorial environments A study of weathering processes and the origins of «white sands» in Kalimantan

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Studies of weathering processes and of associated alluvial sediments in lowland, Kalimantan offer insights into morphogenesis under perhumid, tropical conditions. A discontinuous apron of so-called «white sands» forms a distinctive sedimentary environment around the granitoid landmass of western Kalimanatan, and similar sediments are found in other Equatorial areas. They are associated with alluvial terraces and sandy, coastal plain sediments. Many such sedimentary formations appear to be Middle or Late Pleistocene in age, and may reflect phases of more seasonal climate, during which the forest cover on eroding slopes degraded to more open, savanna and deciduous woodland communities. In so far as these periods are thought to have coincided with ice advances in the Polar regions, many white sand terraces may also have formed on extensions of alluvial floodplains seawards during low sea levels. Similar white sand formations on cratonic surfaces were ascribed by Fairbridge and Finkl to the results of repeated wet-dry climatic oscillations during the Quaternary. These sediments appear to be very thoroughly leached, particularly of Fe, and to be mainly quartz, but gibbsitic clays are also found intercalated with the sands. Although associated with hydromorphic conditions, these sands may also show down profile complexing of organic matter and some minerals including Au. Although Fe staining is seen in places, they are depleted of Fe and water passing though the white sands generally does not precipitate Fe_2O_3 in oxidising conditions.
Similar white sand formations have given rise to much discussion by pedologists, concerning the possible transformation of ferrallitic soils (oxisols) into podzols (spodosols). It is clear that while bauxitic residues appear to form the ultimate weathering stage in many well drained and seasonal forest environments, where Al is retained but Si is lost, in Equatorial areas there is a tendency for Al to be lost along with Si, creating yellow-red tropical podzolic soils, even beneath well drained interfluves. The deep profiles formed are also associated with massive fluxes of clay and Fe down profile, creating a quartz-rich sandy topsoil, over crystalline rocks.
The present study was undertaken in lowland Kalimantan, over undulating (*demi-oranges/meias laranjas*) Cretaceous-Tertiary igneous rock terrain, associated with extensive

white sand valley fills and terraces, where numerous exposures are found in both formations. The multi-convex hills are associated with expected profile and catenary changes and as valley floors are approached the saprolite exhibits colours associated with reducing conditions, and appears as a white, kaolinitic clay. Where water issues from macropores in this material there is an immediate oxidation of FeO which is in striking contrast to the water flowing within and from exposures in the contiguous stream sediments. It is concluded that the sediments are not derived from the lower slopes of valleys, but obtain their materials from the erosion of upper slopes and zones in the weathering profiles. These can be shown to be leached of clay and Fe, and this can lead to the shedding of sandy sediment by surface wash under conditions of exposure to intense rains. Further leaching of Fe will occur within the hydromorphic environments of the valley sediments. A geomorphic interpretation of the white sands involves a combination of weathering under Equatorial conditions in which *lessivage* is more or less continuous, alternating with Quaternary seasonal climates, now understood as having widely affected the inner tropics during at least the Last Glacial Maximum and possibly during other ice advances. Thus neither continuous pedognenesis, nor a simple catenary model is adequate to explain these formations which appear to reflect the oscillatory nature of tropical climates, even in the Equatorial zone. A further complication, however, concerns the age relations of the thick saprolite mantle. In Kalimantan this has been called the «old Sundaland regolith» and ascribed to a Tertiary evolution. While this is not refuted, it is thought that a model of continuous downwearing of the multi-convex landscape may be a relevant precursor to the evolution of the white sands during Quaternary climate changes.
The model developed from this study is compared with other published models of pedogenesis and morphogenesis in perhumid tropical environments.

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Magnitude and frequency analysis of large alluvial rivers

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The magnitude-frequency analysis first proposed by Wolman and Miller (1960) is applied to a range of large alluvial rivers situated in contrasting physiographic and climatic regions. Study rivers include the Brahmaputra River (SE Asia), Upper Missouri and Lower Mississippi Rivers (North America) and the Parana and Paraguay Rivers (South America).
Analyses were based on data from established stream gauging stations with at least 30 years of historical record. Sediment transport data were obtained from routine measurements made at gauging stations during the period of record. Return periods and durations for important flows were calculated using the standard hydrological techniques.
Water surface profiles and stages associated with the range of flows transporting most sediment were plotted on to longitudinal profiles and channel cross-sections to investigate whether there were significant associations between the effective range of flows transporting most sediment and major forms and features of channel morphology.
The results of the magnitude-frequency analyses for each river were applied in engineering-geomorphic studies and proved to be useful in identifying process-form linkages and in predicting the sensitivity of morphological response to river regulation or river training works that would impose changes in the boundary conditions, flow regime or sediment supply.
In each case the analyses revealed a clearly defined range of flow discharges that was responsible for performing the great majority of geomorphological work on the channel through sediment transport. Within that range of effective flows it was possible to define a dominant discharge equating to the single flow doing most sediment transport. Return periods and durations of formative flows were found to be consistently within the range of 1 to 2 years described by Wolman & Miller (1960), suggesting that over medium to long timespans it is in fact flows of moderate magnitude and frequency that are responsible for driving morphological adjustments through sediment transport in large rivers.
Correlation between the dominant discharge, the range of effective flows and specific geomorphic surfaces revealed that the concept that dominant discharge corresponds to bankfull discharge may be a special case. More generally it was found that the range of effective flows was bounded by stages corresponding to «barfull» and bankfull flows at the lower and upper limits respectively. This finding is independent of channel planform, which included both single-thread meandering and multi-thread braided patterns.
Specific applications to engineering-geomorphic analyses included the identification of node-island patterns in the planform of the braided Brahmaputra River, establishment of the likely morphological impacts of proposed changes to the regulated regime of the Upper Missouri River, development of geomorphological guidelines for the design of river training works on the Lower Mississippi River, and mapping of the line of the active river corridor on the Parana and Paraguay Rivers for flood zoning and flood plain management.

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Hazard assessment at Misti volcano and in the Arequipa area (Southern Peru), based on the study of the recent eruptive history

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About 900,000 people live at risk in Arequipa area 17 km away from the vent of the active Misti volcano in the northern part of the Central Andean Volcanic Zone. Misti has been built on 300 m thick ignimbrites (Neogene in age) overlain by 200 m hick lava flows, volcaniclastic sediments, and interbedded ignimbrites. Misti encompasses two edifices: a «modern» stratocone, to the E and SE, has been built up side by side and has overlapped in part an «old» stratovolcano, to the W and NW. The stratovolcano (Lower to Middle?) Pleistocene in age consists of thick and long andesite lava flows, overlain bv debris-avalanche deposits at least 100 m thick towards the W and SW. These deposits burying a piedmont in excess of 50 km^2 in area record the probable destabilization of the old stratovolcano, which occurred sometime before Late Pleistocene. The ca. 30 km^3 and 5,825 m high stratocone consists of stubby lava flows and pyroclastic debris piling up to 2 km in thickness. On top of the cone-shaped summit, the historical crater 500 m across and 200 m deep including an andesitic plug nests in another crater 900 m wide. Both vents are located within a summit explosive caldera 1.5 km across.

Based on fieldwork and interpretation of air-photos and one SPOT satellite image, five groups of deposits record the late Pleistocene eruptive history, as follows.

1. Lava flows, block-lava flows, and buried domes form the lower stratocone (above 3,000 m) towards the S, SW and NE. This is overlain by a pyroclastic sequence (block and ash flows) and stubby lava flows which have built up the cone-shaped summit, above 4,000 m.
2. A pyroclastic sequence (mostly scoria flows and fall) mantles the flanks of the extinct Chachani stratovolcano to the W and the N and NE Misti's flanks. Based on interspersed deposits of giacial source, this sequence can be placed within the last glacial period.
3. A pile of pumice or ash-flow and tephra-fall deposits, rhyolitic in composition, may reflect an explosive episode which led to the formation of the summit caldera. Organic material on top of a brown soil within the upper part of these deposits yielded a radiocarbon age of ca. 34,000 yr B.P.
4. Block-and-ash pyroclastic-flow deposits up to 50 m thick on the S and SW flanks include interbedded pumice and lithic-rich flow deposits. They record alternated dome growth and destruction,
5. Pumice and ashfall deposits 5 m thick and postglacial in age, show that El Misti has erupted explosively at least 10 times over the past ca. l4,000 years. The explosive activity has decreased or come to rest for short periods only, as shown by poorly developped soils in ash. One pumice-rich now deposit has formed a pyroclastic fan ≥ 15 km^2 in area and was channelized 12 km from vent in gorges that cut deeply the S flank. Its basal pumice-fall deposit has a calendar age of 200-0 BC. An ash layer interbedded in block-and-ash flow deposits (on the SE flank) fell between 1292 and 1412 AD. A black scoriaceous ash-fall layer bears witness to the last strong eruptive event at 1440-1480 AD, as referred to in historical narrations. El Misti was reportedly active in 1677, 1784 and 1787, while fumarolic activity at the crater plug resumed in 1948-1949 and 1984-1985.

Stratigraphy and sedimentology point to alternating, plinian and ignimbrite-forming eruptions, and dome growth for at least the past 40,000 years. Thus, the most severe volcanic hazards for the 900,000 people of Arequipa are as follows.

1. Low eruptive columns (5 km) may cause ash fallout in the city, as shown by the approximate extent of the mid-1400's ashfall. For higher columns (20-25 km) based on mapping of the 3 cm and 5 cm lithic isopleths of the 188-2 BC plinian tephra-fall deposit carried towards Arequipa by prevailing NE winds, the thickness of the relevant laver could amount 50 cm in the city.
2. The expected extent of the pyroclastic flows is towards the S, SW, and SSE, owing to the crater wail geometry. The destruction of the summit dome can yield block-and-ash flows which can travel 8 to 12 km downstream when valley-confined; thus, they might hit the NE suburbs of Arequipa. More mobile pumice flows can travel another 4-8 km further downstream toward Chiguata area and in the present suburbs of Arequipa. Deposits of the pumice-flow tuff ca. 2,100 yr B.P. old are observed within the boundaries of the city, as well as subsequent small-volume debris-flow deposits.
3. Finally, flank failures can occur along fractures on the steep-sided W and S flanks of the volcano. Subsequent debris avalanches may choke the Chili valley and spread out on the southern piedmont.

MATTI TIKKANEN

A sedimentary record of the effects of water level changes and forest ditching on a small lake in Central Finland

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The 188,000 lakes in Finland began to develop at distinctly different points in time, depending on their geographical

location, as a result of the deglaciation stage lasting for 3,000 years and the subsequent process of land uplift, and thousands of shallow lake basins have filled in during the last 10,000 years as a result of biomass production in the lakes themselves and fluvial sediments entering from their catchment areas. Meanwhile, tilting of the land surface as a consequence of uplift has caused water levels to rise or fall in the larger lakes in particular and their outlet channels to alter in position. The opening up of the new outlet channel has often been accompanied by a rapid drop in water table, in addition to which almost 3,000 lakes have been artificially drained and the water level in an even larger number has been lowered.

This paper discusses the effects of natural and artificial drops in water level and ditching in the catchment area on sedimentation in a small lake. Changes in the ratio between inorganic and organic material in the sediment were examined by loss-on-ignition analysis and sedimentation rate by pollen analysis, radiocarbon dating and spheroidal carbonaceous particle (SCP) method. The sediment samples were taken with a Russian corer and a Limnos sampler. The surface part of the sediment was sliced into subsamples of size 1 cm.

The lake in question, Perhonlampi, is 0.03 km^2 in area and has a maximum depth of 1.7 m. Its current catchment area is 2.4 km^2, comprising 0.2 km^2 fields, 0.7 km^2 ditched forest land and 1.5 km^2 forest. Two small brooks flow into the lake, on one of which, the outlet from the ditched area, has a large delta of mineral material at its mouth.

The lake basin was isolated from the Baltic as a result of land uplift at the Mastogloia stage around 8000 BP, but initially formed part of the north-westward flowing Great Lake Saimaa complex, so that the water level in the basin was some 12 m above that prevailing at present. When the present outlet channel of this large transgressive lake opened up close to the south-east border of Finland around 5000 BP, this led to an immediate drop of 2 m in the water level. This event, which coincided with the spread of spruce to the area is indicated by a clay stripe in the Perhonlampi sediment.

As a consequence of a period of rapid regression, Perhonlampi was soon isolated to form an independent basin of its own, with a lake surface area of 0.26 km^2 and a catchment of 10.66 km^2. More than 3 m of sediment has accumulated in the course of its existence as an independent lake, and the proportion of organic material in this has risen from less than 10% at the Great Lake Saimaa stage to 20-30%. In the mid-1860's most of the catchment area, i.e. 8.24 km^2, was linked to the adjacent drainage system via an excavated channel, and the surface level of Perhonlampi has been lowered artificially twice during the last hundred years, resulting in a total drop of 2 m. Thus the lake is now only about a tenth of its former size. The most recent lowering, in 1964, is reflected in a fall in loss on ignition values in the sediment.

The greatest change in the sedimentology of the lake took place in 1971, however, when extensive ditching was carried out in the forests of the catchment area. This led to the creation of a delta in the lake, brought about by fluvial erosion, and the lake bottom is now completely covered by a layer of silty material of average thickness 15 cm. Organic matter drops from over 25% to 5-10% at this point in the sediment, accompanied by a distinct rise in the numbers of SCP in spite of the rapid rate of sedimentation, an obvious indication of the sharp increase in the use of fossil fuels in Finland in the 1970's.

A total of some 4,200 m^3 of silt has accumulated in the lake since the ditching operation, with an average deposition rate of 11 mm a year, as compared with an average rate of 0.67 mm a year over the last 5,000 years. The results are a clear reminder that human activity may have a decisive impact not only on the quality of lake water and sediments but also on the existence and lifetime of lake basins. If the sedimentation rate in the basin examined here remains at the current level, the lake will fill up and disapper in some 150 years' time, whereas this would have taken 6,000 years in the natural course of events, and some 2,500 years even if the water level had been lowered artificially.

SERGEI N. TITKOV

Investigations of rock glaciers of the Northern Tien Shan

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There are 1,034 rock glaciers in two parallel latitudinal ranges of the Northern Tien Shan - Zailiysky Alatau and Kungei Ala Too (42,5-43,5 N, 76-79 E). The highest point of two ranges is the Talgar peak (4973 m a.s.l.). The central part of these ranges is strongly glaciated: 880 glaciers of total area about 855 sq. km occur here.

There are 1,034 rock glaciers in two ranges. On the morphological signs, 851 of this amount of total area 90,28 sq. km are considered to be active (Titkov, 1988). The best studied rock glaciers are situated in the central part of northern slope of the Zailiysky Alatau in basins of rivers Bolshaya and Malaya Almatinka.

The investigations of rock glaciers of the Northern Tien Shan started in 1923 by geodetic observations of russian glaciologist N.N.Palgov near the front of Gorodetsky rock glacier. Basing on his geodetic net, the observations were repeated six times till 1994. Additional data on the temporal variations of movement have been obtained resently by the use of aerial photografs taken in different years (Gorbunov & *alii*, 1992).

Over a 71 year period, mean displacement of the central part of the frontal scarp of the rock glacier was 63 m or 0,93 m/yr. The rate of movement of lateral parts of the front did not exeed 0,18-0,23 m/yr. Maximum velocity of surface movement reached 1,3-1,5 m/yr in the middle part of rock glacier about 150-200 m from the front. This difference between rates of movement of surface and front results in formation on the surface of rock glacier transverce ridges and furrows as well as lobes up to 8 m high.

The movement of rock glaciers is influenced by a number of natural factors. One of them is fluctuation of plastic properties of frozen body caused by seasonal and long-term fluctuations of air temperature. According to the results of seasonal observations of the Gorodetsky rock glacier, 2/3 of annual displacement of the frontal scarp occur in the period from July to October.
Most of investigated rock glaciers of the Northern Tien Shan demonstrate average rate of surface movement about 0,5-2,5 m/yr. But sometimes under certain conditions, rapid or ctastrophic movement may occur. Thus, the velocity of the Burkutty rock glacier increased from 4,9 m/yr in 1969-1979 to 13-14 m/yr in 1979-1984 due to increasing of angle of slope of the rock glacier bed from 13-15 to 35-38 so that the danger of a catastrophic landslide appeared.
As a result of study of distribution of rock glaciers, the Map of rock glaciers of Central part of the Northern Tien Shan at scale of 1:200 000 was compiled. The general regularities of lower limits of rock glaciers and sporadic permafrost belts as well as distribution of different types of rock glaciers upon the river basins are shown on this map.

MANATSU TODA

Experimental study for the effects of particles on bedrock channel erosion

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Though the particles such as sand, gravel or boulder seem to be important roll for bedrock channel erosion in a mountain stream, it is difficult to research the effects of those in the field. To understand the influence of sediments on bedrock erosion by running water quantitatively, a experimental approach is useful. A series of experiment was conducted in a 250 cm long, 16 cm wide and 16 cm deep steel flume located in the Institute of Geoscience at University of Tsukuba. The flume fixed at a slope of 0.2 during all runs. It had the artificial rock floor section which could be eroded by running water. This artificial rock was the mixture of sand, cement and water. The strength of this material could be controlled. During the experiment the flow discharge was kept constant in 3.7 1/sec, then the flow velocity and depth were 180 cm/sec and 1.3 cm respectively. In other hand the strength of the artificial rock, the concentration of the sediment discharge and particle size were varied.
To know the influence of particle containing qualitatively, the result of erosion by clear water compared with that by water containing 0.2 mm sand. Following results were obtained. Erosion by clear water excavated a lot of sallow pits or grooves on the surface of the artificial rock and they developed as the erosion continuing. On the other hand, water containing sand made the surface of the artificial rock smooth. In addition to this erosion feature, it affect the erosion rate. The erosion rate by water containing 0.2 mm sand was higher one order than that by clear water. Water with 1.3 mm sand showed similar result. The roll of the sediment in the streams was to smooth the surface of the rock and increase the erosion rate.
Under the constant condition of stream the erosion rate depends on the strength of the artificial rock, which changed from 0.3 kgf/cm^2 to 20 kgf/cm^2. The low strength material was eroded faster than high strength one, and the relationship between the erosion rate and the strength of the material was evident. No erosion was occurred by clear water and by water containing 0.2 mm sand when the strengths of artificial rock were greater than critical values. The sediment supply was varied from 100 g/sec to 800 g/sec to know its effect to the erosion rate. At the small concentration of transported load the erosion rate rose as the concentration increased rapidly. However its rate of increase got lower as the concentration increased and it reached critical value the erosion rate did not increase.
In order to know the effect of particle size, the diameter of sediments were varied from 0.2 mm to 6.3 mm of uniform size. At the small particle size the erosion rate rose as the particle size get larger. However it reaches critical value the erosion rate does not increase. This trend looked like that of sediment supply.
The above results cannot apply to the field phenomena directly, though it seems to be the cue of dissolving the problems how and what influence of the sediment on the erosion.

EIJI TOKUNAGA

Fractal properties and measure of drainage networks

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Mathematical analyses of some self-similar trees with branching numbers 2 and 3 reveal fractal properties of individual streams, stream networks, and drainage basins which relate with each other. The fractal dimension Dn of a whole stream network coincides with that Db of the drainage basin for any value of fractal dimension Ds of an individual stream which is equal with 1 or larger than 1 and smaller than 2. Then Dn=Db<2 in a basin with fractal holes, whereas Dn=Db in a basin without fractal holes. Two-dimensional measures of stream networks in the Peano basin and Mandelbrot's fudgeflake are smaller than the area of their respective basins. The stream networks need not fill upp their basins respectively to be two-dimensional. A drainage basin is filled up with subbasins of the lowest order and interbasin areas. The self-similarity is sustained until these subbasins and interbasin areas become infinitesimally small together with the stream links in the world of fractal geometry. Then any part of a drainage basin has channeled areas and unchanneled areas, however small it is. This

means that a stream network is by no means space-filling
Within the above analysed self-similar tree's, a branching system named Tokunaga's tree by Peckham (WWR 31, 1023, 1995), which has branching number 2 and undetermined junction number in the generator, is most applicable to actual drainage basins. It has, however, some geometric properties common with and different from the other self-similar trees. This implies that the laws of drainage composition derived from Tokunaga's tree are not merely geometric ones but also reflect physical settings which actual drainage networks favor.
The relation of main stream length measured by Gray's method to basin area was examined by using Tokunaga's tree. The result showed that Hack's relation holds perfectly for drainage basins which are composed of infinitesimally small subbasins and interbasin areas. Then the exponent is given by Ds/Db. This shows that the value of the exponent is larger than 0.5 for Ds>1 and Db=2. On the contrary, the log-log plot of main stream length versus basin area for drainage basins composed of finite-sized subbasins of the lowest order and interbasin areas shows a systematic deviation from Hack's relation as demonstrated by Shreve(WWR 10, 1167, 1974). Therefore Hack's relation should revaluated as not an empirical law but a law for a drainage basin model which satisfies completely the condition of fractality.
The fractal properties mentioned above can never be clarified by using Horton's equation for the law of stream numbers. We should inherit Horton's idea which would be developed to the concept of self-similarity. However, adherence to the equation is not available for introduction of fractal geometry to studies of drainage basin geomorphology.

TOLEDO MARIO ARNALDO[1] & LILIANA NEDER DEL VALLE[1]

Anthropogenic influence on landscape degradation in the Tafi Viejo region, Northwestern Argentina

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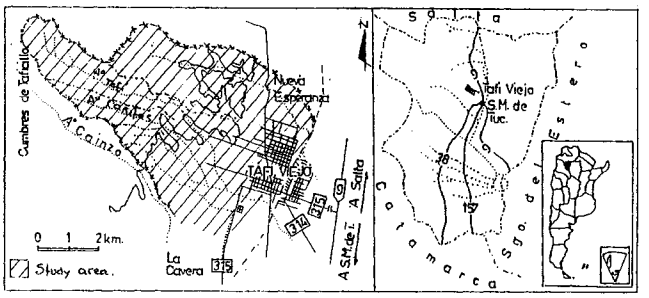
The present paper, describe the damaging effects produced in the Tafi, Cañitas and Nueva Esperanza river basins, located at the eastern slopes of the Sierra of San Javier, by urban growing and land degradation in the upper basins.
The city of Tafi Viejo was founded in 1899, as a summer village for 70 inhabitants, up to 1991 it had grown to 38,000 inhabitants. The railway repair shops, same years away when the largest in South America, wich in its turn pressed upon the urban growth, in an exceptional way. Traditionally it is a citrics area, 75% of the national lemmon production, comes from this area. However, lemmon groves, industries and the urban growing, have notably acentuated, the landscape deterioration, units of the region was subdivided in three sub-units, in order to evaluate by interpretation of aerial photograps and field work, the different degradational processes.
Upper basin: With gradients of 20°, covered by subtropical mountain forest, is affected by mass movement and water erosion. Modification of the natural processes generated by engineering works destined to the correction of torrents without a defined sistematization proyect, have generated mass movement and lateral erosion of the beds, increasing drain of the solids to the torrential rivers.
Upper piedmont area: With gradients of 10°, is an area of lemmon and orchards crops, scarscely populated. The rural population has developments a subsistence agriculture, by wich they exploit small parcels, until they turn them waste, after wich they abandon them and proceed to move to and new one. The most inportant degradational processes are land form erosion and flooding.
Lower piedmont area (urban): The town built on a 5° gradient, generate a water-proof surface that diminisher absortion and increase the runoff generating periodical flooding. Railway tracks, wich run transversal to the slope, act as a contention dam, for the water running downhill from the Sierra of San Javier; the lack of an efficient drainage system raises the flood hazard pluvial/fluvial in the lower altitude sectors and are the cause of large ravines (wich can be as large as 30 m wide and 20 m deep), what at its turn affects the life quality of the urban area.



KONG TAU TRAN[1] & THI KHOA DO[2]

Land use planning in Vietnam

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Up to 1994, the natural territory of Vietnam is 33,104,218 ha, in which land used for Agricoltural purpose is 7,367,207 ha. There are 9,915,100 ha of Forest including 8,910,851 ha of natural forest and 1, l04, 241 ha of plantation, occupying 29,95% of the natural territory of the country. In the end of 1996 Vietnamese population is 76 million people. Average land area per people (accounted according to natural Areas) reached very low-only 0.435 ha/people, about l/6 of average level of world.
Vietnam spreads from 8°30' N with higher 10°C/year; total heat is about 7500°C consequently entirely belongs to the Northern hemisphere tropical belt with reddish - yellow ferralitic soils, typical for humid tropical climate and dense tropical evergreen forest.

Four fifth of the territory of Vietnam are mountains (26,5 million ha - 79,4% of total land area). In accordance with height the different belt can be different from one to another: mountain foot tropical, subtropical and high mountain temperate belt. Surface of Vietnam is not plain and consists of the different kind of rocks with canyons by the high mountains, oeans and seas by continents.
Monsoon causes seasonal rains in the wole Vietnam. Winter moonsoon creates cold, humid with less than 10-15° C (varying in places). Winter in plains and less than 0°C in mountain. In Vietnam territory extending the whole 15 latitudes from 8° 30' N to 23° 22' N; the sun energy undoubtedley forces North-South zoning. Combination of non-geoterranoing law, showed by gradual weakening of Winter monsoon in the same direction and relief of Truong Son mountain range with some mountains extending out from continentd to sea - wind shields - makes North -South differentation more conspicuous (with gradient 0,6-7%/ latitude during winter monsoon, and divided Vietnam territory into two entirely different areas Northern and Southern, the natural barrier is Bach Ma mountainous chain (Hai Van Pass)
Since 1983 Vietnam has carried out the projet «General Developing Schema and Contribution of the Human Power in the whole country». Thank to this project land use planning were carried out with successes; many special regions were formed. Ther are 7 Agricultural Ecological Zones Planned.

A. TRIBAK

Dynamique erosive actuelle et environnement dans les montagnes du Prérif Oriental: cas des bassins des oueds Lahdar et Larbâa

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Le Prérif Oriental, à l'instar des autres zones de la chaîne Rifaine, souffre d'une grave crise morphogénique. L'érosion actuelle s'accélère et atteint un stade optimal. Elle résulte de l'interaction entre différents paramètres. La structure, prédominée par des nappes de charriage, est très complexe. Elle marque la région par un relief vigoureux et des pentes trés accusées. La lithologie, quoique diversifiée, reste prédominée par des substrats tendres et imperméables. Aux marnes et argiles du Crétacé ou du Néogène, s'associent des formations gypseuses et saliféres triasiques. Les pluies maximales se concentrent sur quelques jours de la saison humide; leurs actions sont agressives. A ces facteurs physiques s'ajoute une surcharge démographique qui libére les potentialités de l'érosion et accélère la dégradation du milieu. L'ancienneté de la sédentarisation et la mise en valeur des terrains, basées essentiellement sur la céréaliculture et l'élevage, ont pratiquement détruit la végétation naturelle. Les densités de population, généralement fortes, expliquent cette occupation intensive du sol méme dans des terrains marginaux. Les systèmes de culture, qu'ils soient traditionnels ou modernes, ont aussi quelques effets néfastes sur l'état des sols. Cette accélération de l'érosion cause des dégâts effroyables et pose, par conséquent, des problèmes sociaux pressants et vitaux par les nuisances qui lui sont associées

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From hillslope to floodplain: linking magnitude-frequency relations across steepland catchments

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Understanding the past responses of a catchment to changing climate, vegetation, and land use provides part of the background necessary to predict its future responses to change and to design sustainable land-use practices. Development of this understanding is often a goal of geomorphological investigations. The most complete picture of the environmental history of a catchment is usually found in the depositional record. Sediment deposits are often used to infer the magnitude and frequency of events that produced the sediment: differences in bed thickness are attributed to differences in erosion intensity. Because of the lack of high-resolution depositional sites, it has rarely been possible to relate erosional events directly to the downstream depositional record to determine whether such inferences are justified. Problems of lag-times, depositional censorship, and time-varying erosion thresholds are likely to complicate such interpretations.
The strength of the relationship between hillslope and channel response was tested for the 32 km^2 Tutira catchment in the soft-rock hill country of the east coast of the North Island, New Zealand, by comparing hillslope sediment production for storms of different magnitude and lake deposition. Storm magnitudes and frequencies were described using the 93 year daily rainfall record for the catchment. Individual depositional pulses could be clearly identified in the lake sediments and associated with specific storms, allowing construction of a magnitude-frequency relation for downstream deposition. Shallow landslides triggered by heavy rain are the major sediment source in the catchment. The magnitude-frequency relation for this source was constructed from a relation between landslide intensity (number or volume per unit area per storm) and storm size that had been defined for an analogous site using aerial photo analysis. Comparison of the forms of the magnitude-frequency relationships for landsliding and for

lake deposition, and deviations from these relationships through time, provide a measure of the potential importance of transport lag times, depositional censorship, and temporal variations in erosion resistance in small, steepland catchments. On-going work nearby in the 2,050 km^2 Waipaoa catchment is intended to explore how these influences are affected by processes active along larger, lower-gradient channels.

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The impact of tectonic variations on sediment yield and river basin morphology

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Tectonic uplift is an important control on both the morphology of the uplifted landscape and in the sediments that are shed from it. Qualitative interpretations of the relationship between uplift, erosion, and sediment yield are central to much of geological basin analysis, particularly in regard to the reconstruction of tectonic history from basin sediments. Quantitative interpretations of basin-fill sedimentary packages, however, requires a mechanical understanding of the relationship between uplift rate, sediment yield, and drainage basin sculpture. Here we analyze this relationship using a physically-based model of coupled hillslope and channel evolution. In particular, we seek to address the following questions:

1. What do predicted sediment-yield curves look like (e.g., what is the magnitude and timescale of response to a given perturbation?), and how do they vary as a function of process?
2. What is the predicted relationship between relief, uplift, and denudation rate, how does it vary with time, and how does this relationship compare with sediment yield data?
3. How do morphometric properties such as drainage density vary with uplift rate, and how are these related to the sediment yield response?

The model is based on the evolution equation

$$\delta z/\delta t = U - F[Q(x, y, t), S(x, y, t)] + H[S(x, y, t)]$$

where z is elevation, t time, U uplift rate, Q water discharge, and S surface slope. Here, F[] is a fluvial erosion function that takes the form kQ^mS^n (representing detachment-limited bedrock channels) or $\delta kQ^{m}S^{n}/\delta x$ (representing transport-limited alluvial channels). Several different processes represented by the hillslope sediment production and transport term H[] are considered, including soil production through weathering, diffusive creep, dry landsliding, and pore-pressure-driven shallow landsliding. An important aspect of the model is its ability to track temporal and spatial variations in soil thickness, and to differentiate between erosion of soil and bedrock, which proceed at different rates and by different mechanisms.

Dimensional analysis and numerical simulations indicate that at steady state, where a dynamic balance between uplift and erosion exists, relief within the fluvial portion of a catchment should scale with uplift rate as $R \sim U^{1/n}$, where n reflects the physics of channel erosion. If uplift and denudation rates are approximately equal, this result also implies that denudation rate scales with relief as $D \sim R^n$. This result applies to transport-limited as well as detachment-limited fluvial systems, but only under the steady-state condition. Numerical simulations afford the opportunity to examine transient responses to system perturbations. Here we describe responses to a single step function increase in uplift rate (U). In addition, we consider only single catchments of fixed size and shape, intentionally avoiding the complications associated with lithologic variations, temporary tectonic ponding of sediment, and stream capture. Simulations run under a variety of conditions allow examination of how sediment yield responses differ under different hillslope process regimes (e.g., regolith creep vs. landsliding).

Some preliminary findings can be outlined. In simple detachment-limited or transport-limited model runs, sediment response curves are monotonic, increasing smoothly to match the newly imposed uplift rate. Response timescales are governed both by the fluvial system and by the operative hillslope transport process. For instance, a more rapid response occurs when hillslopes are dominated by mass movement than when they are dominated by diffusive soil creep. However, comparisons with runs involving more complete process descriptions (e.g., tracking soil thickness) emphasize the limitations of the simplified models. Explicitly tracking soil thickness enables us to capture some of the complex dynamics of channel-hillslope interactions that influence runoff rates, drainage density, and rates of sediment delivery to channels. Because sediment stored in soils on hillslopes can be rapidly excavated as channels extend upslope in response to, e.g., a sudden change in baselevel, channel-hillslope interactions can dictate the form of sediment yield response curves, which may deviate significantly from the monotonic increase predicted by simpler models.

KRYSTYNA TURKOWSKA

Rôle morphogénétique des dépôts du Plénivistulien Moyen dans la Pologne Centrale; études détaillées dans la vallée de la Mrożyca

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La Mrożyca est une de petites rivières descendant du Plateau de £ódŸ vers la pradoline de Varsovie-Berlin. Dans sa vallée, il y a déjà un demi siècle, Jan Dylik a commencé des

recherches sur la morphogenèse périglaciaire de la Pologne Centrale. Actuellement, large coupe antropique expose la structure d'une zone périphérique de haute terrasse, principale dans la région, reconnue comme plénivistulienne (Turkowska 1988). Sur le poster, on présente des résultats des études lithostratigraphiques et génétiques, effectuées dans la vallée de Mrozyca depuis le 1995. Dans un article «The state of knowledge about Middle Plenivistulian valley deposits in Polish Lowland», inclus dans un volume de Landform Analysis offert à la Quatrième Conférence Internationale de Géomorphologie, on discute leur contribution à la connaissance générale de l'évolution d'un paléo-environnement au cours de la période en question.
Nous voudrions souligner:
caractères du relief de la vallée dans le secteur étudié, surtout sa dissymetrie - versant d'ouest peu incliné, versant l'est avec belle terrasse de 100 m large et jusqu'à 15 m haute par rapport au fond actuel, morcellée par petits vallons en berceau et ravins, les derniers suivants des axes des vallées sèches affluents, synchroniques à la terrasse même. Coupe étudiée se place au confluent de deux vallées, dans la zone périphérique de forme fluviale et au cône de déjection de la vallée de dénudation;
structure bipartible de terrasse: série I - 4 m de dépôts limono-sableux à litages très fins (dépôt de l'eau stagnante ou très peu dynamique), décapitée et recouverte par série II - 6 m de sables et de poussières intercalées, en couches de 5 à 25 cm d'épaisseur (dépôts nivéo-éoliens);
caractères texturaux et structuraux très divers selon l'endroit dans le profil verical, mais aussi, dans les mêmes couches dans le profil transversal (prédominance de dépôts limoneux le long de l'axe de la vallée de dénudation et sur les versants fossils, couches de sables de plus en plus importantes au front du cône de déjection), déformation syn- et postsédimentaire, surtout de type de load coast;
âge de dépôts, défini par analogie avec autres vallées étudiées et verifié à l'aide de la termoluminescence: Plénivistulien moyen (au-dessous de la surface de discordance) et partie inférieure du Plénivistulien supérieur, antérieure à la transgression glaciaire (au-dessus de la surface de discordance). Il faut souligner qu'en Pologne, toute la période en question, située entre les deux refroidissements vistuliens, on défini souvent comme Plénivistulien Moyen, en réservant le nom du Plénivistulien supérieur à la période glaciaire senso stricto, avec un inlandsis. Dans les vallées de la zone extraglaciaire, elle s'est manifestée par une phase d'érosion et un écoulement en tresse;
On considère un rôle morphogénétique des dépôts du Plénivistulien moyen comme tout à fait fondamental dans la Pologne Centrale. Il se manifeste dans un comblement des formes d'érosion et un adoucissement d'un vif relief du Plénivistulien inférieur (rôle direct, résultant de bilan d'accumulation supérieur à zéro) et dans une définition de l'évolution postérieure du relief (rôle indirect, demontré par l'érosion et lié à la lithologie). Il faut rappeler encore une fois que, dans la région présentée, les bordures de terrasse plénivistulienne et, surtout, les ravins qui morcellent les dépôts fins du Plénivistulien Moyen consistent à nos jours des éléments de relief les plus vigoureux.

MERAB TVALCHRELIDZE

Geomorphology of the Black Sea littoral line of Georgia

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Georgian coastline of the Black Sea is 312 km long. The coastline and the upper part of littoral gained their recent form during the last 10,000 years (Holocene).
During the maximal phase of last glaciation in the coastal line (adjacent to the orogenic systems), riverbed erosion significantly dominated the lateral erosion, and due to it the river-gorges were characterized by great depth and steep slopes. In a vast subsidence zone that was located between orogenic systems the sea gulfs were cutting deeply into the coast along the river-mouths and southwards considerably exceeded recent outlines of the coast line. Such facts in comparatively fewer scales we observe in adjacent to orogenic systems coast lines. Such morphology of coastlines was determined by considerable negative balance of river alluvion volumes (during the last glaciation) comparative to the loss of solid drift volumes.
Alongside with glacioeustatic rise of the world ocean and correspondingly the Black Sea levels magnificantly increased volumes of river alluvions. Abundance of the latter resulted in almost complete disappearance of sea gulfs and the coastline gained almost smooth form. In the coastline dynamic systems were formed, they are characterized by definite dynamic individuality.
In the shelf zone complicated canyon systems were developed, their majority starts near the river-mouths and reaches the sea bottom. Due to its genesis two types of canyons are distinguished - tectonic and erosive.
In the sea at low depth sand bars of two generations are present. They are parallel to the coast. The first bar is relict and it is connected to the regressive phase of the sea in Holocene (Phanagorian). The other one is recent and is featured by mobility, variation of form and volumes and is disposed mainly near the river-mouths. In the depth of the land bars of relict sands (parallel to the coast) according to existing in them archaeological material are related to Nimphean transgressive phase.
Under the influence of anthropogenic factors regularities of natural development of the coastline are considerably disturbed, morphology of the land changed, and consequently overwhelming part of the beach line undergoes degradation and washout.

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Rill development as a consequence of changes in hydrology after forest fires

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The research has been carried out in a forest located in the Cadiretes mountains, which burnt on 7th of July 1994 in Llagostera, Girona province, NE Spain. The fire affected 12.66 hectares of a *Pinus pinaster* and *Quercus suber* forest. The average rainfall in the area is 675 mm/year, with a maximum in rainfall and rainfall intensity in Autumn.
Changes in hydrology is one of the first consequence in burnt soils. On one hand, the unprotection of soil by vegetation and organic matter make difficult the infiltration of all the rainfall, due to water arrives at the surface with too intensity, and on other hand the hydrophobic response of ashes decrease infiltration capacity. The infiltration capacity of the soil, measured by simple rings, was even 6 times lower in the burnt soil than in the control one. The runoff coefficient was determined by means of runoff and rainfall. The runoff was collected in gerlach traps, and the rainfall was measured by a simple rain-gauge. In the first months, the runoff coefficient was until 9 times higher in the burnt areas than in the control unburnt zones. The runoff generated on the slopes arrives concentrated at the forest ways with enough power to develop rills and gullies. The rill development is not a continous phenomenon, only when the rainfall and rainfall intensity is strong enough, the water erode the ways and even cause slump movements in the borders. The total material eroded in the tracks in the study period has been measured by the determination of the volume of the rills and gullies.

GENNADY F. UFIMTSEV

Symmetry of the Earth planetary relief

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Latitudinal belts of relief of Nothern and Southern hemispheres are antisymmetric to each other: Laurasia and Southern ocean, Arctic basin and Antarctic continent. In polar regions of the Nothern continental and Southern oceanic hemispheres are situated central elements - inclusions alien to them. Intersecting alien elements - North Atlantic basin with Greenland and the Andes with Scotia sea region - connect the central inclusions with allied relief of contrary hemispheres. General antisymmetry of relief of the Southern and Northern hemispheres is added by antianaloguous forms: belts of great continental plains of Laurasia and median-oceanic ridges of Southern ocean, Centralasian belt of ridges in strip of tectonic lithosphere clustering and EastAfrican rift belt. Antisymmetry of hemispheres' relief conforms to pear-shaped geoid figure: uplifts of geoid surface conform to oceanic belts, but its lows according to spheroid - to continental belts.
Laurasia relief has a concentric-radial structure and symmetry of cone (∞PL_∞), pointing out an expansion and stability of this continental massif. Especial plane of symmetry near 120 e.l. characterizes the extance of homologic forms on east and west: Ordos and Colorado plateaus; Fenwey and Rio-Grande rifts; Mongolia-Siberian and Verkhoyan-Kolymian mountain belts; the Urals and Appalachian mountains. On the east of Asia disturbance of symmetry of cone: young mountain are changed by island arcs; on peripheries of basins of marginal seas there are formed mountains of destructive types.
Southern continents and subcontinents-fragments of Gondwanaland have similar forms and are characterized by latitudinal translations and translations of similarity. Positions of southern continents and meridional harts of mid-oceanic ridges of Southern ocean are characterized by symmetry axis of fourth order L_4 with disturbance of this symmetry in Western Pacific, where Darwin underwater uplift and belt of backarc riftogenesis and marginal seas' spreading are situated. Equatorial belt of sinistral oroclines consists of horizontal curves of mid-oceanic ridges(a); concaval(b) and convex(c) borders edge of the gondwanaland continents, island arcs(d) and aseismic ridges(e). Leading with Eastern Pacific uplift and to the east it is the combination (abc)-(abc)-abc)-(de). Structure of (abc) group is characterized by three-divisible antitranslations, and of (de) group - two-divisible antitranslations, and of (de) group - two-divisible antitranslations, but position of these groups on Earth - is characterised by symmetry axis of fourth order L_4 with disturbance of symmetry in Western Pacific, where (abc) group is changed by (de) group and the belt of equatorial sinistral oroclines is abruptly extended.
Co-ordination of planetary relief structure with geoid figure and tectonosphere structure (saturation of the Southern hemisphere by asthenosphere layers and lenses) is a foundation for hypothesis of anisotropically expansing-compressing postgondwanian Earth. Tectonosphere of planet is expanded in the Southern hemisphere and is relativelly compressed in the Northern one, but change of linear speed of rotation in equatorial belt stipulates a formation of sinistral curves of forms of planetary relief. Due to rotative processes occurs smoothing of planet figure and displacing of tectonosphere matter (firstly continental massives) to the north.
Disturbance of planetary relief symmetry and availability of high uplift of geoid surface in Western Pacifics point out that in this part main transformation in tectonosphere and on Earth surface takes place.

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Au sujet de l'accesibilité naturelle du relief

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En tant que résultante intéractive dans le géosystème (environnement) le relief participe d'une manière transformante dans l'existence de la société humaine et, de ce point de vue, l'on peut constater que des traits essentiels du paysage des grandes régions ont été influencés ou même déterminés par le relief.
Par l'integration de certains caractères quantitatifs et qualitatifs du relief, nous proposons un indicateur complexe de l'accessibilité naturelle du relief, nous prouvons sa pertinence par des applications dans des régions différentes de la Roumanie et nous le cartographions par un méthode propre, la visualisation progressive.
A part son importance fondamentale pour l'analyse géosystémique et pour la régionalisation géographique, et indicateur a aussi des valences applicatives (dans les études de faisabilité pour les bâtiments, les aménagements fonciers, le tourisme, les voies de communication e. a.).

GERMAN URBAN LAMADRID

Compared geomorphology: three intrusive bodies with morphology inverse: Tlamacazapa, Huitziltepec and Coaxtlahuacan, Guerrero, Mexico

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Three bodies of a medium size (1-1.5 km of diameter) are fairly line up north-south in a 150 km of distance. Such fact in other circumstances could be insignificant but in these cases morphogenetic processes have played an important role to differentiate from each other. From these examples we can gather a lot of worthly lessons of the inmidiate past, specially because most of the bodies are quite exposed, thus it represent a good chance to study them.
Geologic settings are in general quite similar: intrusive bodies with a qranodioritic-cuarzmonzonitic composition have intruded mesozoic limestones, upwarping hills around them. Structurally speaking they are not so different; the domic structure is predominant, and faults above and around are common.
In just 2' of latitude drastic climatic changes occurr. From the southern body (17' lat north) wich is located in warm-humid climate to the middle one in a warm-dry zone; and the northern one in a temperate to warm-dry (18'5 lat. north). Hence Karst processes are quite differenciated among them.
Tlamacazapa (2000 m a.s.l. is the northern one) is surrounded by a wide field of deep sink holes, dolinas, and a huge gruta and spring water sprout at north. A deep basin develops onto granitic rock, with a well integrated dendritic drainage pattern.
Huitziltepec is located at 1500 m a.s.l. Recent diggings by a highway have crop out nitid contacts, and a nice almost flat landscape where the intrusive has been leveled, nevertheless some crests still remain and also some limestone blocks were raised. Eastern part is more gently and even aluvial fans of gentle slope are present at the edge of the valley. A temporal summer pond embellish the scenary, corn fields accomplish it even more.
Basin is almost leveled and closed, surface conections to lower basins ere not so clear, underground connections are obvious, specially because the great cynetic energy in between (800 m difference)
Coaxtlahuacan the last and southern case is quite peculiar and scenic, plenty of sink holes, natural archs and a sumidero and springs are located at the base of the horizontal contact with dolimitic rocks. Around many big vertical blocks «shelter» the intrusive gentle valley. Nevertheless this is perhaps the most eroded one, also en terms of karstic «structures».
Eastern edge meet sandstone rocks with much more posibilities to avoid the erosion. Resulting in a sharp ranqe. The basin has fairly dense dendritic drainage pattern wich disappear at contact with calcareous rocks.
Three cases are related to skarn iron-and polysulphides ores, and to middle distance to another gold-iron mines. Then any light on morphologic evolution will bring new tracks for natural resources exploration.
Now is going a deeper morphometric study and a seasonal video from three cases, wich will put light on many aspects, specially on terms of underground water, landscape evaluation and understanding of geosystem-ecosystem relationships.

JÁN URBÁNEK

Geomophological events of medium scale (case study)

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The subject of this contribution is a hilly region in Slovakia - Myjavská pahorkatina. This hilly land was settled and agricultural exploited since the 14th century. The agricultural soil was divided into numerous small lots, worked manually or with the help of animals. In the mid of 20th century the social and property relations changed. Tiny lots were joined into large fields. Heavy mechanisms and chemical means were used. The streams were regulated and dams constructed. A typical phenomenon in this landscape are intesive present geomorphological processes on slopes, flood plains, river beds.

There is certain traditional hypothesis trying to explain these events. It is the assumption that these processes were caused by changes in land use during 20th century. It is the assumption that single local processes interact and the response has the nature of a fluctuation. But the spatial analysis - spatial analysis of land use system, spatial analysis of small geomophological forms and ephemeral processes, spatial analysis of large geomorphological forms and long lasting processes - cast doubt over this hypothesis. The results of spatial analysis anticipates an other hypothesis. It can be called hypothesis of metastability. It can be formulated as follows: If we investigate the relief within small time-space dimensions, then it appears unstable, as «full» of local topical events. If we investigate the relief within large time-space dimensions, then it appears unstable, as «full» of regional longlasted irreversible trends. There are some medium scale geomorphological processes and forms «between». This medium scale level behaves like buffer muffling both forms of unstability. It can be assumed that this metastability of geomorphological events of medium scale was not impaired even by the distinct change of land use system in the period of the socialist collectivization.

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Solution rate of limestone tablets and CO_2 measurement in soils in limestone areas of Japan

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The CO_2 contents in soils have been studied at the 7 points in Japan: Asahikawa, Abukuma, Chichibu, Akiyoshi, Shikoku, Ryugado and Minamidai to island, since 1992. These areas are covered by Palaeozoic, Mesozoic and Quaternary limestones. The CO_2 contents in soils have been measured at each points for every 4 seasons in order to clarify the factors of solution ratio of limestones. The CO_2 contents in A horizons and B horizons changed in accordance with the water balance in soils as well as ecological contions in soils. Under the grassland conditions, the values of CO_2 show maximum in B horizon after 3-4 days' rainfall. The seasonal and year-to-year variations of CO_2 contents are also related to the water balance in soils at the observation points. In almost of all cases, the highest values are found in B horizons. It is indicated that these CO_2 results are closely reflected to the values of solution rate of limestone tablets in soils. In 1994, the values of CO_2 were extremely small at all observation points, become of anomalously hot and dry wether.
The year-to-year fluctuation of tablets' solution rates are also reflected by the year-to-year fluctuation of the water balance. In 1993, the solution ratio was very high, because of wet weather with high value of CO_2 in soils. However, the solution ratio was very low in 1994, because of the hot and dry conditions of the year with low value of CO_2 in soils. These solution ratio of limestone tablets in soils are 1. 5-2 times higher than the values in the air during observation period at all points.

SERGEI A. USHAKOV & IRINA S. USHAKOVA

Geodynamic nature of Sikhotealin mountains and island Sakhalin

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Geomorphological and geophysical data analysis allows to propose that the Sikhotealin mountains are forming as a result of continental lithosphere contraction and the Okhotsk Sea oceanic lithosphere subduction under them with small linear velocity ($V < 1$ cm/ year). According this interpretation of the Sikhotealin mountains geodynamic origin it is naturally to suppose that island Sakhalin is the summit of large accretionary prism . This prism is formed predominantly from sedimentary rocks with the ophiolite spots. The accretionary prism goes on to form at present being compressed and sheared.

SERGEI A. USHAKOV & IRINA S. USHAKOVA

Geodynamic nature of the Crimea mountains

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The Crimea mountains are not isostaticaly equilibrated. They have maximum altitude close to 1.5 km and isostatic anomalies close to +150 mgl. The negative anomalies zone with minimum anomaly equal to –200 mgl is extending about in 100 km southwards from the Crimea south coast parallel to it. The large conjugate positive and negative isostatic anomalies allowed us to conclude that the Crimea mountains just as the mountains exist at present because the Crimea continental lithosphere upthrusts upon the Black Sea oceanic lithosphere. The Black Sea lithosphere subduction is proved by seismic data (Kogan). According these data in minimum isostatic anomalies zone within the Black Sea lithospheric basement relief the deep trough buried under sediments is detected.

V.V. USHMANOV

The endogenously ordered earth's surface relief: genesis, types, practical use

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The Earth's surface and its seemed to be chaotic relief are quite ordered in reality, the ordered character of them is determined by the existence of the structural energetic framework of the planet. It is a result of the interaction between the uneven Earth s rotation and the Universe. The framework is formed by the crossing of stratifiable (geospheres etc.) and nonstratifiable (geosystems etc.) natural and social objects, their physical fields and sizes of a different ranks, their genesis and degree of ordering. The structural framework in the endogenous geospheres is chiefly material-tectonic and difficult to observe; in the exogenous it is energetic and weakly revealed by traditional methods. The framework is mostly marked and easy to observe for remote methods on the Earth's surface where it is presented by the planet lineament system (nets). The latter is formed by the crossing lineaments and its natural (linear, lattice-like, concentric, cellular, vortex etc.) combinations or lineament systems (Ls). The Ls reflect non-stratifiable ordered geological objects (in plan) and they determine structural-geometrical parametres (form, sizes, structure and symmetry) of the relief fofms of different ranks, appearance, structural complexity, endogenous organization type and degree, genesis (tectogenous, tectonicly determined, a-tectonic).

Tectogenous morphotectures and forms built by the endogenous processes are the most ordered. They completely correspond (in plan) to LS which are in the base. These structures are surface (coinciding with the Earth's surface) forms of the latest or prepared geological bodies, dislocated or material-dislocated. Limits of the surface forms are of the morphotectonic character and they are presented by tectonomorphic or lithomorphic lineaments.

Tectonicaly determined morphostructures and forms are built by the interaction of the endogenous and exogenous factors, they are less ordered for they reflect but the structure of LS in the base. Sizes and eroded character of the morphostructures do not coincide completely with the LS skeleton (in plan) and with the material/material-dislocated geological bodies. Limits are of the exogenous-endogenous geomorphological genesis and of complicated outline.

A-tectonic morphosculptures and forms are built mainly by the exogenous (destructive and accumulative) processes. However, there are also ordered formations among them, their regular (isaometric, circular, rectilinear etc.) form, structure or orientation are determined by the corresponding structure of the tectonic or energetic values of the planet structural frame-work. Outer contours of such morphosculptures are of the exogenous, exogenous-geophysic and exogenous-tectonic genesis.

High endogenous informativity of the Earth's surface ordered relief enables to use it for the prospecting of new types of tectonic objects; for investigation of the geographic structure as the environment of formation and functioning of the society; for determination of the frame-work energetic value localization that influences on the technogenous system state and on the human health.

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Modelling large-scale long-term landscape evolution across the eastern margin of South Africa

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The eastern margin of South Africa is a classical area for studying the morphological evolution of high-elevation rifted continental margins. Traditionally, the evolution of the margin has been reconstructed by correlating onshore erosion surface remnants with offshore sedimentary sequence boundaries. Later, attempts have been made to date recognised erosion surfaces using weathering deposits, as well as to derive denudation histories from offshore sedimentation rates. All these approaches, however, faced serious problems of either correlation, quantitative dating control or demarcation of sediment source areas.

Recently, two of us (Rb & Ms) have collected a large amount of apatite fission track data from the Lesotho highlands and the Natal coastal area, in order to better constrain the denudation history of the south-eastern African margin. These data provide evidence for substantial post-Jurassic (i.e. post-break-up) cooling and denudation, both to the west and to the east of the Lesotho highlands crest. Seaward of the escarpment, >4 (and possibly up to 7) km of crustal section have been removed since ~100-80 Ma. Inland of the escarpment, the data indicate ~2 km of denudation since ~80-60 Ma. The data are in partial disagreement with traditional models of landscape development in eastern South Africa. For instance, the absence of a younging trend of fission track ages from the coastline towards the escarpment is inconsistent with a classical model of escarpment retreat. Also, the fission track ages inland do not corroborate the ages previously assigned to specific erosion surfaces.

We employ a numerical surface processes model in order to quantitatively assess the controls on landscape evolution and denudation history of the margin. The model adopts two main types of processes: «short-range» hill-slope processes (including weathering, mass wasting, slope wash and soil creep) and «long-range» fluvial processes. Hill-slope processes are modelled by a simple linear diffusion law; fluvial transport is controlled by the carrying capacity of rivers and an erosion length scale, which is a measure of the «erodibility» of the substratum and is included to model supply-limited behaviour. We do not aim to reproduce exactly the observed morphology of the south-east African margin. Rather, we aim to constrain the relative importance of factors such as antecedent topography, lithological control, evolution of inland drainage and flexural rigidity of the lithosphere on landscape evolution.

The model tracks the evolution of topography and the denudation history for each point in the grid. From the modelled denudation histories we predict the pattern of fission track ages across the margin. Modelling results are compared with the present-day margin morphology (eg., position and elevation of the top of the escarpment, escarpment slope etc.), as well as with the amounts of denudation inferred from the exposed stratigraphy and the fission track data. The predicted amount of post-break-up isostatic uplift, in response to erosion of the margin, is compared to the elevation of remnants of uplifted Cretaceous-Palaeogene marine sediments within the coastal zone.

Modelling results indicate that the initial (pre-break-up) morphology of the area exerts a key control on the subsequent evolution of the margin. A model in which a pre-existing drainage divide is located 100-150 km W of the present-day coastline gives results that compare best with the observations. It predicts rapid denudation of the entire area seaward of the initial drainage divide during the first 30-50 My after continental break-up, consistent with the denudation histories inferred from the fission track data. Additional first-order controls appear to be exerted by the flexural rigidity of the lithosphere, which directs the amount and distribution of isostatic rebound, and the onset of inland (westward draining) drainage. Best-fitting models are characterised by remarkably low flexural rigidities: they have equivalent elastic thicknesses of the lithosphere on the order of 10 km, which is substantially smaller than elastic thicknesses inferred from geophysical studies. Denudation from the top of the Lesotho highlands appears to have been initiated by an inland drop in base level that occurred at around 80-90 Ma. Although the regional stratigraphy (consisting of a cap of resistant basalts overlying softer Karroo sediments, which in turn overly the hard crystalline basement) has strongly influenced the morphology in detail, the models suggest lithological control on a regional scale to be less important.

W. VAN HUELE, F. PATTYN & H. DECLEIR

Glacial valley form revised

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A common tool to describe the cross profile of a glacial valley is a curve fitting analyses by means of a parabolic or power-law equation. Although the parabolic equation offers a unique and unbiased solution, it is not able to describe the valley form. On the other hand, the power law equation ($y = a x^b$) can describe the valley form through its exponent b but is not suitable as a curve fitting function (see discussion by Harbor & Wheeler, 1992).

Pattyn & Van Huele proposed a general power law: $y - y_0 = a |x - x_0|^b$ taking into account the determination of the

coordinates of the origin and the fact that the cross profile is symmetrical about the origin. A solution is obtained by general least squares adjustment applied to the valley data points and not by a regression analysis to its logarithmic form, as is the case with the previous version of the power-law equation. The advantages of this method are demonstrated by theoretical examples.

Pattyn & Decleir (1995) applied this general power law for the first time to a few glaciers of the Sør Rondane Mountains, a mountain range bordering the East Antarctic Ice Sheet, and demonstrated its effectiveness. The Sør Rondane Mountains are unique in the sense that it consists of a number of massifs, seperated by large outlet glaciers, which are at present characterized both by active valley glaciers and ice free valleys. This allows for a detailed morphometric analysis of different kind of glaciers such as local and outlet glaciers as well as active glacial and deglaciated valleys.

The result of such a systematic morphometric analysis by this general power law is presented and discussed in function of the glaciation of the mountain range. The analyses also shows the importance of the morphology of postglacial processes such as post-glacial fill and slope processes on the shape of valley cross profiles.

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Thresholds for ephemeral gully initiation in intensively cultivated areas in the Mediterranean

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Ephemeral gullying is an important erosion process in the Mediterranean areas suffering from land degradation by increased drought and human impact. Gully incision requires the exceedance of hydraulic threshold conditions that are strongly determined by topography and therefore can be expressed in topographic terms for given environmental circumstances. In this study, the threshold concept has been applied to intensively cultivated areas in the Mediterranean. The objective was to collect field measurements of local slope (S) and drainage-basin area (A) at the initiation of ephemeral gullies in order to investigate the existence of erosional thresholds and to identify the most suitable expression, either as a functional relationship between S and A, or in the form of topographic indices composed of these parameters. The data were collected in Southeast Spain and Northeast Portugal at 50 ephemeral gully sites in each study area. Regression analysis was carried out to reveal the relationship between S and A, which was defined as the mean threshold relationship. The results showed both a statistically unacceptable and acceptable relationship for the Spanish and Portuguese dataset respectively. The significance of the relationship was considerably improved by merging both datasets, and by accounting for local topography and plough direction relative to the gully direction. A minimum threshold line was defined, interpreted and compared with other datasets and theoretical relationships found in literature. Differences mainly originate from the methodology used to measure the parameters and to establish the relationships. Comparison of the threshold relationship between the Spanish and Portuguese dataset was constrained by the lack of complete rainfall data, but shows the importance of other factors than drainage-basin area and local slope alone.

The calculation of the topographic indices resulted in a wide range of values for each dataset. Graphical interpretation shows that the investigated indices are not suitable to describe the general trends of the data. Consequently, an alternative index is proposed.

The results of this study illustrate the potential of the threshold concept for ephemeral gully initiation using topographic information collected in the field. It shows the advantages and constraints of this methodology, and stresses the importance of additional information on environmental conditions necessary for a full interpretation and better understanding of the established threshold conditions.

JEF VANDENBERGHE

Periglacial river systems: a rich diversity in types

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Traditionally a braided pattern has been attributed to rivers from periglacial environments. In the past years other river patterns have been found in the records of former periglacial fluvial systems. Not only braided and meandering patterns have been recognized but also transitional forms between those two extremes occur. Anastomosing rivers of different types are recognized at several occasions.

Soil stability and energy conditions throughout the year seem to be the leading factors determining the river pattern. Although runoff is directly related to precipitation, its effectiveness is largely determined by the presence of vegetation and permafrost. Considerable temporal and spatial changes in the latter factors induced the large differences in river behaviour and pattern that we recognize not only in Pleistocene but also in presentday periglacial environments. Furthermore, basin characteristics like river gradient and grainsize of the river sediment may enhance regional variability.

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Alpine permafrost in upper Valtournenche (Aosta Valley, Western Alps, Italy) inherited from little ice age glaciers

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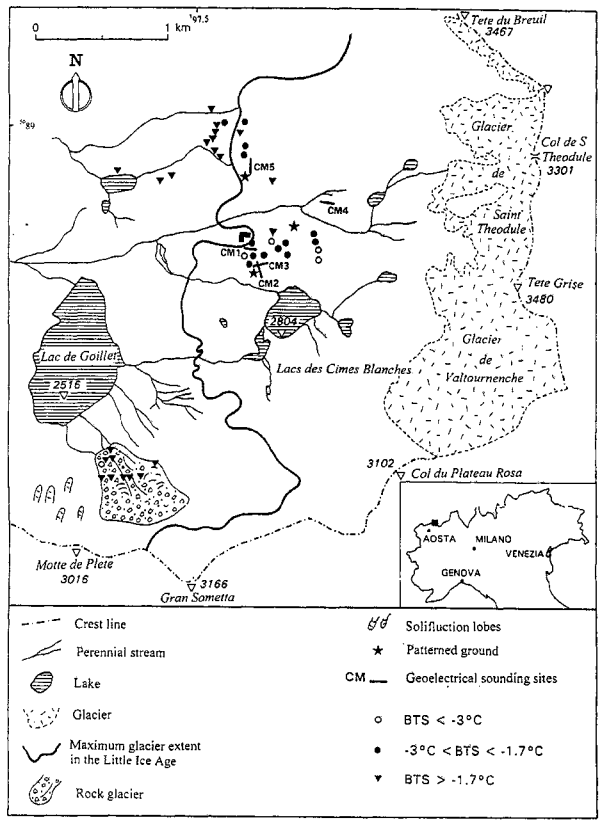
The upper Valtournenche (Western Alps, Aosta Valley, Italy) shows a periglacial geomorphology, with forms depending on seasonal and perennial ground frost (solifluction lobes, patterned ground and a rock glacier) fig. 1.
The slopes from Gran Sometta (3166 m) to Tete du Breuil (3467 m) are covered by an alpine grassland up to the altitude of 2700-2800 m. Glacial deposits laid by the Valtournenche Glacier during the Little Ice Age are present at higer elevation. The Little Ice Age glacial deposits show common patterned ground features (polygons 1-2 m in diameter). Excavations made for ski installation locally found interstitial and massive ground ice.
Measurements of air temperatures have been collected and alpine permafrost distribution has been partly checked using Bts (Bottom Temperature of the Snow winter cover) and geoelectrical soundings.
Bts measurements put in evidence a clear difference between the area covered by Little Ice Age glacial deposits and the external grassland.
In fact 72% of Bts measurements in the area covered by glacial deposits, show values between –1.7°C and –3°C, indicating the possible presence of permafrost. In the external grassland area the Bts measurements show values greater than –1.7°C meaning that permafrost can not exist.
Five geoelectrical soundings have been realized. They show a 7.5-80 m thick high resisitivity layer (21000-35000 (m), indicating the possible existence of permafrost.
In fig. 1 the sites for Bts measurements and geoelectrical soundings are shown.
Bts mesurements and geoelectrical soundings were located at an altitude of 2800-2900 m.
Mean annual air temperature at the altitude of 2850 m was –1,83 °C in the period 1970-80 and –0,5°C in the period 1990-93.
From the obtained data it can be deduced that probably the permafrost is not in equilibrium with the present climatic conditions, but it is subjected to degradation.
Permafrost is located in an area that during the Little Ice Age was covered by Valtournenche Glacier. Therefore it can be assumed that the Little Ice Age glacier allowed the creation/preservation of permafrost in this area, as a consequence of a basal temperature below the melting point (polythermal glaciers).



VEERLE VANWESENBEECK

Geomorphological and sedimentdynamical research on a meso- and microscale in the maritime part of the Scheldt Estuary (Belgium)

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This study is part of a PhD research, that is funded by the Flemish Foundation of Scientific Research (F.W.O.).
The study area is situated in the maritime part of the Scheldt estuary (between the city of Antwerp and the Belgian-Dutch border).
The study has two main purposes. On the one side, the correlation between the geomorphological structure of the bottom of the river, the characteristics of the sediment and the hydrodynamic conditions in the area are investigated. On the other side, the residual sediment transport paths on a relatively small scale are defined and compared over several periods.
In the study area, sonographs were realised with a Klein 595 digital side-scan sonar, while simultaneously bathymetric recordings were carried out by means of a Deso XX echosounder. These registrations result in a bedform map of the bottom of the river, and are used to determine the

position, height, orientation and asymmetry of the sedimentary structures (mainly sand ripples with a height ranging from 0.20 to 1.50 m) that develop in the sediment of the area. Such registrations were repeated several times in the period 1995-1996, with at least 1 month of interval. Part of the side scan sonar registrations were realized in a digital way, by means of the program Delph2. This implies that the recorded images are immediately stored on files and the processing (correlation of different images, map-making,...) is carried out on the Pc.

In the same area, grab samples were taken in a regular pattern, with 300-400 m distance between them. They were subject to a detailed granulometrical analysis and a computer program was used to calculate the statistical parameters. The content of $CaCO_3$ and organic matter was determined as well.

When all results of the study are compared, interesting relations seem to exist between the geomorphological structures, sedimentology and hydrodynamics.

The residual sediment transport paths are determined in two different ways. They are defined from the orientation and asymmetry of the bedforms. It is assumed that sand ripples move forward in the direction of their steep slopes, thus representing the sediment transport in that direction.

On the other hand, McLarcn & Bowles (1985) elaborated a statistical approach to determine the sediment transport directions along a line by examining the sedimentological parameters of all possible pairs of samples on a sample line. Each sample is compared with its eight neighbouring samples with respect to their mean size, sorting and skewness. According to the McLaren model, the sediment becomes either finer, better sorted and more negatively skewed, either coarser, better sorted and more positively skewed in the direction of transport. This method was used as well to define the sediment transport directions in the maritime part of the Scheldt estuary.

There exist quite some differences between the sediment transport paths determined according to the two respective methods, which allows an interesting comparison.

In the determination of the residual sediment transport paths, it is very important to take into account the influence of the dredging activities that are carried out in the framework of the present deepening program of the Scheldt estuary.

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Late Pleistocene syngenetic ice-wedges formation in intermountain depressions of the Magadan Region

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The problem of formation of the thick syngenetic sediments with large ice - wedges (named «edoma» in Siberia) is very complicated and its decision is the key for periglacial landscapes evolution during Late Quaternary. It is believed that alluvium, loess and lacustrine sediments conditions are the medium of the thick syngenetic ice-wedges formation.

It is very important to demonstrate that the slope sediments conditions are also favorable for thick syngenetic ice-wedges formation. The edoma sediments with rock debris and rock gruss are very interest for identification of the geomorphological conditions of sedimentation. Such edoma thicknesses in permafrost zone have not been study earlier.

We have studied large Late Pleistocene syngenetic ice wedges widespread in the intermountain depressions in valley Upper Kolyma River (west of Magadan Region): at quarry near Sinegor'e town, «Phoenix» sequence (height about 15 m, location is more than 400 m a.s.l) and at quarry near Utinoe settlement (height about 8 m, location is more than 330 m a.s.l). The main features of the edoma were the interbedding of the loam layers with rock debris layers and peat. Dimensions of the some rock debris were more than 10 cm. Their content was more than 30%. It is clear pointed out on the slope genesis of the thicknesses.

The oxygen isotope study of different kind of ice has been used for determination of time and climate condition of edoma formation. $\delta^{18}O$ determinations were received from upper fragment of ice wedge complex outcrop «Phoenix» from Late Pleistocene syngenetic repeated ice wedges: +406 m: –30,6‰; +407 m: –30,4‰; +410 m: –32,4‰; +411 m: –32,2‰; +412 m: –32,1‰; +413 m: –32,6‰; +414 m: –32,2‰. Values ‰^{18}O of textureforming ice from the same interval are: +409 m: –25,2‰; +412 m: –26,2‰, and from overlapping sandy loam is +415 m: –23,5‰. The lowermost fragments of ice wedges, located in base of ice wedge complex, near bedrock, have more positive oxygen isotopic composition: in quarry «Phoenix» are - +402 m: –25,7‰; +403 m: –26,7‰; +404 m: –27,4‰; +405 m: –27,7‰; in quarry «Utinoe» - +331,5 m: –29,3‰; +332 m: –25,3‰; +332,8 m: –26,9‰; +333 m: –27,4‰; +333,5 m: –24,9‰. The feature of oxygen isotope vertical distribution may be connected with origin features of ice wedge complex. There is possibility of river water participation in forming of bottom fragment. Values of ‰^{18}O of recent repeated ice wedges (shoots) is: in Upper Kolyma near Verkhniy Seimchan settlement: –27,1‰, in Upper Kolyma floodplain near Taskan River mouth: –27,0‰; –25,6‰; –27,0‰. Values of ‰^{18}O of Upper Kolyma River water is (in August): –22,0‰, of Utinaya River is: –19,2‰, of Yasnaya River near quarry «Phoenix» is: –22,8‰. Textureforming ice has values ‰^{18}O as follow: in Holocene peat «Chukachi» near Verkhniy Seimchan settlement are 0,5 m: –21,3‰; 0,8 m: –20,1‰; 1,5 m: –18,6‰ and 1,6 m: –18,9‰, and in Holocene thicknesses in Upper Kolyma floodplain (Ivanovskiy Island): –19,0‰.

The comparison of the isotope data is confirmed of the Late Pleistocene (about 35-15 ka BP) age of the Phoenix end Utinoe edoma thicknesses in the intermountain depres-

sions in valley Upper Kolyma River and evidenced the cold winter (on 8-10°C colder than modern ones) conditions during time of their formation. The slope origin of the sediments in these outcrops is evident and demonstrate the possibility of edoma formation in different geomorphology conditions.

ELKIN VELASQUEZ, & RICARDO VIANA

Geopotential analysis a tool for land-use and environmental planning in Colombia: analysis and perspectives

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After Environmental Law of 1993 the environmental planning process of Colombia became of more importance for the contry. Different efforts on research has been initiated from many organization to generate tools, methods and methodologies in order to optimize such a process and from many points of view: physical, biological and sociocultutal. From the physical point of view it was constated the little development of techniques to value the information on geology, geomophology, pedology, hydrology and others disciplines specifically for the purpose of environmental planning. It has been necessary to work on such a way to better explicitate teh land possibilities as well as its restrictions for different land uses. Some criteria used to value the physical environment and to integrate its differents elements has been used to assess the Potential of the Physical Environment or the Geopotential. New maps, geopotentail maps, are being produced as a tool to facilitate the communication between scientists and decision-makers and planners.

DANIELE VENEZIANO, JEFFREY D. NIEMANN,
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Self-similarity of fluvial topography: nature, origin, and scaling implications

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A striking feature of fluvial erosion topography is self-similarity, in the sense that, when a small basin is properly magnified in both the horizontal and vertical directions, it «looks like» a larger basin. Self-similarity manifests itself through scaling relations such as Hack's law, Tokunaga's cyclicity for river networks, the slope-area law in channels, and the power form of the contributing area distribution. This paper addresses three basic questions related to topographic self-similarity:

1. in which precise sense is fluvial topography self-similar?
2. where does such self-similarity come from, and why is it so pervasive or «universal»?
3. what are the scaling implications of topographic self-similarity?

Regarding the first question, we examine self-similarity in both the classical, simple-scaling sense, and the multifractal or multi-scaling sense. We conclude that a proper condition for simple-scaling self-similarity is that, at any given time t, topographic elevation $H(x,y,t)$ satisfies

$$\{H(x,y,t)-H(x_0,y_0,t)\}\big|_A \overset{d}{=} r^{-\theta}\{H(rx,ry,t)-H(rx_0,ry_0,t)\}\big|_{r^2A} \quad (1)$$

where (x,y) are geographical coordinates relative to the main stream source and refers to a basin of total area $|_A$. The symbol $\overset{d}{=}$ stands for equality of all finite-dimensional distributions. Equation 1 should hold for some real θ, any positive r and A, and any given (x_0y_0). Replacement of θ with a random variable Θ gives the condition of multifractality.

The second question is addressed in the context of the simple dynamic evolution model,

$$\frac{\partial H(x,y,t)}{\partial t} = U - \beta(x,y,t)A^m(x,y,t)S^n(x,y,t) \quad (2)$$

where U is uplift rate, $\beta(x,y,t)$ is a random erosivity field, A is contributing area, S is slope, and m and n are fixed parameters. The structure of the random field $\beta(x,y,t)$ is a key factor that controls whether the topography reaches a steady state. It also determines the statistical properties of $H(x,y,t)$ in such a state. The simplest and perhaps most interesting result we obtain is that, if $n = 2m$ and the geology is horizontally stratified with erosivity that varies with depth z as any stationary process $\beta(z)$, then $H(x,y,t)$ approaches a statistically stationary configuration that satisfies Equation 1 with $\theta = 0$. Other conditions on $\beta(x,y,t)$ lead to simple-scaling topographies with different values of θ and to multifractal topographies. The relation $n \approx 2m$ is supported by much theoretical and empirical evidence. In addition, the fact that the above result holds for <u>any</u> stationary process $\beta(z)$ explains the «universal» character of topographic self-similarity (with $\theta = 0$) and its robustness relative to climatic and (horizontally stratified) geologic conditions.

For the last question, we use Equation 1 and its multifractal counterpart to derive and extend many scaling laws, including those mentioned above. We find that, when flow distance is measured using a ruler whose length varies proportionally $A^{0.5}$ to where A is contributing area at the measurement site, then both Hack's law exponent α and the exponent γ of the contributing area distribution should be 0.5. We argue that this is the correct way to measure flow distance. For the case when the ruler has constant length, which is the usual case in practice, we find that $\alpha \geq 0.5$ and $\gamma = 1-\alpha$. This is consistent with a large body of empirical

data. Based on Equation 1, we reformulate Tokunaga's concept of self-similarity for drainage networks, in a way that incorporates both geometric and topologic features. Our definition does not use the notions of Strahler's orders and streams, which are not well defined in self-similar topographies. We also show that many natural river profiles are consistent with $H(x,y,t)$ satisfying Equation 1 with $\theta = 0$. In the past, different conclusions were reached on the self-similarity of such profiles, based on self-similarity conditions different from Equation 1. Finally, we show in which sense river courses and width functions are self-similar.

GEORGE VENI

Methods and problems in conducting hydrogeologic vulnerability assessments in Karst Areas

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Karst aquifers are the most sensitive to groundwater contamination. Historically, such problems have been limited to small and rural areas, but recent urbanization of karst terrains has increased the risk and frequency of pollution, and especially increased the need for hydrogeologic assessments appropriate to their aquifers. Dye tracing is an important and often-used technique in conducting vulnerability assessments of karst sites, and is well documented for its utility in delineating groundwater flow paths and conditions. Geophysical techniques have also been used to assess karst areas. However, their precision varies according to local conditions, they are best suited to locating the relatively larger subsurface features, and broad areal use of these methods is often very expensive.

Increasing numbers of urban karst site assessments are being made solely by morphological examination of surface karst features, although until this paper, effective standardized techniques for such evaluations had not been proposed. A case study of over 700 caves and karst features along the southeastern margin of the Edwards Plateau, Texas, U.S.A., supports the following geomorphological karst feature assessment methodology outlined by the following critical elements:

1. identify strata with greater secondary solution;
2. identify fracture orientations with greater secondary solution;
3. develop an evolutionary model for the karst aquifer and apply it to interpreting feature vulnerability;
4. determine if a feature has airflow;
5. note that features with no soil or with A horizon soil infills are more likely to rapidly transmit contaminants into the aquifer than features infilled with soils of the B and C horizons;
6. delineate the drainage basin of each feature, and its likely relationship to other local recharge features;
7. excavate as needed for more accurate evaluations of the features.

While the above methodology is effective at identifying vulnerable karst features and areas, it alone will not prevent groundwater degradation. Data clearly show that karst aquifers can be readily contaminated if pollutants are present on the karst surface, and that karst vulnerability assessments only identify the most sensitive sites in these highly sensitive terrains. Successful management of karst in urban environments is best achieved by preserving the most vulnerable areas and their drainage basins in their natural state, coupled with minimizing pollutant loading of the aquifer by limiting impervious cover to 15%.

CHRISTINE VERGNOLLE-MAINAR

Nouvelles technologies et réhabilitation des formes de relief dans les études de géomorphologie

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Les nouvelles technologies fournissent de nouveaux outils d'analyse et permettent ainsi de vitaliser certains champs de la géomorphologie. Elles sont aussi étroitement liées à une évolution dans la façon de considérer l'objet des études géomorphologiques, le relief.

L'utilisation de Modèles Numériques de Terrain permet une nouvelle représentation graphique du relief. Ils proposent une visualisation en trois dimensions sous de multiples angles de vision. Et dans leur utilisation la plus fréquente, ils gomment les aspérités de petite taille et privilégient les grandes masses, leur morphologie générale et leur agencement. Ils permettent également des changements d'échelles, sans rupture de l'une à l'autre, et incitent à relativiser l'opposition entre creux et saillants, une même forme pouvant être l'un ou l'autre suivant le niveau considéré. Cette nouvelle façon de représenter le relief favorise un retour en force des formes, de leur géométrie et de leur agencement. Un nouveau regard réhabilitant le relief pour luimeme est donc en train de se forger. Ceci est à mettre en relation avec le fait qu'au cours de l'histoire les modifications majeures dans la représentation de l'espace (comme l'utilisation de la perspective) ont accompagné ou précédé un changement dans la façon de le concevoir. Le maniement d'images en trois dimensions est une de ces ruptures. Cette approche rompt en effet avec celle de la géomorphologie classique davantage centrée sur la genèse des formes, sur la chronologie et les modalités de leur façonnement.

Dans le même temps, émerge une demande dérivant des préoccupations environnementales et portant sur une meilleure connaissance de la fonction des formes de relief dans l'organisation et le fonctionnement des milieux. En effet,

par leur géométrie, leur agencement et leur dynamique celles-ci jouent un rôle. Cette fonction a été longtemps considérée dans le cadre de causalités linéaires et a débouché sur un déterminisme physique implicite et parfois meme explicite. En réaction contre cette vision, les études de milieux se sont fondées sur une approche biologique et les préoccupations environnementales ont longtemps peu intégré la dimension morphologique. Cependant, la demande sociale contemporaine fait évoluer ces études dans un sens qui favorise la réinsertion du relief. Ainsi, le souci d'accorder plus de place à l'analyse de l'inscription des phénomènes dans l'espace va nécessairement de paire avec une meilleure prise en compte des données morphologiques. En particulier, cette évolution conduit à s'interroger sur la fonction d'indicateur qu'ont les formes et sur la façon dont une société les intègre dans ses pratiques et ses stratégies d'aménagement.

Le développement de nouveaux outils de représentation de la surface de la terre et l'émergence d'un questionnement scientifique sur l'environnement morphologique convergent donc vers un regain d'intérêt pour les formes de relief. Leur étude peut bien évidemment tirer profit des théories mathématiques dites morphologiques (Boutot, 1996). En effet, celles-ci considèrent les formes pour elles-mêmes et non comme le seul résultat des forces qui leur ont donné naissance. Elles considèrent chaque niveau de formes comme un tout et les abordent de façon globale. Mais, il faut également prendre en compte les relations d'une société aux formes qui l'entourent. Or l'imagerie virtuelle bouscule ces relations (Gauthier, 1996). En effet, en modifiant les angles de vision et en multipliant les signaux éphémères, elle transforme les représentations symboliques qui donnent forme aux objets, donc au relief. Le regard ainsi façonné va à l'encontre de celui transmis par la mémoire collective qui résultait d'une lente élaboration et débouchait sur un net démarquage symbolique par rapport aux formes physiques. Deux filtres de perception coexistent donc dans notre approche actuelle de l'environnement morphologique.

Pour la géomorphologie, les nouvelles technologies sont donc porteuses de profonds changements, moins par leur rôle d'outil que par leur dimension sociologique. Elles ouvrent ainsi un nouveau champ de réflexion sur la fonction des formes, qui suppose d'articuler des données mathématiques et abstraites avec d'autres plus sensibles et culturelles. Ce faisant la géomorphologie pourra apporter une contribution plus riche à la demande sociale contemporaine.

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Sheet fractures and associated forms, and their engineering implications

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Sheet fractures are widely interpreted as due to erosional offloading, but several lines of evidence and argument point to their being associated with the release of compressive stress. Offloading is mechanically difficult. Direct measurements show that substantial areas of the crust are in compression. Quarried rocks expand on becoming unconfined. Sheet fractures occur in rocks that have never been deeply buried. Many sheet structures postdate orthogonal and other fracture systems, along which pressure release ought to be accommodated. Dislocation is evidenced along many sheet fractures: they are small displacement faults. They are typically developed on bornhardts the persistence of which is explained in terms of compression. Sets of sheet fractures form synforms in some bornhardts. They are associated with a set of minor forms including A-tents which can only be explained in terms of crustal compression. Sheet systems developed parallel to recent surfaces are planes of least principal stress.

Thus sheet fractures, related sheet structures, and associated minor forms are best understood as expressions of tectonism, not of erosional of floading ,save insofar as all fratures are expressions of pressure relkase. Many are neotectonic forms, indeed some A-tents have formed within living memory (some as recently as 1996).

In practical or engineering terms, a compressional environment is significant for general practice and in terms of safety codes. Rock squeeze causes disturnbance of engineering structures. Zones of stress are subject to rapid erosion, e.g. in spillways. Slopes underlain by sheet structures are prone to slippage. Both fracture systems and rift and grain are important in quarry management, for fractures are flaws tobe avoided, or they can be sought as assisting in lif ting blocks. Appreciation of bornhardt geometry, which is determined in profile by sheet fractures, indicates distribution and thickness of overburden. Minor forms like A-tents indicate seismic risk and the mass of disturbed blocks allows magnitude of seismic events to be estimated (important in areas lacking instrumental coverage), both factors being helpful in design and construction of dams, pipelines, cables and mines. Massive outcrops form excellent local catchments for water conservation schemes, and sheet defined bornhardts are not only suitable but their essential properties extend beneath the regolithic f ringe. But the general appreciation of a compressive envirnment if of greatest importance.

GONÇALO T. VIEIRA

Hydro-aeolian processes in granite mountains: the case-studies of the Serra do Gerês and Serra da Estrela (Portugal)

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Hydro-aeolian processes in the Portuguese mountains were first characterized and described by the author in the

Serra do Gerês (NW Portugal). This mountain is a granite range with a maximum altitude of 1545 m a.s.l. (fig. 1) and is characterized by a complex plateau where bare-rock outcrops are dominant. In this plateau, the interfluve of Outeiro do Pássaro was studied in detail and a geomorphological map at 1:5 000 was presented. Such a detailed study allowed the identification of small accumulations of coarse sand and granules which present a superficial layer of about 1cm depth formed by homometric granules of quartz and feldspar. Under this layer, the material is more heterometric and sandy-silty with a higher organic matter content. The sedimentological analysis of the deposits and the comparison of the aspect of the micro-accumulations with a map showing the anemomorphic deformations of small shrubs of *Chamaespartium tridentatum* and *Calluna vulgaris* allowed an hydro-aeolian interpretation for their genesis. This means that both wash and wind erosion seem to be the main processes involved in the evolution of the observed features. A first accumulation phase of aeolian origin is necessary, followed by the deflation and washing of fines, which give origin to a lag-surface about one-granule-thick at the surface of the accumulation. Although, for the thickening of the lag-surface, posterior episodes of accumulation over it are needed. After these smaller accumulation events, deflation and washing take place again, contributing to the coarsening of the superficial layer. This would explain the sedimentological characteristics of the superficial layer (Figure 2). In what concerns to the sub-superficial layer, their sedimentological characteristics seem to be more closely related to the first accumulation event and by posterior fine-sand, silt and organic matter contamination. The importance of needle ice in the genesis of the grain-size differences between the two layer is also being studied.

The author is now developing a similar study in the Serra da Estrela (fig. 1), which is also a granite mountain with plateaus between 1500 and 2000 m a.s.l. The poster will present the studies done in the Serra do Gerês and Serra da Estrela and a comparison of both evidencing the main similarities and differences concerning the occurrence of hydro-aeolian processes.

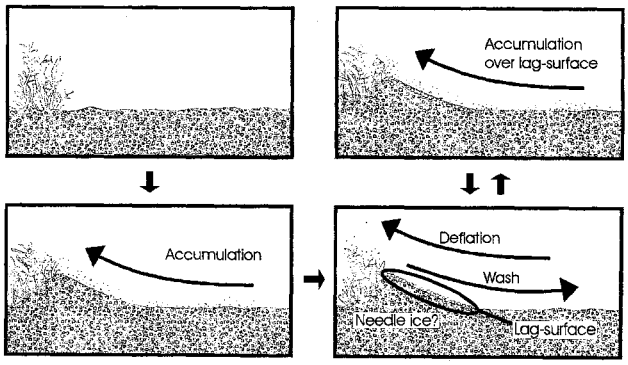

FIG. 2 - Hypothesis for the genesis of micro-accumulations against obstacles

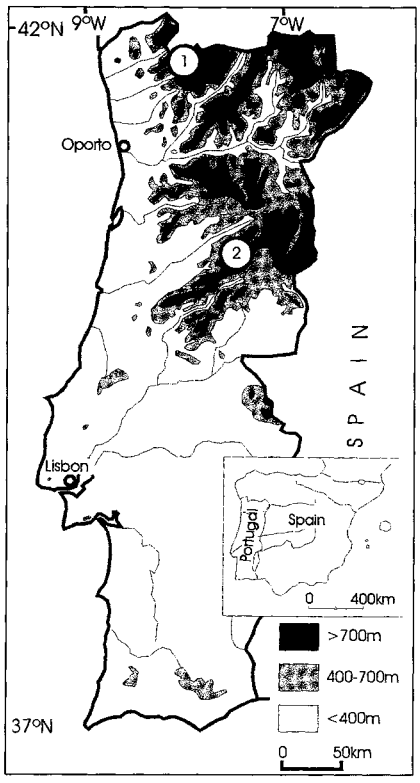

FIG. 1 - Location of the Serra do Gerês (1) and Serra da Estrela (2) in Portugal.

HEATHER A. VILES

Disturbance and the dynamics of rocky coasts

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Rocky coasts composed of cliffs and coastal platforms provide an ideal opportunity to study the dynamics of biogeomorphological systems, and the influence that various disturbances over different timescales have upon them. Specific questions of interest are: how are changes in biological systems reflected in geomorphological change (and vice versa)?, and to what extent are extreme natural events important to the biogeomorphological evolution of rocky coasts?

The Glamorgan Heritage Coast in South Wales provides an ideal site in which to investigate these questions. Liassic limestone cliffs of great instability are fronted by limestone coastal platforms dissected by a complex range of microtopographies, and populated by a suite of sessile and mobile organisms. Data on erosion rates, population dynamics, microenvironmental conditions, climatic variability and anthropogenic disturbances, allied with simple modelling techniques, provide a clearer picture of the coastal biogeo-

morphological dynamics here. Distinct differences can be drawn between the response of rocky coastal systems to disturbance and the responses of sedimentary coasts.

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Geomorphologie tropical Venèzuèlienne

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Le Venezuela est un pays qui a beaucoup changè â partir de son ancienne paleogeographie surtout, au début du tertiaire. Nous avons eu pendant l'Eocène le soulevement des Andes et aprês le paroxisme antillane dans le Pliocène.
La mer a fait son travail et nous a donné avec le concours de fleuves une geomorphologie actuelle três important. Nous avons aujourd'hui une côte três changeante dan l'est comme dans l'ouest du pays.
Dans l'ouest nous avons le lac de Maracaibo, la presqui'île de la Guajira (três sec), la presqu'ile de Paraguaná, ancienne île du début d'Holocene, la côte centrale influencée par la tectonique et la côte ouest oú nous trouvons des vallées sous-marine et en plus le delta de l'Orinoque.
Venezuela est un pays qui a beaucoup de regions naturelles originaires et nous essayons a l'Ecole de geographie de l'Université Centrale de Venezuela d'étudier la geomorphologie tropical venezuelienne depuis vingt ans avec l'aide du Conicit, gouvernement et le Cdch de la U.c.v. (Universidad Central de Venezuela).

SEBASTIANO VITTORINI

Climatic change and badland processes in Tuscany (Italy)

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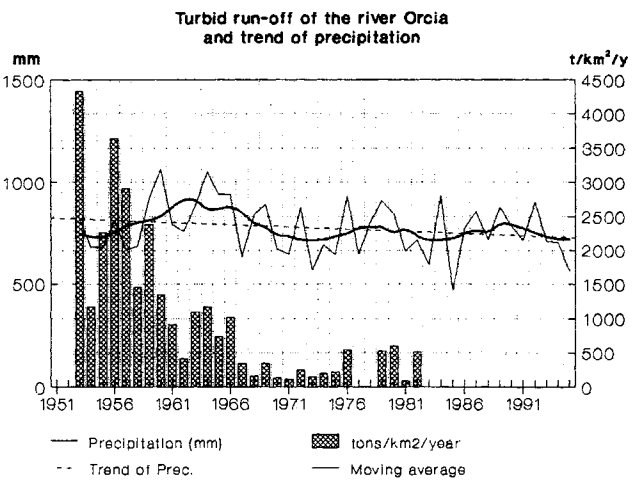
This work takes into consideration the parameters of the water balance of Thornthwaite, in particular potential evapotranspiration (PE), surplus (S), deficit (D), run-off (RO) and finally Total Moisture Detention (TD), which represents the total amount of water stored in the soil, the water corresponding to snow cover and the water fraction still remaining in the soil during the process of run-off.
These parameters allow a better approach for clarification of the spatial and temporal relationship between climate and the erosion of the Italian badlands. In previous research of the author it has been found that in the Tuscan Pliocene clayey regions the formation of *calanchi* does not depend on the concentrated and continuous action of surface waters, but mainly on mass movements (mudflows, slumpings, earthflows), caused by hypodermic run-off, and which occur violently in particular conditions of climate, meteorology and soil humidity. These conditions are illustrated by the value of the parameters of the climatic water balance of Thornthwaite. In particular, it has been observed that the mass movements are strictly correlated with RO and TD and occur when the values of these parameters are high.
On average the months in which erosional phenomena occur more frequently are January and February, but in the last fifteen years this period of greater intensity has moved towards spring, probably due to the climatic change taking place. Also in Tuscany air temperature is increasing, whereas precipitation, in accordance with what is occurring in general in the Mediterranean Basin, is decreasing. The climate of Tuscany is therefore shifting towards greater aridity, as shown by the value of the Moisture Index (Im) of Thornthwaite relative to Volterra, Siena and Monteoliveto, all located in the centre of the Tuscan badlands:

Period	Volterra	Siena	Monteoliveto
1921-1935	61,1 (Humid B3)	2,5 (Sub-humid C2)	—
1936-1955	24,5 (Humid B1)	15,7 (idem	–5,8 (Sub-arid C1)
1951-1980	18,4 (Sub-humid C2)	48,8 (idem	–2,6 (idem)
1981-1995	8,4 (idem)	-4,8 (Sub-arid C1	–16,4 (idem)

At the same time a considerable variation in precipitation regime is taking place, with a strong decrease in winter values and an increase in those of spring and summer. As a consequence, in the last fifteen years, compared with the beginning of observations, the run-off value has decreased by 66% at Volterra, 47% at Siena, whilst at Monteoliveto it has completely disappeared.
From direct observations on the soil it has been seen, at least for ten years, that there has been a diminishing frequency of mass movement and the *calanchi* have tended to become «healed», being covered by grassy and shrubby vegetation. At the same time there has been a decrease in turbid run-off, as shown by the graph regarding the river Orcia, in whose basin Monteoliveto is situated.



THEA VOGT[1], HENRI VOGT[2] & AUGUSTO P. CALMELS[3]

Problèmes morphotectoniques du Plateau de la Pampa (Argentine)

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Le plateau de la Pampa (36-39° S, 65-68° W), qui culmine à environ 400 m entre la Meseta basaltique à l'Ouest et la cuvette subsidente de Macachín, partie de la plaine de la Pampa, à l'Est, est caractérisé par une série de vallées (*'valles'*) subparallèles W-E à WSW-ENE incisées de 100-200 mètres. Elles ont été interprétées comme des dépressions tectoniques ou comme d'anciens cours du Rio Colorado, qui limite le plateau au Sud.
L'étude sédimentologique des dépôts plio-quaternaires étagés des 'valles' révèle pourtant des débris de basalte provenant de la meseta, que le Colorado ne draîne pas. Le plateau est actuellement séparé de la Meseta par le cours N-S du Rio Salado-Atuel, incisé de plus de 200 m sur le revers du plateau. Ceci implique un changement profond du réseau hydrographique au Quaternaire. Par ailleurs, le plateau se raccorde à la plaine par un talus N-S haut d'une centaine de mètres taillé dans les siltites du Miocène supérieur (*'Pampeano'*) et qui n'est pas déterminé par une incision fluviatile.
Cet ensemble de faits parle en faveur d'une compartimentation du relief par des mouvements quaternaires N-S, parallèles aux Andes. Le craton de la Pampa aurait alors été ravivé par une tectonique liée à la surrection de la chaîne andine.

DANIEL VONDER MÜHLL[1], WILFRIED HAEBERLI[2], ANDREAS KÄÄB[1] & EMILE KLINGELÉ[3]

Geophysical and photogrammetrical investigations to prevent natural hazards at Gruben (Valais, Swiss Alps)

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In the area of Gruben glacier (Saastal, Valais) the development of ongoing changes of the glacial and periglacial features are observed since the 1960ies. In particular, several lakes have formed caused by the dynamic of glacier and permafrost. In 1968 and 1970, an ice-dammed lake burst out underneath the glacier. Debris flows were triggered in the frontglacial huge moraine dam, causing sever damages in the village Saas Balen further downstream.
Since 1985 especially two lakes enlarged increasingly: one caused by the retreat of the glacier, the other by a thermocarst process in the permafrost. The evolution of the glacier, of the creeping permafrost and of the lakes during the last 25 years is analysed by aerophotogrammetry. The internal structure and the stability of the morain dam are investigated using refraction seismics, DC resistivity soundings and gravimetry.
The changings since the mid 1980ies enhanced the outburst risk of the two lakes. The geophysical surveys showed that the frontglacial morain dam is rather stable. Using an index which is based on a seismic and an electrical parameter, zones with a high porosity and with a considerable water content were distinguished and localised. In 1995 and 1996 corresponding protection works were executed to prevent the village from floods and debris flows.

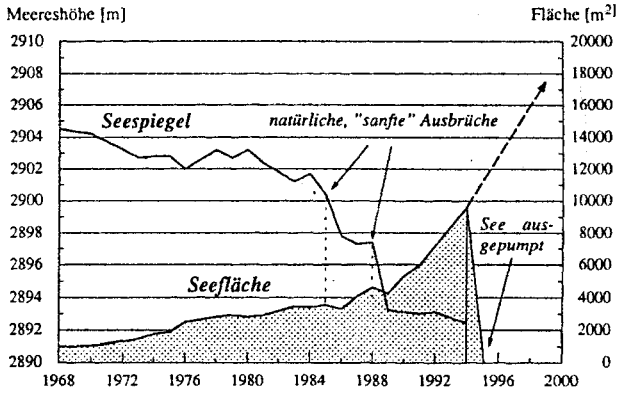

FIG. 1 - Level and surface change of the thermokarst lake since 1968.

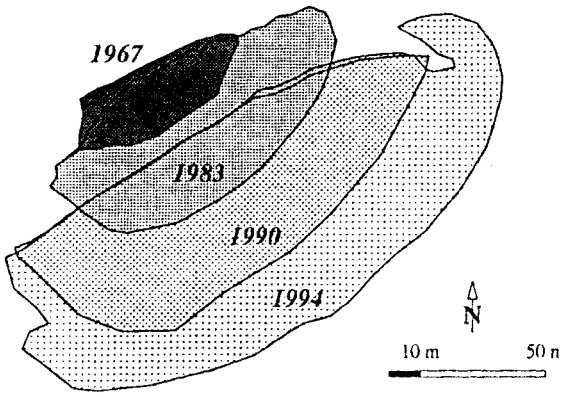

FIG. 2 - Evolution of the thermokarst lake on Gruben rock-glacier since 1967.

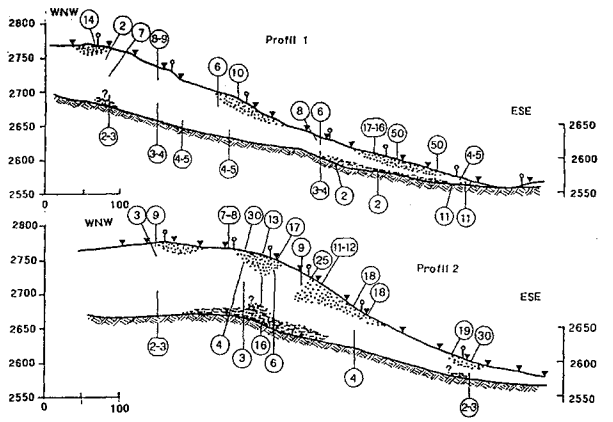

FIG. 3 - Two cross sections of the moraine dam near «Sea 1» at Gruben glacier (profile 1, to the left)? Numbers in circles refer to the index discussed in the text. The light dotted area shows loosely stratified layers, the line-dotted area represents possible occurrances of ground water.

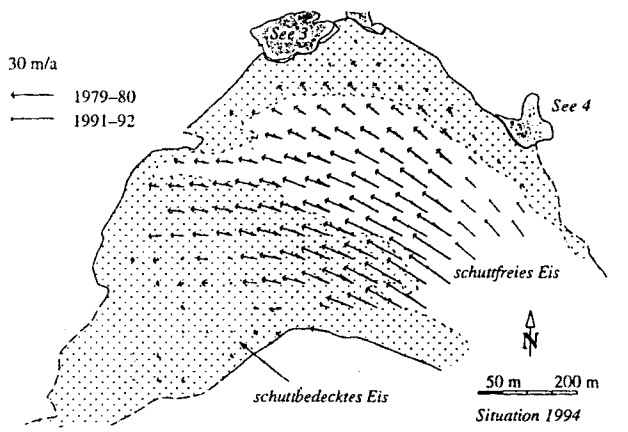

FIG. 4 - Annual surface velocity on the tongue of Gruben glacier 1979-80 and 1991-92.

GALINA V. VYKHOVANETS

The role of aeolian processes in development of coastal accumulative forms

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The coastal zone of Seas is an entity within which all occuring processes are interconnected and interdependent: wave, aeolian, biogenetic, lithological, etc. The coastal zone is characterized by longitudinal and cross structure. In composition of longitudinal structure the following morphological elements can be pointed out: abrasive sectors - dynamically stable sectors - accumulative (accretive) sectors - river mouths. The connection of these morphological elements occurs by means of alongshore drift flows within common lithodynamical cell. On indigenous abrasive shores in cross structure the following morphological elements are distinguished: nearshore bottom (active bench) - beach - cliff (bluff). The connecting link is waves and accompanying them wave currents, wind-wave surge of water and conditioned by them crossing drift. Aeolian processes have subordinary importance, and the wider the beach, the greater the role of these processes.

Within accumulative forms in cross structure the following morphological elements are distinguished: nearshore bottom - sea beach - aeolian zone - limanic zone - nearshore slope of liman (lagoon, bay). No doubt, the connecting link between nearshore bottom and sea beach zone is crossing drift, which develops under the influence of waves and wave currents and wind set up of the level. Interaction of sea beach, aeolian and limanic zones most often occurs by means of aeolian processes, more seldom - under the impact of stormy waves and accompanying storm surge. The wider the accumulative form, the more effective aeolian processes.

Depending on the width, on untidal shores accumulative forms can be subdivided into narrow (the average width is less than 250 m) and wide (the average width is greater than 250 m). On narrow bars, spits or barriers the connection between different zones occurs by means of wind-sandy flow and the higher the rate of wind, the stronger the aeolian sediment-exchange during such wind situation. On wide bars, spits or barriers, in contrast to narrow ones, each zone develops relatively autonomously; the connection between sea beach and limanic zone becomes apparent during long time and by means of aeolian form (coastal dune) movement. That is why sediments from sea beach come on the limanic side with the same speed with which the dunes move from sea side to limanic (lagoonal, bay) side. Aeolian processes are one of the elements of mechanism of support of accumulative form preservation, inspite of the fact that the marine shoreline of the prevailing majority of them retreats up to 2-3 m/year and more.

On the World Ocean shores narrow bars, spits, barriers are met more seldom than wide ones. But on the Black and Azov Seas coasts narrow ones prevail, because of natural sediment deficit is usual in the coastal zone.

Whatever values of short-term linear and volumetric deformations of bars, spits, barriers or beaches are, for the period of several dozens years the average linear and volumetric values remain in general the same, because surrounding physic-geographical conditions are the same during long time. These conditions change very slowly

and therefore are background ones relative to short-term changes. The shown relative stability conditions the existence during long time on the whole one and the same average amount of sediments in accumulative form composition, i.e. accumulative forms have certain lithodynamical cubic content. It refers both to wave and aeolian elements. Therefore the most important conclusions are:

– aeolian processes and forms in the coastal zone differ of those in sandy deserts and must be considered in close genetic unity with the coastal zone development mechanism;

– the analysis of aeolian process role in the coastal accumulative forms development must take into account lithodynamical longitudinal and cross structure of the coastal zone of Seas and Oceans;

– aeolian processes and forms on sandy shores are necessary element of stable development and long preservation of barriers, bars, spits, beaches;

– according to landscape structure of accumulative form surface, interaction of separate landscape «zones» is done by free sediment exchange between them under the influence of wind-sandy flow and stormy waves, which is also a necessary conditions of stability and preservation of these forms;

– development of narrow and wide coastal accumulative forms, processes of sediment exchange and interaction of separate landscape elements are different, and 250 m is a relative borderframe of width; the wider the accumulative form, the less longitudinal landscape elements («zones») are connected between themselves.

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Hydrology of bajada slopes, New Mexico

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In many deserts, runoff from upland areas debouches onto low-angle aggradational surfaces, termed bajadas. Almost nothing is known about the hydrology of these surfaces. What is evident, from the flooding of playas downslope of bajadas and the washing out of roads and railway lines built across them, is that, despite their aggradational character, bajadas do shed runoff during major rainstorms. This runoff may have its source in the upland areas upslope of the bajadas or it may derive from the bajada surfaces themselves, as small-plot runoff experiments conducted on bajada surfaces suggest. This paper reports on the ongoing work at the Jornada Experimental Range, New Mexico, to characterize the hydrology of bajada slopes under different vegetational covers as part of a Long-Term Ecological Research Project (Lter).

Although the overall form of bajadas is divergent, field observations show the presence of local convergent flows where rills and even small washes form. It is thought that the interactions between sediment transport, transmission loss and initial topography play a major part in the formation of these features. Spatial variability of storm events is also a critical factor controlling the response of these slopes. Field experiments have been carried out to investigate the characteristics of runoff generation from interrill sites, and show variable characteristics according to the position on the bajada and vegetation cover. These data give information on flow production, flow hydraulics and sediment transport. Further experiments have been carried out to investigate the flow properties of rills, particularly in terms of their transmission losses and hydraulics. By integrating these two sets of data, the production and transport of water across the bajada surface can be assessed.

To combine these datasets effectively, numerical modelling of the slopes has been carried out. First, the small-scale features have been assessed using hypothetical modelling of slope characteristics and the sensitivity of various combinations of features to flow or transmission loss. Secondly, the results from this and from field observations have been combined to analyze flow patterns over a whole bajada surface. This modelling combines analysis of Dem data at the 30m scale as well as remotely sensed imagery to obtain parameters. Work is ongoing to validate these models with field data. These studies illustrate the complexity of bajada response and the practical need for continued studies on this issue.

YING WANG

Effect of military activities on environment in eastern and southern China

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Several unique historical examples in China relate to actual impact of the military activities on the environment. Two major migration of the Yellow River were created artificially as a result of military activities aimed at causing flooding: 1128 AD and 1938 AD. The technique was unsuccessful in stopping the advancing invaders, but 5400 km^2 of fertilized land was flooded and changed to badlands and drowning many people. While the Yellow River migrated from the Bohai Sea and entered into the Yellow Sea during the period of 1128 Ad to 1855 AD, it had formed 800 km long of muddy flat coast along the Yellow Sea around the Yellow River mouth, and the coasts of Bohai Sea had suffered from erosion and formed chenier beach ridge by break wave currents. The dynamic processes ad coastal morphology were completely different then before. While the Yellow River changed its course again back to the Bohai Sea, with the huge sediment discharges of 1.2 billion tons silt, it has formed muddy coast there again by tidal processes. But, the abundant river mouth of the Yellow Sea has suffered serious erosion. Thus, it has also shown that the human impact on the coastal environment through river - sea system.

In a strategic plan for frontier defense, the north Jiangsu plain was deliberately incised by numerous channel networks in the early 1950's. This military activity had the positive effect of bring more farmland under irrigation.

Hainan Island and other small islands in China were deliberately left undeveloped for more than 30 years because it was believed that these area would be the front-line of the «Third World War». Until the 1980's the islands were in a state of relatively low economic development. However, most islands have retained their natural, environments and ecosystems. In addition, most surplus army facilities were converted for civilian use during 1980's and have provided some benefits to local populations.

TETSUYA WARAGAI

Rock temperature effects on the formation of rock surface features in Karakoram Mountains

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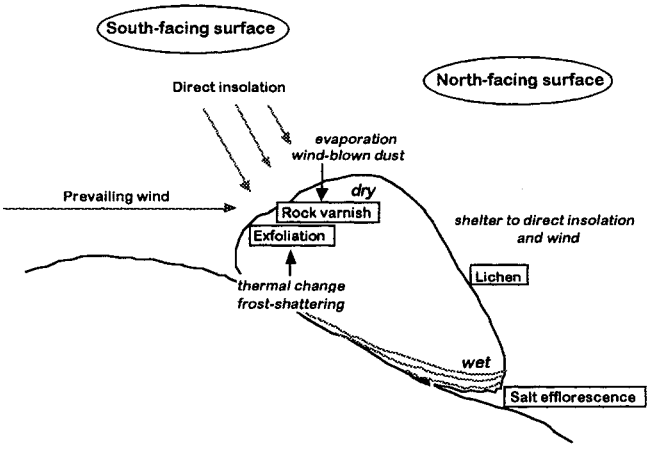
Old and new moraines of different formative times widely distribute at the around of Batura and Passu Glaciers in the Hunza Valley, northwestern Karakoram mountains, Pakistan. In many boulders in the surface of the old moraines, exfoliation and rock varnish generally develop on the south-facing surface, and lichens and salt efflorescence are

found on the north-facing surface. To elucidate the formative conditions of these surface features, temperatures of a granodioritic moraine boulder (3.0 m X 2.5 m X 1.5 m) at two points of north- and south-facing surfaces were measured with an interval of l-hour in accompanied by air temperature for a one year from July 1994. The study site (2,662 m a. s. l.) is located on the ridge of the old lateral moraine of Batura Glacier. Previous studies have been provided the following climatic information about the surroundings of the study site: 1) annual precipitation is less than 100 mm, and 2) prevailing southeastern wind in winter and spring is very strong.

Results of the temperature measurement are as follows: 1) annual mean (13.6 °C), absolute maximum (49.0 °C) and minimum (–13.5 °C) temperatures of the south-facing surface were 1~4 °C larger than those of the north-facing surface, 2) the south-facing surface had a diurnal temperature range of 30 °C with no seasonal change, while the north facing surface had a diurnal range of 20 °C in summer (May to August) and a range of 5 °C in winter (September to April), and 3) a maximum heating and a cooling rates of the south-facing surface were high being 12.6 and –14.5 °C /hour, while those rates in the north-facing surface were low being 6.5 and –7.7 °C /hour, respectively.

These results suggest that the difference in microclimatic conditions affect the formation of rock surface features ; for example, high rates of change of rock temperature on south-facing surface make exfoliation.



ROBIN F. WARNER

«Natural drainage» channels in urban areas: their adjustments to urbanisation and their assimilation of contaminants

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Natural channels do not survive for long in their pre-urban states, once the impacts of increased runoff, higher (in construction) and then lower (in established urban areas) sediment yields, and variable stormwater (and sewage) loads start to cause adjustments in these complex-response systems. To date most of the research in geomorphology has been directed to the physical adjustments in the conveyance system, where parameters like width and depth are most readily modified. These changes prevail particularly in alluvial/soft rock valley-floor troughs. Adjustments are much less obvious where channels are cut in more resistant bedrock troughs.

Whilst such information is useful to geomorphologists and engineers who may need to alleviate flooding and erosional threats to urban infrastructures by structural devices, it is of peripheral value to those whose concern is with the conveyance of contaminants and the ecological sustainability of small urban drainage channels. The channel and its modified evolved ecology have to cope with stormwater runoff and its variable loads of pollutants, as well as sewage at times.

At this level of concern, other aspects like: the contemporary modified regime of the stream; the storage capacity of pools; the nature and volumes of influent flow losses; the role of evaporation; the nature of riffles for reaeration; in-channel vegetation and fauna requirements; modified biological components; the role of bed sediments as temporary and more permanent storages; the role of overbank locations as pollutant stores; and so on all become important. Each of these has an important but often not well understood role in the natural assimilation of introduced contaminants.

Some of these aspects have now been studied by researchers at Sydney and it is a major aim of this paper to review some of this work, as well as to indicate other studies which will add to this understanding of small river systems. It appears that release of discharge and contaminants to main receiving waters may be as few as 6 to 10 times a year. Thus recovery time in main water bodies are often sufficient for ecological sustainability. Many researchers have written on the health of rivers using the medical connotation of various means of curing fluvial ills. It is now time to study the «natural immune system» of rivers, with a view to see what rivers can do for themselves. This will help to determine their levels of tolerance to what is done to them in various human-induced levels of degradation. Temporary ills may be cured; permanent problems are more likely to be fatal.

ABDERRAHIM WATFEH

Evolution des côtes atlantiques marocaines pendant le Würm et l'Holocène

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La période würmienne occupe dans les classifications classiques du Quaternaire marocain, l'espace temporel qui s'é-

tend entre la transgression Ouljienne (Stade isotopique 5e) et la transgression Mellahienne (Stade isotopique 1). Elle a été considérée comme une seule phase pluviale synchrone la régression générale würmienne.
Actuellement, des nouvelles données sur une région du littoral atlantique marocain, permettent de revoir et de proposer une nouvelle reconstitution tout en analysant les significations eustatiques et climatiques de ces données nouvelles. Elles montrent qu'au sein du Würm (Soltanien) il y a eu plusieurs contrastes climatiques.

HELEN K. WATSON

Factors influencing the distribution of gully erosion in the Mfolozi catchment, South Africa, land reform implications

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The Mfolozi catchment covers 10% of the province of KwaZulu Natal. Over 40% of it is already severely eroded. Its mean annual sediment load is extremely high and deposition on its flood plain during extreme events has caused very serious financial losses. There is concern that the catchment's soil erosion scenario will be exacerbated by landuse changes incumbent on the post apartheid government's land reform programme. As peasant farmers particularly perceive gully erosion as a problem, this study sought to identify those parts of the catchment that are unsuitable for allocation to them because they are either already severely gully eroded or are susceptible to this form of erosion. Two principle data sources were available for use. Firstly, an unpublished geomorphological map showing the location of eleven length classes of gullies. And secondly, maps and associated memoirs delimiting and detailing the topographic, substrate and rainfall characteristics of the catchment's landtypes. Data on the Veld Type, bioclimatic and landuse characteristics of these landtypes was extracted from various additional sources. The density of each gully class within each of the possible 16 landtypes within each of the catchment's 43 subcatchments was recorded. Statistical analysis of the resultant gully and landtype data sets focused on the significance of differences between and groupings within components of each set, and on functional relationships between the two sets.
This study identified four and three of the 16 landtypes represented in the catchment as susceptible and very susceptible to gully erosion, respectively. It rated a total of 25 subcatchments as unsuitable for allocation to peasant farmers. Ten of which are already severely gully eroded while the remainder contain substantial portions of susceptible landtypes. The findings of this study also suggest that most of the gullies on white owned land are of natural origin pre-dating the presence of Early Iron Age communities. By contrast most gullies present in African communal lands are more recent features caused by overgrazing.

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The thermal history of the Laura Basin, North Queensland, Australia, and implications for denudation of the region

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The Laura Basin in northern Queensland contains up to 1 km of Middle Jurassic (Bathonian) to Early Cretaceous (Albian) fluviatile and shallow marine strata, with a thin covering of Cainozoic terrestrial sediments. Basement comprises Middle-Late Palaeozoic sedimentary rocks and granites.
Vitrinite reflectance (Vr) values from samples throughout the Mesozoic sequence range from 0.6-1.0%Ro, and there is no increase in Vr with depth. The data indicate that all the Jurassic-Cretaceous strata have been heated to temperatures in excess of 100 °C; these temperatures are also indicated by apatite fission track analysis (Afta) on Mesozoic samples from one well in the centre of the basin.
The timing of this heating is constrained by Afta data from the well samples, and also from samples of Palaeozoic basement underlying Jurassic sediments along the southern margin of the basin. These data show that the Mesozoic strata reached temperatures in excess of 100 °C prior to cooling at around 90 Ma.
In order to reach the temperatures indicated by both the Vr and Afta data, the Mesozoic sequence must have been overlain by about 2.5 km of sediment, assuming the present geothermal gradient of 40 °C/km. If the gradient was 60 °C/km, the maximum believed reasonable for passive margins apparently unaffected by intrusions or volcanism, about 1.5 km of sediment must have covered the area.
The cooling recorded by the Afta data could represent the removal of this overlying sediment by denudation. Since the denudation occurred at around 90 Ma (Late Cretaceous), the sediment eroded must have been Late Cretaceous in age. However, a substantial thickness of sediment of this age is unlikely ever to have been present in the Laura Basin. Firstly, no onshore basins in Australia contain significant thicknesses of Late Cretaceous strata (Fielding 1996). It has been proposed that during this time Australia lay on a geoidal high, so that compared to other continents flooded by Late Cretaceous eustatic high sea levels, Australia was topographically elevated (Gurnis, 1994). Secondly, there is only a narrow time window of 10-15 Ma for deposition and removal of the entire Late Cretaceous sediment package in the Laura Basin.

Thus burial-related heating cannot easily explain the AFTA data, and the lack of correlation of the VR values with depth also argues against this process. Alternative explanations are required for the palaeotemperatures recorded. The heating mechanism may have involved high temperature groundwaters within the sediments; extensive Late Cretaceous hydrothermal activity affected the Bowen Basin to the south (Golding & *alii*, 1996).
No matter what the process, in the Laura Basin the Vr and Afta data cannot be used as accurate guides to the amount of burial and denudation that has occurred.

HERBERT WEINGARTNER[1] & EWALD HEJL[2]

New fission-track data from northern Greece and their consequences for Neogene surface development interpretation

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Geomorphological investigations in the Aegean and surroundig areas have revealed uncountable evidence of paleo surface- and weathering-elements. The legacy of paleo relief development is represented by specific geomorphologic relief features like inselbergs, karst cones, cupola-karst, karstic and non karstic planation surfaces etc. as well as paleosoils together with deep chemical weathering horizons and significant remnants of paleo weathering indicators like clay (kaolinite, montmorillonite) and heavy minerals like haematite.
In many cases the distribution of the paleo surfaces is marked by a distinct steplike arrangement. According to this steplike relief formation the question arises whether a piedmont-model of surface development may be applied or tectonic vertical movements - due to the tectonically highly active Aegean area - are responsible for the present planation surface arrangement.
Fission-track dating, which was used to contribute substantially to the explanation of relief development history within and at the borders of the northern Aegean, shows the following preliminary results:
– The fission-track data generally show a high amplitude of ages.
– From the Pelagonic to the Rhodopoe zone the ages tend to become younger.
– In the Pelion and Ossa Mountains similar ages in different altitudes hint post Middle Miocene vertical movements.
– Comparable data in the Symvolon Mountains and on the island of Thasos prove an isolated island development of Thasos younger than 8 Ma.
– Growing ages from the borders of the Rila Rhodope Massif towards the center indicate an earlier uplift of the central Rhodope Massif.
– Higly contrasting ages of samples in Skiathos (20,38 resp. 7,14 Ma) reveal a close neighbourhood between solid older and younger tectonic active parts of the Aegean microplate.
These new data demand a new estimation of paleo relief development in the northern Aegaen, which has been too strongly polarized between the imaginations of tectonic or subaerial processes.

STEPHEN G. WELLS[1], KIRK C. ANDERSON[1], DIANA E. ANDERSON[1], T. WILLIAMSON[2] & Y. ENZEL[3]

Geomorphic and sedimentologic responses to Late Quaternary hydrologic events: implications for paleo-precipitation regimes across the hyperarid Mojave River drainage basin of Southern California, USA

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A Late Quaternary history of hydrologic events (i.e., increased fluvial discharge and pluvial lake stands) and their associated precipitation regimes [herein referred to Hypr] is reconstructed from geomorphic, sedimentologic, stratigraphic and ^{14}C analyses of alluvial, lacustrine, and shoreline deposits within the largest arid fluvial system of the Mojave Desert. This system, the Mojave River, currently terminates in the Silver Lake, Soda Lake, Cronese Lake (Ssc) playas, but episodically flowed beyond it present terminus into the Silurian and Dumont Valley (Sdv) and ultimately into Death Valley (Dv) playas. The Sdv and Dv were hydrologically connected to the Mojave River during at least two times between 18 to 11 ka, as water overflowed during the major high stand of Lake Mojave. Increased precipitation within the near-coast San Bernardino Mts. (Sbm), 200 km away from pluvial Lake Mojave, resulted in large-scale flooding and concomitant high lacustrine sedimentation rates (0.8 to 1.4 m/ka). A relatively complete record of pluvial events is recorded in the Cronese basin, with the major pluvial periods from 71.5 to 79 ka and 9.9 to 21.5 ka and important but shorter duration lakes circa 5.8 ka, 1.8 ka, 0.7 ka, 0.55 ka, 0.38 ka, and 0.2 ka. Recent coring and stratigraphic analyses within the Sdv indicates that perennial lakes with interbedded fan-delta complexes derived from locally derived fluvial systems existed between 30 ka and 18 ka. The runoff that formed pluvial lakes within the hyperarid Sdv area could only have resulted from significantly increased discharge in the local desert mountain ranges exceeding approximately 2000 m in elevation and not from increased discharge and overflow the ancestral Mojave River system. Reconstructions of Late

Quaternary hydrologic budget for the Mojave River system requires quantitative estimates of discharge from the trunk drainage as well as the contributions from local continental interior watersheds. A mass-balance model, incorporating the paleo-lake parameters and historic hydroclimatic data for calibration, suggests that the Mojave River's discharge during its overflow into the Sdv and Dv area increased due to a 50% augmentation in mean annual precipitation in the near-coast Sbm and an accompanying decrease in average temperature over the deserts. Although the Mojave River's discharge during the early Holocene decreased sufficiently to limit overflow from Lake Mojave into the Sdv and Dv, intermittent pluvial lake conditions existed episodically for the past 9,000 years.

A regional comparison of Holocene fluvial deposits indicates that five periods of significantly increased precipitation produced high-magnitude floods on the trunk river, created fluvial terraces in headwater and canyon-constriction areas, and formed shallow short-lived ephemeral lakes in the terminal playas. Both ^{14}C methods and age estimates from playa sedimentation rates (0.28 m/ka from Ssc playas) document flooding of the Mojave River and pluvial lake stands within the Ssc Lakes area between 0.2-0.7 ka, 3.5-3.9 ka, 5.0-6.0 ka, 7.0-7.5 ka, and 8.7-11.4 ka (latter = waning stands of pluvial lakes). We infer that each Hypr lasted form only a few decades up to a century in response to increased frequency of winter storms across southern California, resulting from shifts in winter atmospheric circulation patterns over the North Pacific. Increased sheet-flooding across desert piedmonts surrounding the Ssc and DV playas occurred during one or more Hypr, implying increases in the local desert precipitation as well as orographic precipitation in the Sbm. However, enhanced precipitation within the hyperarid parts of the Mojave River drainage basin during the Holocene apparently did not contribute significant runoff to these short-term pluvial lakes. Measured and simulated peak discharges for historic lake-producing flood events on the Mojave River, resulting from this type of circulation pattern, range from 500 to 24,000 m^3/s. Such floods are capable of significantly altering the channels of both fluvial systems by lateral avulsion and/or incision, depending upon the local channel/valley conditions. The most complete records of fluvial adjustments to these Hypr appear to be in the headwaters of the Sbm where coarse gravel aids in preserving the flood deposits. The nature of these Holocene Hypr in the largest arid fluvial system with differing hydroclimatic settings suggests that short-duration climatic changes affected broad regions of southern California.

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Exposure history of palaeosurfaces around the margins of Øksfjordjøkelen, North Norway, as revealed by cosmogenic isotopes

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Nunatak/tors and blockfields in presently and past glaciated regions have long been the subject of controversy regarding their age, weathering origin and glacial history. Around the margins of Øksfjordjøkelen recently deglaciated areas of bedrock and surficial deposits have been identified and suggested as having potentially very different ages and resulting from different formative processes. Some bedrock regions are heavily striated with many quarried lee-side rock faces indicating extensive subglacial erosion. Other bedrock areas show evidence of possible subglacial erosion but are extensively weathered. Finally, nunatak/tors show no evidence of having undergone subglacial erosion, but are extensively weathered by both chemical and mechanical processes. Blockfields are found in other areas around the margins and in places are greater than 1 m deep. They are composed of a mixture of blocks and fines and contain patterned ground and are found on low-angled slopes sometimes in association with tors. Until now, most of the dating research has focused on these saprolite blockfields. The quantity and clay mineralogy of the fines have led to the suggestion that they are palaeosurfaces perhaps predating Pleistocene glaciations. The only modifications occurring during the Pleistocene being frost heaving with some mechanical and limited chemical weathering with little or no glacial removal. The nunatak/tors and the weathered, possibly subglacially eroded, bedrock surfaces are composed of coarse, Caledonian gabbros which are suitable for cosmogenic 3He-21Ne exposure history studies. Results from these studies provide the first exposure history data on these erosion surfaces. From this we are able to tell relative age differences between the surfaces thus allowing determination of the weathering environments surfaces have been exposed to and thus the processes which have formed them.

SUSAN WHITE

Karst of the Cainozoic limestones of the Otway Basin, Southeastern Australia

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The Tertiary and Quaternary limestones of the Otway Basin in south western Victoria and south eastern South Australia include Miocene and Oligocene marine limestones and Pleistocene calcareous dune and beach facies. These highly variable limestones of high primary porosity and high permeability show diverse karst features both in surface

expression and underground, presenting particular problems with regards to the usual concepts of speleogenesis. Although there have been some studies of karst development in the Tertiary, the Pleistocene dune karst areas (White 1994) and of the some of the surface karst (Grimes, 1994), these are generally of small areas (less than 100 km^2) and show some interesting contrasts in features. The Otway Basin is a large karst area where there is the potential to understand the regional patterns of karst development in particular the times taken for karst development in Pleistocene calcareous dunes.

Karst development in these limestone lithologies shows substantial variation across the basin and between the different lithologies. The karst shows important differences in the number and type of cave present per volume of limestone, total passage length, passage orientation, passage size, and cave form. Substantial differences in other karst features are also evident such as the presence of the distinctive cenotes and other surficial features in some areas and yet their complete absence in otherwise similar sites.

Although environmental factors such as relief and climate do not vary greatly across the basin, there are significant changes in lithology, structure and underground water conditions. The variation in karst features can be explained partly by lithological variation; especially in such highly variable karst host rock. The overall regional view can add some important insights into concepts of speleogenesis.

G. RICHARD WHITTECAR[1] & W. LEE DANIELS[2]

Use of hydrogeomorphic concepts to design created wetlands in Southeastern Virginia, U.S.A.

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Mitigation wetlands constructed in southeastern Virginia during the past decade have experienced problems with inappropriate water levels, excessive erosion and sedimentation, low levels of soil organic matter, overly compacted substrates, and sulfidic soils. Most of these problems can be recognized in the future with adequate planning that permits sufficient study of the geomorphic and hydrologic processes active at the mitigation site, and if greater attention is given to the history of geomorphic processes that created natural wetlands in that area. New procedures of assessing wetland functions that use the «hydrogeomorphic» (Hgm) classification of wetlands require examination of both surface and subsurface processes. If these Hgm concepts are expanded to include geomorphic evolution, they will greatly improve recent practices in the design and construction of mitigation wetlands.

STANISLAS WICHEREK

The transfer of pollutants as a result of soil erosion

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During recent years research has been carried out to the north of the Paris Basin on two watersheds in areas of large scale farming land (loess). In this area there is a considerable problem of flooding and soil water erosion (up to 30 tonnes/hectare/year). These two processes are major contributors to the transfer of pollutants which influence greatly soil and water quality.

In order to quantify these fluctuating movements of liquids and solids within the watersheds, experiments were conducted and recordings were made in synchronous and instantaneous time. The direct link between these movements was identified in the different plant covers and the different modes and techniques of land use, making it possible to establish a classification of zones at risk, from erosion and deposition, the two processes contributing to the alteration of relief. To confirm these results another work method was also employed, the soil erosion marker Caesium-137.

Suspended matter such as nitrogen, phosphorous and other fertiliser components were the main pollutants to be found. Although the concentration of nitrogen and phosphorous did not exceed the published legal limit, the concentration of suspended organic matter (Som) and pesticides were very high, for example 260 g/l of Som and 690 mg/kg of atrazine sediments. The strongest concentrations were found in May, during the short runoff period and the large erosion when the pollutants were not diluted. On the other hand, concentrations in fertiliser applications were far less in August.

From these results it is possible to suggest a type of planning for rural areas, a cartography of risks and to contribute to the study for sustainable development in agriculture.

VANESSA WINCHESTER[1] & STEPHAN HARRISON[2]

Dating with lichens and trees in a west patagonian landscape subject to flooding

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The overall aim of our 1996 field work in southern Chile was to investigate recent landscape changes in the Arco and the Colonia glacier valleys on the south eastern side of the North Patagonian Icefield (Npi). Periods of change

were dated using lichenometry and dendrochronology. These two techniques are particularly useful for dating surfaces recently exposed by shrinking glaciers in regions like Andean Patagonia where there are almost no historical and very limited meteorological records.

However, to provide any useful results it was first necessary to establish values for a number of variables affecting lichen and tree dating. The variables, relating to micro environment, included calculating a growth rate for the most common rock-inhabiting lichen species (*Placopsis perrugosa)* and obtaining reliable estimates for delays in colonization before growth can start on freshly exposed surfaces.

A minimal dating framework of aerial photographs and a largest lichen on a cairn erected by a previous expedition suggested a growth rate of 4.7 mm/yr, identical to that of its sister species *P. patagonica* on the western side of the Npi (Winchester & Harrison, 1994). Colonization delays for the lichens, varying from a few months to 18 years, were extrapolated from the age in years provided by (a) subtracting the date obtained from a size/growth rate correlation of the cairn lichen from the cairn construction date and (b) from the date provided by the largest lichens in the youngest populations growing above the rocks exposed by recent glacier downwasting. Other indicators (see below) showed that, for the tree genus *Nothofagus* (the southern beech), colonization here can take from 26-100 years. A further variable required for tree dating is an estimation of the number of years of tree growth below coring height. This was quantified by measuring the height of small trees and counting the number of rings at the base of their trunks. We found that a 120 cms tall *Nothofagus* could vary in age from 6-12 or more years depending on the amount of local environmental stress.

Our initial estimate of the delay before tree colonization was based on the discovery that there were lichens growing on a glaciofluvial terrace beside Lago Arco which were much older than the trees there. A 1944 aerial photograph shows a flood covering the terrace; this was clearly a fleeting event terminated by a glacier-dammed outburst which killed the previouss generation of trees while the lichens survived. The flood thus provided an event horizon and a maximum possible delay before tree colonization here of 26 years. The 100-year delay was deduced from the difference between lichen and tree ages in an exposed environment.

Our findings on the variability and time range of lichen and tree colonization and tree age below coring height, illustrate the importance of detailed field investigations aimed at obtaining realistic estimates. Plainly, if these variables are researched insufficiently, misleading dating may be achieved particularly in areas of recently deglaciated terrain where time spans are short.

As regards recent landscape change, the key finding was the regional importance of glacier-dammed outburst floods, with major flooding outbursts from Lago Arco in 1896, 1944 and 1958. The 1896 outburst flood was deduced from differences in tree and lichen ages, with a largest lichen growing on a moraine crest being some 15 years older than the oldest trees growing near a vegetation trimline on the valley wall 30 metres *above* the moraine. A rough calculation of the difference between the volume of the present lake contained within its valley and a lake-full situation shown by tree trimlines on the valley walls, suggests that the initial glacier outburst of 1985 could have released between 300-445 million cubic metres of water, depending on the Arco Glacier's ice front position at the time. Since that date the tree evidence suggests that flooding has declined, with decreasing levels of seasonal floods over the last 40 years.

Clearly the Colonia Glacier requires watching. At present its tongue barely closes the foot of the Arco valley, but if it should readvance and the Arco outwash channels under the Colonia ice become blocked then further glacier outbursts may be expected in the future.

LISA WORRALL & TIM MUNDAY

Geomorphology applied to mineral exploration in the ancient landscapes of Western Australia

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An understanding of long term landscape evolution is critical to mineral exploration in Australia. This is because prospective outcrop has largely been explored and companies are now moving into regolith dominated terrains. The term regolith is used here to describe unconsolidated rock material at the Earth's surface whose character and/or disposition is related to near-surface processes. Exploration companies need to know how the regolith has evolved in order to source pointers to primary mineralisation, and to locate sites of secondary mineralisation.

In countries where the landscape has been shaped by glaciation and is very young, exploration companies have been able to use an understanding of glacial processes to reconstruct dispersion trains. On Gondwanic fragments such as Australia the landscapes are very old, and may have been shaped by subaerial processes over billions of years. These landscapes are polygenetic and the distribution of regolith materials within them is a reflection of the combined effect of numerous different processes.

In landscapes with such a long and potentially complex history the nature of contemporary processes and the surface distribution of regolith materials may be a poor guide to the character of regolith materials at depth. Mapping aids such as air-photos, TM/Spot and radiometrics are useful, but not wholly adequate, as these technologies have limited skin depths. Airborne ElectroMagnetics (Aem) is an important adjunct technology in this context, as it can return information on regolith materials and the geometry of regolith units at regional scales and to considerable depths (>100m).

In this paper we describe a study conducted in support of gold exploration at Lawlers in the Yilgarn Craton, We-

stern Australia. Earlier workers using air photos and Tm have mapped contemporary drainage lines, extensive colluvial plains, and eroding outcrops of ferruginous and saprolitic materials. The Aem, which was flown for this study, reveals considerable and previously unsuspected character in the subsurface. A palaeodrainage system discordant with the contemporary drainage is identifiable, and the data are sufficiently detailed to enable reconstruction of the geometry and flow direction associated with the major palaeochannels. The margins of some of these palaeochannels can be seen to be associated with breakaways formed by ferruginous duricrusts.

Our interpretation of the available data supports the suggestion that landscape evolution in Yilgarn has been dominated by the impact of local scale relief inversion, facilitated by the cementing of toeslope and valley floor materials with iron. As relief inversion proceeds valley floor ferricretes may become duricrusts and form breakaways in the landscape. Whilst the relief inversion process may operate in a similar fashion throughout the landscape over long periods of time, and very probably continues to the present day, the process is likely to be local and non-uniform in its application. The ramifications of these findings for gold exploration in the local area will be discussed.

JANET S. WRIGHT

«Desert» loess versus «glacial» loess; quartz silt formation, source areas and sediment pathways in the formation of loess deposits

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Loess and loess-like deposits cover large parts of the earth's land surface. It is now widely accepted that these deposits are aeolian. However there is still some debate about the production of quartz silt particles which are the single most important constituent of both loess deposits and contemporary dusts. Quartz is very common in igneous and metamorphic rocks, but it occurs in these rocks at a much greater mean size than in dusts and loess deposits, for example the mean size of quartz in gneisses and massive igneous rocks is approximately 700μm. Therefore the quartz component of dusts and loess deposits has experienced a considerable reduction in size since it's release from bedrock. It is generally assumed that the subglacial environment is the only environment where conditions are sufficiently energetic to comminute sand sized and larger grains into the size range characteristic of loess on the scale large necessary for the formation of loess deposits. However, it is now apparent that the Sahara has produced considerable quantities of quartz silt and results from a series of laboratory experiments have demonstrated that a range of geomorphic mechanisms may be capable of reducing sand-sized quartz to silt-sized particles. The mechanisms investigated were aeolian abrasion, fluvial comminution, glacial grinding, salt weathering and frost weathering. The findings from this laboratory work indicate that glacial grinding may not be as effective in comminuting sound unstressed sand sized quartz particles to silt sized particles as has generally been presumed.

Using these findings hypothetical pathways that show the sequence of events involved in the formation of aeolian dust particles and dust deposits will be presented. The purpose of these will be to illustrate the potential contribution of the geomorphic mechanisms investigated experimentally to the production of quartz silt and hence to the formation of loess deposits. In order to assess the feasibility of these geomorphic mechanisms as contributors to global silt production these hypothetical sequences of events will be applied to a range of dust source regions and loess and silt deposits from the natural environment. In doing this probable event sequences for these dusts and dust deposits will be constructed using information obtained primarily from published sources. In the construction of these sequences the following factors will be considered; (1) particle characteristics of various loess and silt deposits, (2) particle characteristic of present day dusts and contemporary dust deposits (3) the geology of source areas, receiving areas and the areas through which material is transported, (4) climatic and palaeoclimatic conditions of source areas, (5) characteristics of current subglacial debris. These sequences will allow some conclusions to be drawn about the role of glacial grinding, fluvial comminution, aeolian abrasion, salt weathering and frost weathering in the production of total global silt. This research suggests that if the term «desert» loess is replaced by the term «non-glacial» loess the search for a desert or non-glacial source for loess deposits is not misguided. Limitations of this work and suggestions for future research into the «desert» loess versus «glacial» loess controversy will also be discussed.

KEGANG WU

Runoff and sediment response of badland gully to rainfall, Southern China

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Badland gully is not uncommon in the deeply weathered saprolite that has a wide distribution in Southern China. In Deqine County of Guangdong Province, out of 378 km^2 area effected by soil erosion (16.8% of the total area) there are 150.2 km^2 effected by gully erosion and 65.6 km^2 by badland gully. There are 23,293 badland gullies in the area effected by soil erosion, 61 gullies per km^2 on average. For-

mations of such intensive eroded landform is said to be partly the result of the intensive rainfall. The discharge and sediment output of badland gullies in a watershed (0.9 km^2 area) in Shenchong, Deqing County, Guangdong Province, China have been monitored in order to determine the response of gully to rainfall events. V-notch weir, Parshall flume and tri-level flow dividers were used to monitor a few active gullies ranging in catchment area from 490 m^2 to 1400 m^2. Sediment concentration were sampled during storms at the weirs and flumes.

The discharge and sediment output of the gullies are examined in the context of their response during rainfall events and the their correlation to various intensity of rainfall events. The correlation of discharge Q (l/s) and sediment discharge Qs (g/s) resulted in the regression equation:

$$Qs = 606.387\ Q - 1117.48$$

Three different zones are identified within a gully system: the zone steep head and side wall, the zone of colluvium and the zone of gully floor. Each contributes differently in the erosion process. The erosion rate of each zone was monitored by using erosion pins. The consistent high sediment concentration and the strong linear correlation (R^2 = 0.899) between the Q and Qs is interpreted by the readily supply of loose colluvium that collapsed and stored at the head area of the gully systems prior the storms. Although the runoff occurred in the gullies only during rainfall it has been found that the threshold precipitation required to initiate runoff and erosion is very low. Tensiometer data obtained during the monitored period has showed that the arriving time of peak flow of sediment discharge is closely linked to the antecedent soil moisture. The peak of sediment discharge could arrive before the peak of runoff discharge.

Annual erosion rate was calculated for each gully monitored and the results were compared to the sediment output at outlet of the watershed to estimate the sediment erosion-storage-delivery ratio.

BARTLOMIEJ WYZGA

Methods for studying the response of flood flows to channel change

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The usefulness of various analytical methods for identification and representation of the influence exerted upon flood flows of a stream by its changing morphological conditions is shown by a study of two mountain rivers from the upper Vistula River drainage basin, Poland. With stable vertical channel position, the Raba River initially increased its sinuosity, and the change was accompanied by growing tendency to flood-wave attenuation. Afterwards, the river was rapidly degraded in response to channelization, this being reflected in increasing downstream magnification of peak discharges with the advancing incision. Channel incision occurred on the Wis³oka River during the whole period of discharge observation. However, its rate has markedly increased since the mid-1950s, and the shift from downstream attenuation to magnification of flood waves attended this change.

Flood-frequency analysis and statistical tests for stationarity of the record of highest discharges have failed to recognize the increase in flood hazard on the rivers following the incision of their channels. This failure results from the compensating effect of changes in precipitation pattern and in land use which caused a reduction of floods generated by the upper part of both catchments in the few past decades. The methods relate to absolute magnitudes of floods and this study shows that the effects due to channel change may be compensated for by the opposite trend in flood-flow magnitude (or strenghtened by a trend of the same direction) caused by meteorologic factors or a change in another physiographic factor. Therefore, the methods cannot be seen as definitely indicating the lack or existence of a genetic non-stationarity of flow record introduced by a change in channel morphology of the stream.

To overcome the mentioned difficulty, three procedures are presented which analyse temporal trends in the relationship between inflow and outflow peak discharges of flood waves passing the modified reach. The techniques comprise examination of the record of annual maximum discharges, of the largest floods from particular periods (e.g. decades), and of the whole spectrum of flood flows occurring at successive periods. The essence of these procedures lies in separating changes in flood flows accomplished in a reach under investigation from those born in the upstream part of the catchment.

Annual maxima analysis allows direct comparison of the timing and relations between changes in channel morphology and their response in flood flows. Introducing an empirically found correcting factor into the analysis of the ratio of outflow to inflow peak discharges shows how the conditions of peak-flow transformation in a reach have changed since the beginning of a study period. Relating temporal variations in the 'corrected' ratio of outflow/inflow peak discharges to changes in vertical channel location makes it possible to estimate the significance of alterations in channel morphology for observed trends of flood magnitude.

The record of minimum annual water stages on a river has been used for evaluating temporal changes in vertical channel location in a given reach. The high consistency of changes in vertical channel position of the analysed rivers and of variations in transformation of their flood flows shows the importance of channel incision for increasing flood hazard on channelized stream. This increase results from the growing concentration of flood flows in a channel zone with the advancing incision, that reduces floodplain retention and causes self-acceleration of flows in a deepened channel.

KANGNING XIONG, CAIHUA HE & XING CHENG

Analysis of structural features of rimstone in karst caves

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This paper, based on fieldwork and experiments, looks at structural types and features of rimstone in karst caves. The rimstones developed in caves are quite different from those formed on river beds, the former appear porous, like tufa, which are resulted from higher temperature and biological process. The rimstones in caves, apart from their features similar to river rimstone, obviously appear compacted and graded. Three types of rimstone are identified according to different conditions of water movement and different shapes of water recharge distribution, water-way model, fan model and circle model. Each reflects different condition of water movement. Water of the water-way model is from stream or intermittent stream for recharge. Plan distribution of the fan model rimstone appears fan-shaped and the relevant recharge type is mainly fissure water or dripping flow. The circle model rimstone looks semi-circle-shaped on plan, which is a rare type developed in a special mini-topographic environment, formin from dripping recharge. Hydraulic conditions of these types above are respectively changing from strong to weak. The cave rimstons are also classified, from profile shape, dip angle and inner structure of lamination, as vertical dam, steep dam (60°-90°) and slope dam (<60°).These dip changes also reflect the conditions of water movement from strong to weak respectively. In addition, the paper notes some special rimstone types such as double dam, dam-in-dam, ect. and the relevant hydrogeological significance, presents relationship between cave rimstone structure, inner lamination and flow conditon of recharge water, reveals factors of water movement in rimstone formation, and disscuses initial morphological problems of rimstones.

SHUJI YAMADA

The role of soil creep and slope failure in the landscape evolution of a head water basin: field measurement in a zero order basin of Northern Japan

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This study examines soil creep processes and slope stability and focuses on the preferential location of soil creep and slope failure in a zero order basin. A zero order basin is usually composed of three slope forms, i.e., nose, side slope and hollow. Field measurement on soil creep processes and slope stability was conducted on each of these slopes in a zero order basin near Sapporo, Hokkaido, northern Japan.

Soil creep was continuously measured by a strain probe method at three sites from June 1994 to May 1995, and was compared with soil moisture condition and ground temperature. In summer, active soil creep occurred only when rainfall led to large soil moisture changes and a near saturated condition, which was most likely induced by the shrink-swell of soil. In winter, soil creep was caused by seasonal frost, although the mass transport was limited due to the insulation provided by snow cover. These results indicate that the soil moisture change and soil moisture content during a rainfall event in summer are the major factors controlling soil creep in this basin.

Soil moisture conditions were measured by tensiometer at 16 sites from July 1994 to October 1994 on the nose, side slope and hollow. On the nose and side slope, active soil-moisture changes took place during rainfall events. The hollow tended to maintain higher soil moisture condition than the nose and side slope, because subsurface flow concentrated on the hollow. Thus, the soil moisture change which is suitable for the soil creep hardly occurred in the hollow.

Sediment transport rates on the nose, side slope and hollow were estimated from the results of the measurement of soil creep and soil-moisture condition. As the first step, The sediment transport rate per unit width S was assumed to be proportional to the soil-moisture change, and is given by

$$S = K\Sigma\Phi_c$$

where, K is a constant, Φ_c is the change in the pressure head during a rainfall event when the near saturated condition is attained. $\Sigma\Phi_c$ was calculated for each of the 16 sites for which the soil-moisture conditions were measured, and its average for each slope was used for the calculation of S. K was obtained from the sediment transport per unit width measured by the strain probe during a rainfall event and from the change in pressure head during the same event. Further, sediment transport rate Q was calculated as

$$Q = S\,l$$

where l is the perimeter length of each slope, and defined to be the length of the lower end of a slope. From these analyses, sediment transport rates were estimated to be 207.0, 159.5 and $9.0 \cdot 10^{-3}$ m^3/yr on the nose, side slope and hollow, respectively, and the resultant mass balance was –207.0, +25.1 and $+172.9 \cdot 10^{-3}$ m^3/yr, respectively. These results clearly demonstrate infilling in the hollow by soil creep, together with removal of soil material on the nose.

Slope stability was analyzed by the infinite slope model. The potential of slope failure was evaluated from the relation between critical water depth H_{cr} and soil thickness D. The analysis revealed that increase of D causes a marked decrease of H_{cr} on the side slope, indicating the high potential of slope failure on the slope. In contrast, both on the nose and the hollow, the decrease of H_{cr} for the same increase of D was lower than that on the side slope. However, slope failure on the side slope and soil creep on the nose infill material in the hollow. Thus, increase of D in the hollow is higher than that on the other slopes; this leads to an increase of slope failure potential.

These results indicate that the soil creep and slope failure act as the infilling and evacuating processes of a zero order basin with different intensity depending on the slope form: soil creep removes the soil materials on the nose and accumulates them in the hollow, whereas slope failure removes the materials on the side slope and accumulates them in the hollow, and when infilling develops a thick soil in the hollow, slope failure evacuates them from the hollow.

SAYUMI YAMASHITA

Marine terraces and crustal movements during the late Quaternary in the Oga Peninsula, Northeast Japan

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Japan island arc is situated along a plate boundary region where Eurasian, Pacific, North-American and Philippine Sea plates interfere, and is a tectonically active region. Well-developed several steps of marine terraces have been formed in the late Quaternary. South Kanto district is a type locality of these marine terraces and their age are established by relations between marine formation and tephras; Shimosueyoshi, Obaradai and Misaki surfaces in South Kanto are dated to oxygen isotope Substage 5e, 5c and 5a, respectively. In Japan, the correlation of marine terraces in an area to those in South Kanto have been clarified by using tephrochronological method. However, four steps of well-developed marine terraces in the Oga Peninsula, situated in eastern margin of Japan Sea, have not yet been correlated with those in South Kanto.

In this study, major widespread tephra layers in Northeast Japan, such as Toya ash (Toya; 105ka), Sanbekisuki drifted pumice (SK; 9ka) and Aso 4 ash (Aso-4; 7.5ka) are used as keys bed for correlation of those terraces. Four terraces are named for Kamishinzan, Shimoshinzan, Katanishi and Kotokawa surfaces, starting from the highest. Because Toya and SK are intercalated in Katanishi terrace deposits and Aso-4 in Kotokawa terrace deposits, Shimoshinzan, Katanishi and Kotokawa surface are correlated with Shimosueyoshi, Obaradai and Misaki surface, respectively. The age estimate of Kamishinzan surface is Stage 7.

Each paleoshoreline altitude of four terraces show that these terraces accumulately tilt toward northwest. It is suggested that the Oga Peninsula has tilted and uplifted continuously. When an historical earthquake occurred in 1939, the distribution of vertical displacement tended to be higher toward southwest. Therefore it is suggested that a NW-SE thrust exists at the west coast of the peninsula. But uplift pattern of this earthquake is differ from that of paleoshorelines. Consequently, the tectonics indicated by paleoshoreline analyses depend on accumulation of different type (other earthquake that cause a uplift pattern according with paleoshoreline altitude ?) crustal movements.

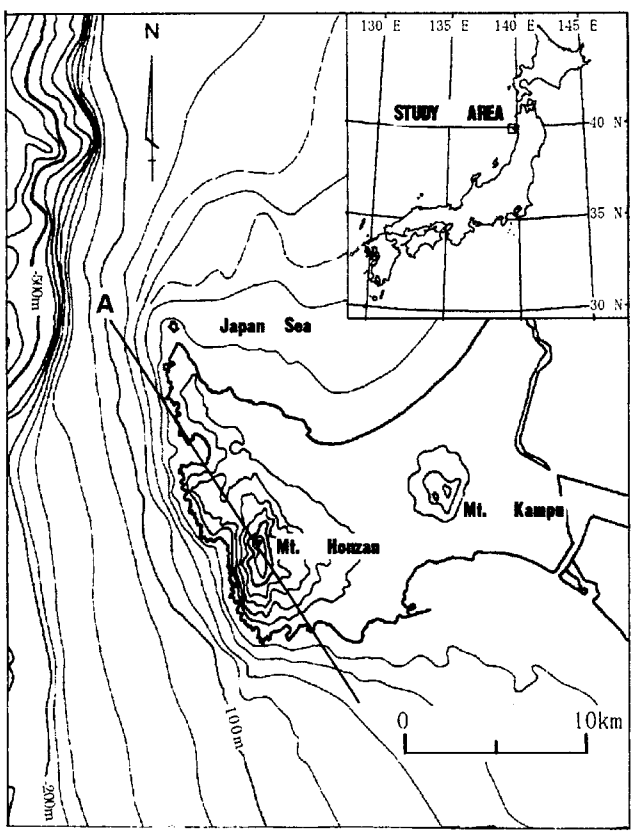

FIG. 1 - Topographical map in and around the Oga Peninsula Contour interval in the ground is 100 m. Line A shows direction of the vertical projected profile in Fig. 2.

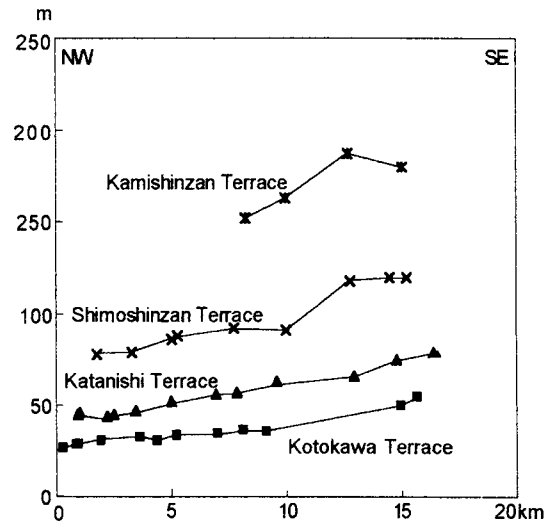

FIG. 2 - Vertically projected profile of paleoshoreline height.

XIAOJUN YANG

Landsat imagery and geographic informatic system (Gis) for updating terrain mapping in the Yellow River Delta, China

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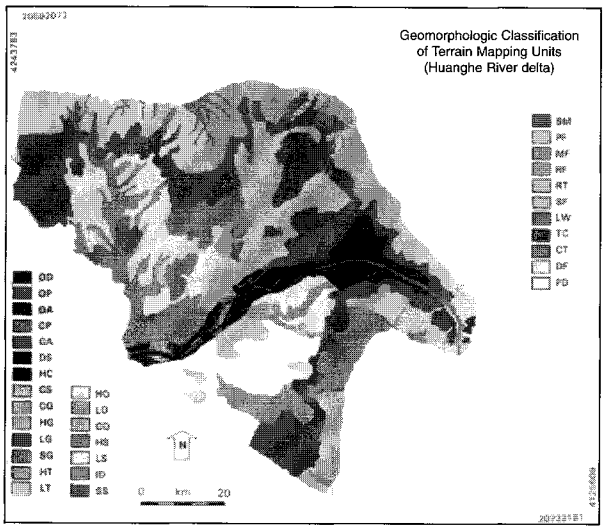
An integrated approach combining satellite remote sensing (Rs) and geographic information system (Gis) techniques has been successfully operationized for geomorphic classification of terrain mapping units on 1:400,000 scale in the Yellow River Delta, China. Landsat Thematic Mapper (Tm) imagery data are the main sources of data in this study. Three (1/4) windows of Tm Cct (Computer Compatible Tape) data (April 2, 1992; May 23, 1993; and April 24, 1994) as well as one whole scene of Tm scanned data (Nov. 12, 1992), combining with other sources of non-image data, such as topographic maps, landuse map, and soil map, are used for data analysis. Imagery data have been carried out a standard procedure of digital image processing (Dip) aiming to facilitate interpretation work.The subsequently (digitally) systematic interpretation was performed with the On-Screen Digitizer module under an Ilwis environment. With the module Change Window, map scale can be enlarged up to 1:3,500 for the image with a 30 m pixel size. It permits an adequate mapping accuracy. The image interpretation has been supplemented by observations on the ground at selected key localities through a two-month fieldwork.

Using genesis as the major discriminant factor in the classification, three genetic landform types are mapped. They are landform of fluvial origin, landform of fluvial-marine

origin, and landform of marine origin. A number of factors, such as geomorphic process, relative age, relief, sediment, drainage, landuse / vegetation cover, and slope, have been synthesized for further (sub)classification. In an image-based terrain mapping, those terrain parameters are extracted by combining the image characteristics such as spectral, spatial, temporal, colour, tone, pattern, etc. An updated geomorphic classification of terrain mapping units, together with an attribute database in a geographic information system, are produced. This work started from the mapping of the abandoned channels in relation to the abandoned dates. Three genetic landform types with four main units as well as thirty-two units have been differentiated.



SUBAERIAL DELTA

1 Upper Delta Plain (UDP) -Fluvial Origin
- 1.1 Active flood plain along the present river course (QFP)
  - 1.1.1 High flood plain between dikes, mainly overbank deposits of levees, splays, and backswamp (OD)
  - 1.1.2 Middle flood plain along a previous distributary, mainly complex of splays, minor infilled channel(s), and backswamp (OP)
  - 1.1.3 Low flood plain along the dikes, with very gently sloping, mainly splays, minor infilled channels, levees, and backswamp (OA)
  - 1.1.4 Present river channel (CP)
  - 1.1.5 Distinct accumulations filling abandoned channel (CA)
  - 1.1.6 Distinct point- and alternating bars and swale formation (BS)
  - 1.1.7 Highly active shifting zone (HC)
  - 1.1.8 (Large) Crevasse splay (CS)
- 1.2 Previous flood plain along the abandoned course Guokouhe-Shenxiangou (GFP)
  - 1.2.1 Abandoned channel (CG)
  - 1.2.2 High flood plain, 1-2 m higher than the surrounding, mainly lateral accretion and overbank deposits (HG)
  - 1.2.3 Low flood plain, mainly interchannel or backswamp depression with overbank deposits (LG)
  - 1.2.4 (Large) Crevasse splay (SG)
- 1.3 Previous flood plain along abandoned course Tiangshuigou - Xianshuigou (TFP)
  - 1.3.1 High flood plain, mainly channel fills and lateral accretion deposits (HT)
  - 1.3.2 Low flood plain, very gentle sloping, mainly overbank deposits (LT)
- 1.4 Previous flood plain in the south of delta (OFP)
  - 1.4.1 High flood plain, mainly overbank deposits, channel fills, and lateral accretion deposits (HO)
  - 1.4.2 Low flood plain, mainly depression with overbank deposits (LO)
  - 1.4.3 (Large) Crevasse splay (CO)
- 1.5 Previous flood plain along the abandoned course Shuenjianggou (SFP)
  - 1.5.1 High flood plain, 1-3 m higher than the surrounding, mainly accumulations filling abandoned channels and levees (HS)
  - 1.5.2 Low flood plain, very gentle sloping, mainly overbank deposits (LS)
  - 1.5.3 (Large) Interchannel or backswamp depression (ID)
  - 1.5.4 (Large) Crevasse splay (SS)

2. Lower Delta Plain (LDP)--Fluvial-Marine Origin
- 2.1 Salt marsh or schorre (SM)
- 2.2 Tidal flat (TF)
  - 2.2.1 Extremely prograding tidal silty flat (PF)
  - 2.2.2 Prograding tidal mud flat, or slikke (MF)
  - 2.2.3 Extremely retrograding tidal coarse silty flat (RF)
  - 2.2.4 Retrograding tidal silty flat (RT)
  - 2.2.5 Stabilized tidal silty flat (SF)
  - 2.2.6 Remnant of coarse silty levees or wedges (LW)
  - 2.2.7 Active crevasse zone with actual tidal influence (TC)
  - 2.2.8 Large tidal creek (CT)

SUBAQUEOUS DELTA

1. Delta Front (DF)--Marine Origin
2. Prodelta (PD)--Marine Origin

TAB. 1 - List of the classified units.

AGBAR R. YARMUKHAMEDOV

On the nature of recent geodynamic activity in the lithosphere of Central Asia

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The Tien-Shan mountains are the binding link between the Eurasian and Indian lithospheric plates. Mountain structures and depressions were formed here as a result of the Neogene-Quaternary motions with the amplitude up to 10-12 kilometers. The processes of orogenesis are continued at present and that fact is corroborated by geomorphological and geologo-geophysical data. The main aspect of the newest and recent tectonic activity in the Tien-Shan is the ascertainment of the submeridional (regional) horizontal compression. Stresses of different hierarchical levels characterized by different type, depth and destribution along lateral stand out against a background of the compression. Earthquake sources located mainly on the boundary of different-type stresses form the different-range seismolineaments. The latter coincides in most cases with rupturing dislocations located between mountain structures and depressions. The Tien-Shan orogenesis can be explained by successive or simultaneous manifestation of both the deep processes and the collision of the Indian and Eurasian lithospheric plates.

GONGMING YIN & YANCHOU LU

The geomorphology, neotectonics, and geochronology of the Yanqing basin, Beijing, China

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The Yanqing faulted-down basin with NEE extension and area of about 840 km^2, is located on the southern margin of Yanshan Mountains. The basin has developed since the late Cenozoic and can be regarded as one of the tensional basins at the northeastern tip of Shanxi shear fault zone. The distinguishing geomorphologic feature of the basin is the strip landforms. Our detailed investigation of landform and sediments and analysis of neotectonics ocurring in the basin and its surrounding region permit us to preliminary understand the characteristics of landform evolution of the basin. The geomorphology of the basin was formed mainly from 500 ka BP, and might be developed in three phases having their individual specific features. The landform evolution was not related with climate, but was mainly dominated by three major neotectonic events occurring in the basin and its surrounding region during last 500 ka.
According to the characteristics sediments related with the landform evolution and three major neotectonic events, many samples from lacustrine calcareous layer were dated by using electron spin resonance (Esr) and the relevant samples were dated by optically stimulated luminescence (Osl) which is suitable for aqueous phase sediments since about 200 ka BP, and the age estimates of the three geomorphic development phases or three neotectonic events were obtained.

LILIANA ZAHARIA

Les transports solides et la dynamique du lit fluvial de la Putna (Roumanie)

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La Putna est l'une des plus représentatives rivières de la «région de courbure» (l'Arc des Carpates et des Subcarpates roumaines). Grâce à l'intéraction des facteurs naturels et anthropiques, cette région connaît une dynamique très accentuée du relief, indiquée, parmi d'autres paramètres, par le taux d'érosion le plus intense de la Roumanie. Par conséquent, la charge d'alluvions en suspension de la Putna et de ses affluents atteint des valeurs qui, dans le secteur des Subcarpates, dépassent 10-15 t/ha/an (pour l'ensemble du pays ce paramètre est de 2 t/ha/an environ).
Notre étude présente l'analyse des séries de temps des débits d'alluvions en suspension et met en évidence la tendance de la dynamique verticale du lit fluvial de la Putna et de ses affluents principals. Géneralement on constate une tendance à la dégradation aux sections situées dans la région montagnarde et une tendance à l'agradation aux section de la région collinaire.

VLADIMIR S. ZALETAEV

Biogenic relief in arid and semiarid zones of Central Asia, genesis and ecological role

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Biogenic relief on arid and semiarid territories in reality occupies more significant places than it is supposed. Special geomorphological researches done in various landscapes of sandy, loess, clay deserts and semideserts of Central Asia, Kazakhstan and the south of Russia showed that vegetation cover, active ground-digging, «building» activity of animals, their trophical links with plants and impact on the soils on the pastures appear to be the powerful factor of straight influence on relief of ground as well as transforming relief-forming effect of aeolian processes and processes, connected with surficial flow of precipitation, with water erosion and with accumulation and spare of ground water.
Several zonal-typical form of relief in subboreal northern and subtropical southern deserts (including deserts of Kara-Kum, Kizil-Kum, Usturt, deserts of Mongolia and semideserts of Northern Precaspian plain and south of Tuva) formed as the result of biogenic and abiogenic environmental factors interaction. It refers as to forming of specific types of nano, micro and mesorelief on the sandy, clay and even stone substrates and also such macroforms as hillock, row semianchored sands and «zoogenic depressions relief» of clay desert, that in its turn arose the mosaic damp soil and complexity of vegetation cover.
Animals activity often serves as initiation factor defining the changes in direction of morphogenesis on the ground on the vast territories. As the result of synergetic effect, that appears under wind impact and digging of animals (mostly *Rhombomis opimus, Meriones meridianus, M.lybicus, M.tamariscinus, Spermofilopsis leptodactilus, Citellus fulvus*) the specific class of «zoo-aeolian» and «zoo-phyto-aeolian» processes begin. The result of them is the Hillock sandy relief of «ephedro-peschanko towns» - complicated hillock-like bars up to 10-20 m at the bottom and up to 5 m high. These bars have table form, sometimes complicated by phytogenic «ephedra hills». This type of relief is characteristic for the deserts of Eastern Kara-Kum. The author showed for the first time the formation mechanism of this relief type of sandy deserts and also other characteristic forms of relief of Asian sandy deserts and clay semideserts.
Large quantity of various forms of micro, nano and mesorelief of clay semideserts is conditioned not only by straight impact of animals on the ground, but also by arousing of «zoopedohydromorphous geomorphological processes» and «zoophytohydromorphous» in their concrete regional geographical determined manifestations.

MILOS ZEREMSKI

Les morphostructures des blocs en tant que principaux elements des processus neotectoniques de la Serbie Centrale

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Le relief de la Serbie centrale (la Sumadija) dont on considérait jusqu'au milieu de ce siècle qu'il avait résulté des processus abrasifs de la mer pontique (Cvijic, 1909) et plus tard qu'il est d'origine fluvio-dénudante (Jovanovic, 1951 & *alii*), comprend des blocs de morphostructure en tant que principaux éléments des processus post-pontiques néotectonique. Ces blocs ont été examinés par rapport à la direction de leur propagation-rectilignes, en arc (conditionnés par les failles et les blocs de magma); ensuite, par rapport à la hauteur relative-positifs, négatifs; par rapport à la position des vallées - non-concordants, épigénétiques, pseudo-épigénétiques, concordants, divergents, convergents; par rapport à l'aspect morphologique - en forme de vo te-inverse, en forne de vo te-conforme, (en forme de plaques de biais, de fossé, de cuvette, de ravin, de dépression) et, enfin, par rapport à l'age, ils ont été créés de présarmatien jusqu'au pléistocène récent.

La conséquence de la dynamique des blocs relatifs de morphostructure s'est manifestée dans le relief de la Serbie centrale (la Sumadija), qui est marqué par le processus néotectonique-fluvio-dénudant.

JOSÉ L. ZÊZERE, A. BRUM FERREIRA
& MARIA L. RODRIGUES

Landslides in the North of Lisbon Region (Portugal): conditioning and triggering factors

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The detailed field mapping of five sample areas in the North of Lisbon Region, at the 1:2,000 and 1:10,000 scales, allowed us to collect a whole set of geological and geomorphological data and to correlate them with the spatial occurrence of landslides. As regards the temporal distribution of the landslides, a correlation was made between the rainfall regime and the periods of recognised slope instabilities.

Among the conditioning factors, the following must be stressed: 1) Lithology: as concerns the nature of the geological substratum, we must emphasize the importance of the marls and the marly limestones; nevertheless, the shallow translation slides (ranging from 11% to 56% of the total in the five sample areas) are related to the Upper Quaternary and Recent loose deposits. 2) Geomorphology: the most important process is the lateral sapping along the banks of the fluvial channels, in the root of slide/falls (24% to 67% of the total). 3) Occurrence of old landslides: the reactivated landslides identified in the total sample areas correspond to 27 % of all mass movements. 4) Angle of slopes: in the five sample areas, the shallow translational slides are related to the higher mean slope angles (from 22° to 26°) and the deeper translational slides correspond to the lower mean slope angles (although varying from 11° to 22°).

An important triggering factor of the landslides in the North of Lisbon region is the human activity. The significance of the anthropic action as a triggering factor in the five sample areas ranges from 9% to 31% of all mass movements, but in the case of the shallow translational slides those figures reach 22% to 63%. Man's intervention manifests itself in ill-consolidated fills, cuts of potentially unstable slopes (normally for construction of roads and houses), and, in a few cases, in the changing of river paths.

Nevertheless, the most important triggering factor of the mass movements in the North of Lisbon Region is the rainfall regime. Two principal situations are to be individuate (Table 1): 1) high intensity rainfall episodes, originating numerous earthslides and earthfalls, principally along the fluvial channels (for instance, november 1967 and November 1983); 2) heavy rainfall long periods originating translational, rotational and the larger complex slides (for instance, february 1979 and december 1989). The fact that the largest recent landslides recognised in the North of Lisbon Region (Calhandriz, Quebradas-Fanhões and Albogas) took place at a very close date (9-11th February 1979) show a clear rainfall signal. These landslides are related with an accumulated antecedent precipitation of 694 mm in 75 days, that correspond to a return period of 25 years (Table 1).

TABLE 1 - Rainfall accumulated from 1 to 120 days and corresponding return periods for four sliding events (rainfall data from S. Julião do Tojal; R - raifall; RP - return period).

		1 day	5 days	10 days	30 days	40 days	60 days	75 days	90 days	120 days
1967	R (mm)	137	142	156	249	307	307	310	310	318
25 nov.	RP (y)	55	5	3	2.5	3.5	2	1.7	1.5	1.3
1979	R (mm)	26	138	161	335	351	533	694	694	760
10 feb.	RP (y)	1.2	5	3.5	7	5	12	25	16	12
1983	R (mm)	164	230	265	404	407	407	407	407	409
18 nov.	RP (y)	160	55	25	15	8	4	3	2.5	1.7
1989	R (mm)	27	79	128	390	495	543	627	644	655
21 dec.	RP (y)	1.2	1.4	2	13	21	13	15	12	6

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Computer representation of shallow translational movements for hazard assessment using Gis tools in a study area north of Lisbon, Portugal

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This contribution proposes a systematic strategy for the construction of landslide databases to be used in modeling slope-instability hazard for regional zoning. Some types of complex landslides which concern large masses represent relatively rare events, and rotational movements are generally too infrequent, to statistically characterize their geomorphologic settings in geographical information systems or Gis. More frequent superficial earth and debris flows, however, can be studied statistically and their settings can be predicted by spatial data analysis.

For the purpose of predicting geomorphologic settings which are similar to those corresponding to the mapped landslide type, i.e., shallow translational movements, the assumption is made that those settings can be represented by a set of maps covering the study area and which are constructed so that the mapping units and the features in them are known to bear clear relationships with the mass movement. For instance, a map of relevant engineering geology units, a land use map, maps of topographic slope angles and aspects intervals respectively, and maps representing relevant distance intervals from roads or from drainage lines. In addition, maps with the distribution in space and in time of the specific type of landslides are needed.

A first group of landslides is then used to establish bivariate relationships between the mapping units and the landslides using the pixel or picture element spatial coincidences. Their frequencies are used to construct evidential support for a proposition that an arbitrary point in the Gis database is likely to be affected by a landslide of the given type given the presence of the evidence represented by the ancillary map data. The second set of landslides contained in a different map corresponding to a subsequent time interval (or representing a spatial subset of the landslides) is then used to validate the prediction which is based on the application of Bayesian probability to model hazard and to map it into zones of different values. Such validation can be made by assessing the area percentage of later landslides which correspond to the different hazard values in 5% areal classes from the highest downward. In this manner, both sensitivity analysis of either the ancillary mapping units or of the entire maps, and comparability analysis of the prediction models can be performed when more than one model is used.

An experimental data base for a study area north of Lisbon, Portugal, is used in which the following data were transformed into computational forms: (a) field observations, (b) graphic and attribute data about the landslides and the ancillary map units, (c) cartographic representations of geomorphologic symbols and patterns, and (d) transformed data into normalized information for modeling. The study area is located just north of the city of Lisbon and is part of the Western Sedimentary Basin close to the Tagus alluvial plain. Rocks are of sedimentary and eruptive nature dating from the Upper Jurassic to the Upper Miocene and present very different hardness, permeability and plasticity. The lithological context and the presence of a monoclinal structure with low to moderate dip has facilitated the development of cuestas reliefs. A test sub-area corresponds to a valley in the dip slope of the Lousa-Bucelas cuesta, where a detailed 1:2,000 geomorphologic mapping was made using systematic descriptions of the landslides events recorded in field forms. The shallow translational slides correspond to 50% of the mass movements in the sub-area where the mean slope angle is 22/ and the mean area per landslide ranges between 660 m^2 and 730 m^2. The application provides the ground to identify and discuss the advantages and the limitations of Gis techniques for geomorphologic hazard zoning within Newtech, a cooperative research project of the European Union's Environment and Climate Programme.

DAPING ZHANG & S. TOSAKI

Model of sandy beach erosion by storm waves involving sea-level rise

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Difficulties in field measurements and morphological surveys during the severe stormy weather or accelerated sea-level rise have hindered the study of sandy beach erosion due to geomorphological change. In order to construct a model predicting sandy-beach erosions by storm waves accompanying with accerated sea-level rise in the near future, mechanisms and processes of sandy-beach erosion as breaker-induced bar formations were investigated in the light of vortices induced by higher breaking waves and sea-lever change by the small-scale and prototype-scale experiments (180 m long, 4 m wide, and 5 m high).

A movable-bed experiment using four kinds of uniform (1/20) and non-uniform beach profiles as the initial boundary condition, setting ten kinds of storm waves and sea-level rise, indicated that scarf and longshore bars (single bar, double, triple, and quadruple bars) were formed. It is found that these bars were formed only by the vortices reaching bottom; the number of bars formed coincides with that of such vortices. The breaker-induced vortices reaching bottom, acted the bed material and lifted the sediment up into suspension; the suspended sediment is transported offshore by the mean offshore flow field, causing net offshore sediment movement to form a bar, scarf, and shoreline recession, and produce sandy-beach erosion.

Occurrence conditions for single and multiple bars using data of small-scale and prototype-scale experiments were described by $K = H_b/gT^2\ (i\ )^{-2}\ (D/H_b)^{-2}$ where i is average slope of the surf zone and D is grain size of beach material. The bar volumes are almost same as the erosion volume at beach face. The temporal and spatial changes of shoreline position and vertical eroded volume in the surf zone induced by higher wave action and sea-level change, were found to be controlled by topographic changes of longshore bar formation and scarf. By prototype experiments, these characteristic features were analyzed quantitatively by dimensionless parameters of H_b/gT^2, D/H_b, i, t/T, and B/H_b where t is time and B is the height for sea-level change.

The change of sea level was found to decide depths of breaker-induced-vortices. The lonshore bar moves as sea level rise duo to the breaker-induced vortices. Also, the height and rate for sea-level change and the initial morphological profiles were found to be important for the erosion pattern of sandy beach.

It is obvious that the breaker-induced vortices reaching bottom are crucial for sandy-beach erosion and give a clue to solve the mechanisms and processes of sandy-beach erosion by sea-level change. Beach erosion occurs by longshore bar's development induced by the breaker-induced vortices, while the effective depths of vortices change duo to sea level rise. Basing the results of the mechanisms and processes of morphological changes and the temporal-spatial changes under the higher wave action and sea-level change, a model for predicting sandy-beach erosion profile generally was constructed. This model will be useful for reductive planning and engineering of disasters by storm and typhoon waves accompanying with accerated sea-level rise in the coastal cities of the worlds.

HUNAN ZHANG & WEIGUANG CHEN

Features of tectonic landform of fault blocks in South China coastal area

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In this paper, the south China coastal area is divided into several fault block areas (first class), sub-areas (second class) and mini-areas (third class) based on their dynamic signs, heridity, uniformity, particularity and the mode of action of tectonic stress. Their tectonic geomorphological features are elaborated and the amplitude as well as the rate of relative motion since the end of the late Pleistocene epoch are estimated from ^{14}C data of the samples which fundamentally represent the sea level in different periods. It is found that the value of amplitude and rate of fault block movement, tend to become smaller from the east and west towards the middle. This feature could he related to the «screen» effect of the Taiwan-Penghu-Quanzhou-Shantou strong earthquake area and the Leizhou-Qiongya earthquake area.

WEIQIANG ZHANG, ZHENGUO HUANG, RUIRU HE & ZHENGCHONG HE

Laterite evolution, climate change and tectonic motion in China

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From the studying of 189 profiles of red earth in China, there is a couping relationship between the red earth evolution, paleoclimate change and tectonic motion. Three main cycles of tectonic-climate (red earth) can be deduced since Quaternary, and each cycle can subdivided into two stage. The former is characterized by relatively structural stillstand and warm climate (interglacial stage), the latter, tectonically active preiod and cold warm (glacial stage) . The red earth periods are corresponded with the warm climate and relatively structural stillstand.

BIQIANG ZHAO[1] & WEIQIANG ZHANG[2]

Plate tectonics and Quaternary volcanicity in China

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There are 10 groups of Quaternary volcanoes in China. From the relationship between volcanicity and plate tectonics, the groups of volcanoes can be into the follwing seven types, as follows:

1. Volcanicity of ocean bottom and oceanic island of inside plate in South China Sea basin.
2. Volcanicity of rift valley of plate margin in Leizhou Peninsula and Northern Hainan Island.
3. Volcanicity of Taiwan Island arc which is a consuming zone of plates.
4. Volcanicity of rift valley of plate margin in the bay of Bohai Sea.
5. Volcanicity of rift valley of inside plate along the Da Hinggan Mountain and Datong fault trough .
6. Volcanicity of plate margin along the Xiao Hinggan Mountain and Changbai Mountain which are affected by subduction of plates.
7. Volcanicity of inside plate in Tengchong and northern margin of Tibet Plateau which is affected by collision of plates.

According to incomplete statistics (collected 231 dating data of volcanic rocks up-to-date) dating data during Q_1, Q_2, Q_3 and Q_4 make up 37.2, 46.8,12.6 and 4.0 per cent, respectively, which show the change of volcanicity during Quaternary in varying degrees: the most strong period of volcanicity is in Q_2, the secondary is in Q_1, and the most weak period of that is in Q_3 and Q_4.

From the study of the important events of plate movement in China or East Asia i.e. in Eastern China (Taiwan Island) the collision between Philippine Sea plate and Eurasian plate occurred in the Himalayan movement between Pliocene and Pleistocene, in Southern China the second spreading of South China Sea and the Shikoku basin north of Philippine Sea plate spreaded in 32 ~17 and 30 ~15 My BP (from Holocene to Miocene) respectively and in Western China the accelerating uplift of Tibet Plateau was since Pleistocene, which was caused by the collision between India plate and Eurasian plate, the distribution of Quaternary volcanicity in China can be epitomized into one basin, three rift valleys and three volcanic arcs.

The modern volcanicity occurred only in Taiwan Island, the Xiao Hinggan Mountain and Changbai Mountains of North-east China.

XITAO ZHAO

Development of the coral reefs and the *tombolo* of Luhuitou Peninsula, Sanya City, Hainan Province

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Luhuitou Peninsula situated at the southern end of Hainan Island is one of the areas where the Holocene fringing reefs are the most developed in China. It consists of three parts: the Luhuitouling tombolo island, the Yezhuang tombolo and the Nanbianling-Huoling hills.

In order to suggest the stratigraphy, development of the coral reefs, the coastal evolution and the sea level changes in the Quaternary, the author drilled a hole of 26.5 m deep, the Luhuitou L_1 hole,which had penetrated the whole Quaternary strata. The L_1 hole is located at the southwest part of the dried lagoon in the Yezhuang tombolo (109° 28' 38" E, 18° 12' 32" N). The surface of the hole mouse is 1.12 m above the sea level. The strata and sediments, ^{14}C and thermoluminescent datings, as well as the foraminiferal and spo-ro-pollen assemblages of the L_1 core have been obtained.
On the basis of the data from the L_1 core and other researchers,the following conclusions can be obtained:
1. The Yezhuang tombolo consists of two marine layers, the middle-late Late Pleistocene and the Holocene, and continental layer of the end of Late Pleistocene in between.
2. The Holocene reefs were mainly constructed on the basement of the Late Pleistocene continental or marine sediments.
3. The Holocene coral reefs in Luhuitou Peninsula can be divided into the following stages:
The Ximao stage (8500-8000 aBP), a developing stage of the coral reefs in this area, when the sea level had raised up to –13 to –9 m or higher, the sea water had merged the Yezhuang area and seperated Luhuitouling from the mainbody of Hainan Island.
The Luhuitou stage (6300-4800 aBP), a flourishing stage of the coral reefs in this area, when the sea level was 2-3 m or more higher than that of the present. The reef corals flourished in the warm sea water along the coasts of sanya harbour, Luhuitouling island, Nanbianling and Houling hills, forming an unified broad reef flat. The length andthe wedthof reef flat could be over 2 km.
Since about 5000 aBP, the sea regressed on the whole. While the general trend of regression, there were still two or more oscillations. At the Yezhuang stage (4400-4000 aBP) and the Dongmao stage (3800-3600 aBP), development of the coral reefsin this area entered a degenerative stage, whereas bars and spits started to be deposited, and the Yezhuang lagoon was formed. This lagoon lasted untill to 2500-1300 aBP. After then the Yezhuang lagoon disappeared and the Yezhuang tombolo came out. At the same time, the Luhuitouling tombolo island connected with the mainland of Hainan Island.

XIAODONG ZHU

The geomorphologic characteristics and evolution of the radial submarine sand ridges in the inner continental shelf of the southwestern Yellow Sea, off Jiangsu, China

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The submarine tidal sand ridges in the southwestern Yellow Sea are a unique giant submarine geomorphologic and depositional system in the world. The ridges developed on the one of widest continental shelves of the world, the Yellow Sea-East China Séa continental shelf which lies between the largest ocean (the Pacific Ocean) and the largest continent (the Euro-Asian continent) of the world under the influence of two large famous rivers, the Yangtze River and Yellow River. The formation of the ridge depositional system (including the forcing mechanism, the sediment source and age) is the result of the interaction among sea level change, coastal geomorphology,coastal dynamics and the ancient large rivers (the Yangtze River and the Yellow River) since the late Pleistocene. So the huge submarine geomorphologic system bears specially important paleo-environmental information which is of typical significance to the interpretation and correlation about the interaction between land and marine geomorphologic processes. Recently, we have made some important progresses in understanding the system. Therefore, we feel happy to introduce the system and our recent work to the international colleagues at the Conference.

TADEUSZ ZIĘTARA

Influence of neotectonics on development of young tectonical scarps in the Gobi Altay and Khangai (Central Asia)

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In Central Asia (Mongolia) there are huge blocks and montane ridges uplifted during the Alpine orogene along tectonic dislocations. Those dislocations appeared at the end of Jurrasic and beginning of Cretaceous periods. The Gobi Altay is a huge tectonic horst which is some hundred km long within which particular blocks have been uplifted on different height along transversal and longitudinal faults. The southern slopes of the Khangay are separated from the South-Khangay Upland by tectonic basins, bottoms of which are on different levels and directions of their drainage was changed in the Quaternary. Different amplitude and age of uplifting of particular blocks influenced different stage and advancement of tectonical scarps relief. Then the scarp slopes have been destroyed by gravitational movements of rocky masses, they go backwards leaving the zone of tectonical dislocations. Pediments which are covered with debris from fall-outs and talus cones or with deposits from torrential cones are developed at the foothills.
There are 3 stages of young tectonic slope development. In the first stage slope development is accordant to the course of tectonical cracks. Slope is not dissected by chutes and goes backwards gradually and parallelly and there are steps reflecting the surfaces of dislocations in its upper part. There is a small segregation of big rock blocks on surfaces

of which there are preserved polished tectonical surfaces. If there was an earthquake connected with dislocation rejuvenation there are created fall-outs and slope goes backwards partially or the whole zone of tectonical loosenings is destroyed.
In the second stage slope destruction is accordant to joint fissures. There are chutes on walls and at the foothills talus cones overlap each other and make accumulative part of the slope. Then chutes change into corrasional valleys and in the zones of tension or with greater density of cracks there are formed valleys with zig-zag or perpendicular pattern. Faces of those scarps in the first stage are of a trapezium and then of a triangle shape.
In the third stage slopes are more gentle and inclination of them does not exceed 45-50° and waste cover is created on them. The cover is taken away episodically during disastrous wash-outs. The material washed out from the upper and middle part of slopes covers talus cones which are changed into torrential cones. They are much longer and they have gentle concave profiles. In that stage of development young slopes become mature ones.
Within the Gobi Altay and Khangai foreland slopes of young, early and late mature stages can be distinguished.
Young slopes consist of 2 parts - rocky wall in which tumbling and breaking off take place and talus cones which are results of material deposition.
Early mature slopes consist of 3 elements. There are convex, upper, parts of slopes which are modelled by cutting. Middle parts of slopes are regularly inclined and transportation and washing-out take place. Pediment is built at the foot and material deposition and transportation takes place there.
Late mature slopes consist of 4 elements. They consist of a very short convex part which is modelled by cutting, long concave part on which transportation and furrowy washing-out take place. The third part is made by cryptopediment on which deposition and transportation takes place. The fourth part is made by washing-out pediment which often in its lower part becomes parapediment.
During the earthquake in 1972 a fault 600 km long and 2-16 m high was formed. It transversally cut pediments and cryptopediments in the northern part of the Altay. Some dislocations in the Khangay were rejuvenated. The surfaces of younger dislocations are accordant to older tectonical zones and new tectonical scarps are formed. Their height is different but does not exceed 45 m. Those scarps transversally cut hanged valley bottoms and local erosional bases are formed. Scar or frontal landslides were formed above tectonical dislocation zones. Common pattern of those forms and their greater density is clearly connected with the amplitude of uplifting. Greater density of landslides occur in places of a single greater uplifting or subsidence of the surface.
At the foothills of tectonical slopes within pediments and cryptopediments there are clear new scarps connected with present tectonical movements. Those young dislocations take place not only in the zones of older tectonical loosenings but there are also formed new dislocations on the foreland of the old ones. They are marked by zones of frontal landslides. Such pattern of present dislocations leads to creation of local erosional bases and in the same time to zonality of the present erosional and denudative processes. Tectonical dislocations are accompanied with eartquakes what is confirmed by deep landslides which are situated not only in the dislocation zone.

MARKUS N. ZIMMERMANN

Morphological changes following the 1991 eruption of Mt. Pinatubo, Philippines

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The June 1991 eruption of Mt. Pinatubo Volcano, Philippines, spewed some 8 to 9 billion cubic meters of pyroclastic sediments and ash into the atmosphere. Approximately 6 to 8 billion cubic meters were deposited in 8 major river basins, which drain the slopes of the volcano in all directions. It is supposed that within 10 to 20 years about half of this volume will be transported downstream by lahars and hyperconcentrated flows. These processes occur regularly during heavy rains. The first five rainy seasons caused major lahar activity in all river basins. A total of about 2 billion cubic meters has been already washed down. The pyroclastic flows as well as the subsequent lahars caused major morphological changes in the headwaters and in the lower river reaches.
The pyroclastic flows travelled as far as 15 km from today's crater. Accumulations of up to 250 m thickness occurred. Whole valleys were filled and new river networks developed. Even 5 years after the eruption the pyroclastic sediments are still hot. The infiltration of rainwater causes secondary explosions (phreatic explosions). As a consequence large secondary pyroclastic flows can occur. Due to such flows the river network in the headwaters is frequently changing. A large secondary pyroclastic flow during Typhoon Kadiang (October 4 to 6, 1993) caused a major impact on the whole area: about 21 square kilometres of primary sediment sources shifted from the Sacobia River to the Pasig-Potrero River. The shifting of such large volumes had dramatic consequences for the Pasig-Potrero River during the rainy seasons 1994 and 1995. The development of the piracy point showed that vertical downcutting contributed almost the total volume for the lahars; the sediment delivery from adjacent slopes is minor.
The lahars which transport the sediments to the lower river reaches are largely controlled by the occurrence of typhoons. Volumes of 5 to 30 million cubic meters per event were observed. In the upper reaches of the alluvial fans the sticky, debris flow-type lahars deposited sediments up to 40 m thick. Rivers, deeply incised in the alluvial fan prior the eruption, were completely filled and the subsequent lahars started to shift over parts of the fan. In the Pasig-Potrero River a reverse process started at the end of

the rainy season 1995: a deep channel was eroded during two typhoons. In addition, the river started meandering. It is supposed that this reverse process will also occur in other channels, after the major sediment sources are depleted. The previously deposited sediments have been and will be re-eroded and transported farther downstream by hyperconcentrated flows and fluvial sediment transport. Due to new watershed areas the river channels will not necessarily adjust to pre-eruption conditions. Changes in the water and sediment regime affect almost all river channels for a distance of 50 to 100 km over the coming decades.

Beside an unprecedented magnitude of the natural processes the socio-economic impacts are enormous: the eruption hit one of the most populous areas of the Philippines which serves as the granary for Luzon Island, including the capital area of Manila. To date about 350 square kilometres of agricultural land (mainly rice and sugar cane) are already covered by lahar sediments. A total of 1.5 million people are living within the endangered area. Nearly 70,000 families lost already their homes. The eruption itself and the ongoing lahar activity constitute a major impact to the economy of this Southeast Asian country.

ZBIGNIEW ZWOLIŃSKI

Mineral matter circulation within a polar geoecosystem, south Shetland Islands

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In the areas free from permanent glacier ice on the coast of King George Island (the South Shetlands), mineral material found in the Admiralty Bay geoecosystem comes primarily from volcanic rocks. Additionally, it is supplied by glacial transport from ice cups, aerosol transport from the Admiralty Bay waters, littoral and aeolian transport (of various ranges), and meteoric fallout. These sources, however, are much less significant. Under the severe climatic conditions bedrocks undergo high-magnitude weathering, especially mechanical (disintegration, multigelation, exudation etc.). The big amounts of rock waste thus produced undergo denudation easily, and in effect are transported outside their area of provenance. Among the dominant denudation processes are mass movements, glacial erosion, abrasion, fluvial erosion, and deflation. Each of them involves its own type of waste transport: slope (including avalanches), glacial, littoral, fluvial, and aeolian. Of lesser significance are the periglacial and nival types of transport. In each of these morphogenetic environments deposition and redeposition takes place at various spatial and temporal scales. As a result of diverse transformation of the waste in morphogenetic and sedimentary environments, the Admiralty Bay drainage basin receives material of different origin, but mostly slope, glacial, fluvial, abrasion and aeolian.

The material delivered to the Admiralty Bay assumes three forms: dissolved, suspended and solid. All three come as glacial and fluvial, partly also abrasion, material. Solid material derives exclusively from slope and aeolian processes. The supply of solids is determined by the occurrence of above-zero temperatures, and is only episodic unless produced by glacial and fluvial processes. The glacial and fluvial supply of dissolved and suspended material is continuous even in the short periods of sub-zero air temperatures. The supply of this type of material to the Admiralty Bay basin is decisive for the primary production of biomass. The waste reaching the Admiralty Bay can be transformed in only one or in many morphogenetic environments with different hierarchical patterns.

Besides land mineral matter, there are huge amounts of matter (mostly dissolved and suspended) reaching the Admiralty Bay from glacier fronts and Bransfield Strait in daily and seasonal cycles. Of no little significance is also meteoric fallout and aeolian fallout of a global range.

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