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TYPES OF SLOPES IN THE TRANSYLVANIAN DEPRESSION (Rumania)

ABSTRACT: JOSAN N., *Types of slopes in the Transylvanian Depression (Rumania)*. (IT ISSN 0391-9838, 1996).

The Transylvanian Depression is the largest depressionary area inside the Carpathian Mountains. After the basin stage (Upper Cretaceous-Lower Neogene), in parallel with the withdrawal of the Pliocene lake waters and the depletion of erosion levels, sub-aerial modeling began. In this new stage several types of slopes appeared: cuestas, structural surfaces and complex slopes formed in concordance with the geological structure, the Quaternary bioclimatic conditions and the direction of rivers.

KEY WORDS: Slope evolution, Types of slope, Transylvanian Depression, Rumania.

RIASSUNTO: JOSAN N., *Tipologie di versanti nella Depressione Transilvanica (Romania)*. (IT ISSN 0391-9838, 1996).

La Depressione Transilvanica è la più vasta area depressionaria dei Carpazi. Fra il Cretaceo ed il Neogene Inferiore essa fu un bacino marino e successivamente ospitò laghi pliocenici, a seguito dello svuotamento dei quali, con l'abbassamento del livello di base, iniziò la fase di erosione subaerea. In questo nuovo stadio apparvero diversi tipi di forme, quali cuestas, superfici strutturali e versanti complessi formati per concordanza fra struttura geologica, condizioni bioclimatiche quaternarie e direzione delle aste fluviali.

TERMINI CHIAVE: Evoluzione dei versanti, Tipologie di versanti, Depressione Transilvanica, Romania.

GENESIS AND EVOLUTION OF THE RELIEF

The Transylvanian Depression lies in the central part of Romania, inside the Carpathian arch. It is actually the greatest depressionary area inside the Carpathian Mountains, lying at altitude of 450-700 m and having a relief energy of 100-300 m and a density of fragmentation of 0.50-1.75 km/km^2. the area is dominated by friable sedimentary formations and presents a visible trend of maturity due to intense slope processes to landslides in the first place. Therefore, a study of slope types and evolution is extremely interesting both from a theoretical and pratical viewpoint.

The evolution of the Transylvanian Depression relief is marked by two major stages: the basin stage and the subaerial modelling stage.

The Basin Stage

The Transylvanian Depression was formed by the nonuniform sinking of a hage Carpathian area. The shaping of the depression began during the Upper Cretaceous after the structural elements of the Eastern Carpathians, the Apuseni Mountains and the bottom of the depression had been fixed during the Alpine Orogenesis. Geophysical, magnetometric and seismometric investigations have proved that the crystalline bottom of the depression had sunk unevenly, with three high crystalline steps being distinguished between 1 000 and 3 000 metres, separated by areas maximum submersion (sinking) where the crystalline lies between 5000-8000 m deep (CIUPAGEA & *alii, 1970*).

The crystalline basement is covered by thick sedimentary deposits superposed during five sedimentation cycles: Senonian, Paleogene, Burdigalian, Baddenian - Sarmatian and Pliocene, the last two being particularly important for the morphography of the Transylvanian Depression. The sedimentary deposits of the Transylvanian Depression belong almost entirely to the Neozoic, characterized by uniformity facies. These neritic low depth epicontinental sea deposits consist especially of marls, diorite sands, clays with intercalations of vulcanic tuffs.

In point of tectonics, the Transylvanian Depression falls into three zones:

– at its North-Western and Northern and Northern Fringes, the zone in which the Paleogene is developed, the deposits a slightly dipping monocline (5°-15°) towards the centre of the depression;

– inwards there is an area of diapir folds occasionally, with outcropping salt cores;

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– the dome area in the central part of the depression, there is with declivity to 15°.

The sub-aerial modelling stage

It starts at the upper part of the Neogene when in parallel to the withdrawal of the Pliocene lake waters a drainage network was being shaped.

According to processes dominating a certain time-period and to the ensuing landforms two stages can be outlined: the stage of erosion levels modelling and the stage of drainage network deepening and the formation of the valleys.

TYPES OF SLOPE

The main factor which determines the principal types of slope in the Depression of Transylvania is the geological structure. The monocline layout-anticlines or domes generated a cuesta type relief, with two specific slope types: the front of cuesta and its reverse side (structural surface).

The front of cuesta, or simply the cuesta, is a characteristic element of the region's relief. Its inclination, plane and profile aspects depend on strata declivity and lithology. The predominance of sands, slightly cemented with thin marl intercalations engender a steep cuesta, with a linear or even slightly convex slope profile. Such situations are specific to the South-Eastern part of the Târnava Mica Hills, where the Upper Pontian is predominant. Sands here no more than 300 m thick. On marls and clays cuestas have a lower declivity not only because of their diminished resistance to erosion, but also because landslide processes are very active on diminished resistance to erosion, but also because landslide processes are very active on their surface. Slope declivity in this case is reduced and its profile is obviously concave, the way it is in the Transylvanian Plain. The alternations of marls sand stones, conglomerates and volcanic tuffs confer to the cuesta a transversal profile with many slope discontinuites, structural steps and low declicity slope sectors. The cuesta looks like complex slopes. The presence of certain erosion-resistent strata, considerably thick enhance the complexity of the cuesta-type slope by the apperance of layered cuesta with each slope sector evolving independently (fig. 1) (JOSAN, 1972, 1979).

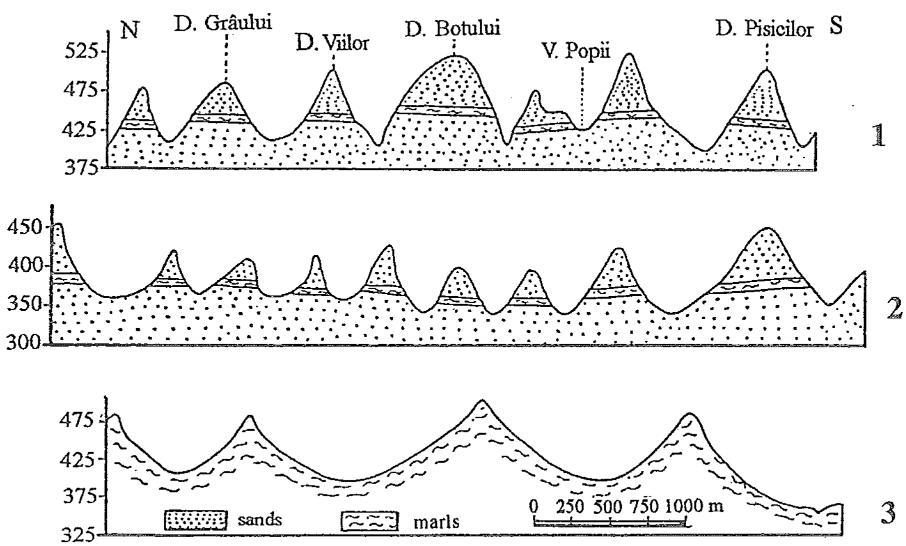

FIG. 1 a - The influence of lithology in the aspect of secondary valleys: 1) Viticai Hills, 2) Dumbravenilor Hills, 3) Boiului Hills.

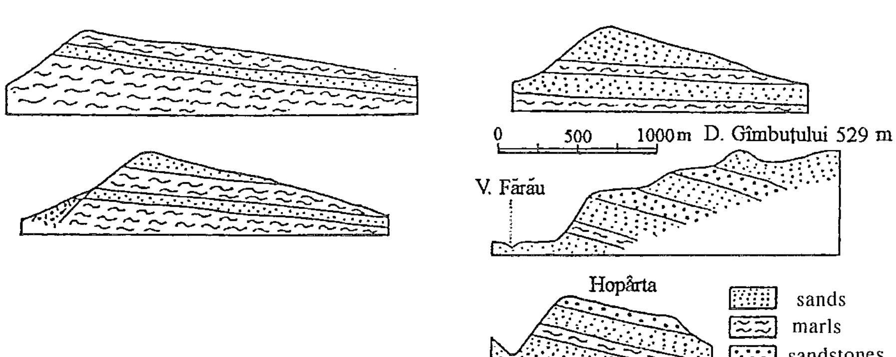

FIG. 1 b - The influence of lithology in the aspect of cuestas.

According to the plane pattern of the cuesta, one can distinguish linear, sinuous, angular and semicircular cuesta.

The structural surface or the reverse side of the cuesta is less prominent because the surface they develop on lack of a rough stratum. So, the majority of these slope types are actually quasi-structural surfaces. Like in the case of cuestas the lithological nature of the sedimentary formations stamps the physiognomy of quasi-structural surfaces. Those developed on sandstones, conglomerates or limestones are well maintained, e. g. the Somesan Tableland. Although less prominent in the centre of the Transylvanian Depression, they are very well preserved on marls, being far less prominent and even obscure on Pontian sands.

In the central part of the Transylvanian Depression, the relief features boy dome structures wide cupolas-like in shape where the strata have a radical inclination. This, in its turn, determines a certain disposition of the drainage network, hence of structure-controlled forms. Thus, the following situation can be distinguished (fig. 2):

– two cuestas set one in front of the other(a), when drainage network occupies the axial area of the dome;

– two cuesta set in opposite direction when certain watersheds in the axial area of a syncline are superposed (b);

– two structural surfaces facing one another when drainage network occupies the axial area of a syncline (c);

– structural surfaces oriented in an opposite direction express a relation of conformity between the geological structure and the relief (d);

– the alternation of cuestas and structural surfaces in the most frequently encountered situation, the result of the deepening of the drainage network on the sides of the domes (e).

BIOCLIMATIC CONDITIONS DURING THE QUATERNARY

The analysis of slope deposits shows that the present aspect of the Transylvanian Depressions is due largely to the morphological processes that had taken place during the Pleistocene and Holocene. During the early Pleistocene, sharp deepening of rivers with the formation the present valley system occured against the background of certain positive tectonic movements. During the late Pleistocene, a relative tectonic calm and the onset of the Riss glaciation, morphoclimatic processes become predominant, developing widely on slopes (CARCIUMARU, 1973).

In the Wurm periglacial climate slope modelling became extremely active, playing an essential role in the formation of certain superficial deposits, both at the base of the slope and on its morphological thresholds. Because of these processes, the surface formations pre-existent of the last glaciation, where weathered resettled and altered.

In the glacial stages, when there was little vegetation, the slopes were subjected to cryogenic processes of cryoplanation, solifluxion that let to a deluvial-type accumulation. The outcome was the rapid evolution of slopes toward an equilibrium profile. In the inter-stadial phases, moister and warmer, different types of landslides and linear fragmentation, prevailed the effect of which was a certain revigoration of the relief.

During the phases of relative slope dynamics calm pedogenesis set in (JACOB, 1988). On the ground of buried soil, stripes found in the central part of the Transylvanian Depression, the existence of at least three periods favorable to the pedogenesis during the Wurm could be detected.

PRESENT-DAY BIOCLIMATIC CONDITIONS

The Depression of Tansylvania is generally characterized by a moderate temperate-continental climate with some oceanic influences coming from the West of Europe. So, the mean annual temperature runs between 9.5°C in the West and below 8° in the East. Mean temperatures in January (the coldest month) fall below - 4° C, with values of July (the warmest month) averaging some 20°. Rainfall values are increasing from the West to the East (581 mm, 645 mm at Targu Mures).

Lately, slope evolution in the Transylvanian Depression has deeply been affected by the anthropic factor especially

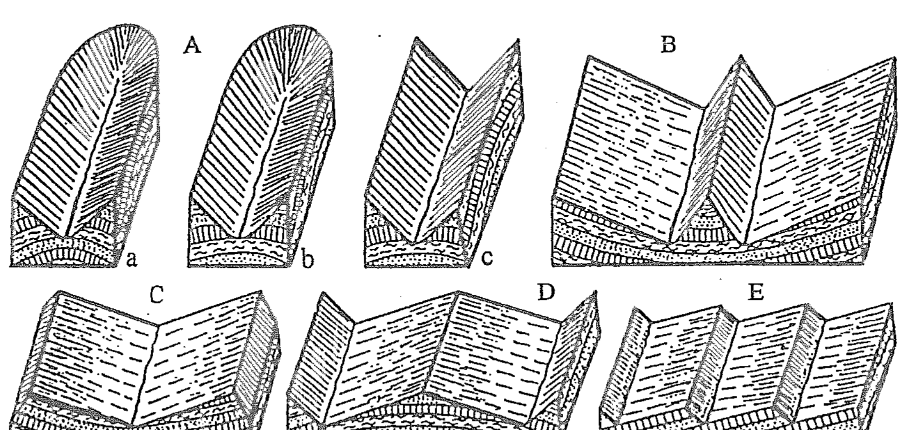

FIG. 2 - The disposal of relief features related to the structure of domes. Schematic block diagrams: A) face to face cuestas, B) opposite cuestas, C) face to face structural surfaces, D) opposite structural surfaces, E) alternance of cuestas and structural surfaces.

through massive deforestation, carried out ever since 17th century, agrotechnical works and landuse (intensive grazing).

Some of the present processes, mainly landslides and gully erosion, play a major role in slope modelling. This continuous and complex process is associated with sheet erosion, creep, falls and other like phenomena. By their wide spead areas and range landslides represent the severest present-day process on the slopes of the region (GRECU, 1992).

PATTERNS OF SLOPE EVOLUTION

The slope can be regarded as an open morphodynamic system, where the inputs and outputs of mass and energy are related to dependent and independent variables. In analyzing the slopes one should proceed from the idea that slope is a cascade system, formed of many sub-systems among which a «matter and energy are cascading». In the evolution of a slope, the rate of weathering of a certain surface is of most importance because while cascading on another surface, it changes the morphology of both the surface it had been wrenched from and the one it settles on. In view of above, several types of slope evolution in the Depression of Transylvania can be distinguished:

A) *Cuesta-type slopes*

Generally, the intense rate of denudation enhances the evolution of this kind of slope let us take a look at some of them:

a) *uniform cuestas*, with a very steep slope, developed on a few consolidated sands, such as those situated in the South-East of the region. Covered especially with grass or forest vegetation, the processes affecting them have rather a superficial, fact that slows down the evolution of slopes. The material dislodged from the upper section of the slope spreads down to its base (fig. 3). Thus, between the erosion and the depositional section a «natural» compartment of a

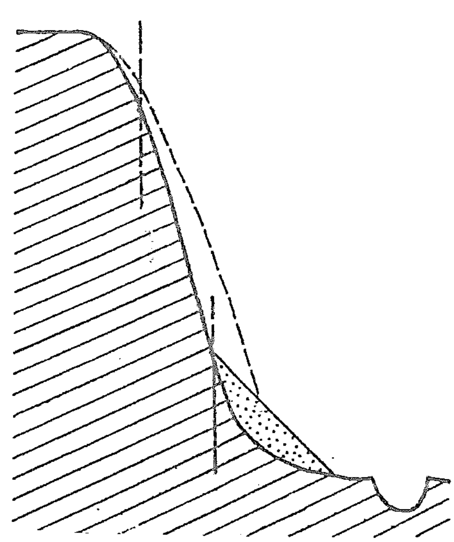

FIG. 3 - The evolution of a cuesta developed on consolidated sand.

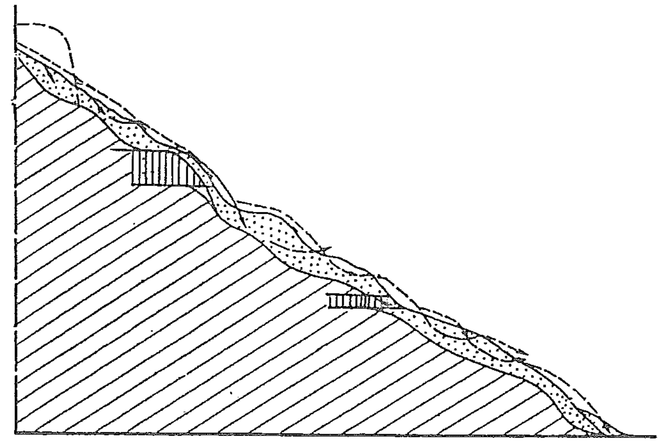

FIG. 4 - The «step by step» modelling of a structural surface.

maximum lenght is maintained. Since there is little material coming from the upper part of the slope and the drainage network is capable of removing it fast enough, the glacis formed at the base of such slopes are generally small in size.

b) *cuesta developed on an alternation of marls (at the base) and sands or sand-stones (at the top)* are marked by landslides located in the upper part of the slope. They supply an important quantity of material which causes significant discontinuites on the slope. The upper sector slope is a very steep slope representing the escarpement corniche, of the above-mentioned processes. The median slope sector is sligtly convex due to the deluvial deposits which stopped here temporarily.

In a more advanced phase of evolution, a glacis-type colluvial base strip is formed. The upper sector of the slope is quickly retreating under the action of landslides, sheet erosion, creep, and gully erosion, whereas in the median and the lower sector a redistribution of the materials takes places and entropy is maximum. The withdrawal of the upper section of two opposite slopes can finally leal to their intersection. In this phase, the slope profile has a reduced declivity, being loaded with thick deluvial deposits up the top. The phenomenon of planation becomes dominant and the quantity of material removed from one place is redistributed and stocked for a while in the nearby place (fig. 6).

B) *The structural slope-type surface*

The evolution of this slope-type is less spectacular than the cuesta. However, it manifests itself under the impact of surface processes, in line with the minimum variation principle through a step-by-step erosion and accumulation (fig. 4). The step by step denudation is the more obvious the more elongated and less steep the quasi-structural surface is. Sometimes the evolution of this kind of slopes is fastened by the onset of gully erosion, ravines and torrential phenomena. The evolution of slopes is closed connected with the evolution of cuestas, which, the moment the interfluve is left behind, affect in their retreat the upper part of the opposite structural surface as well.

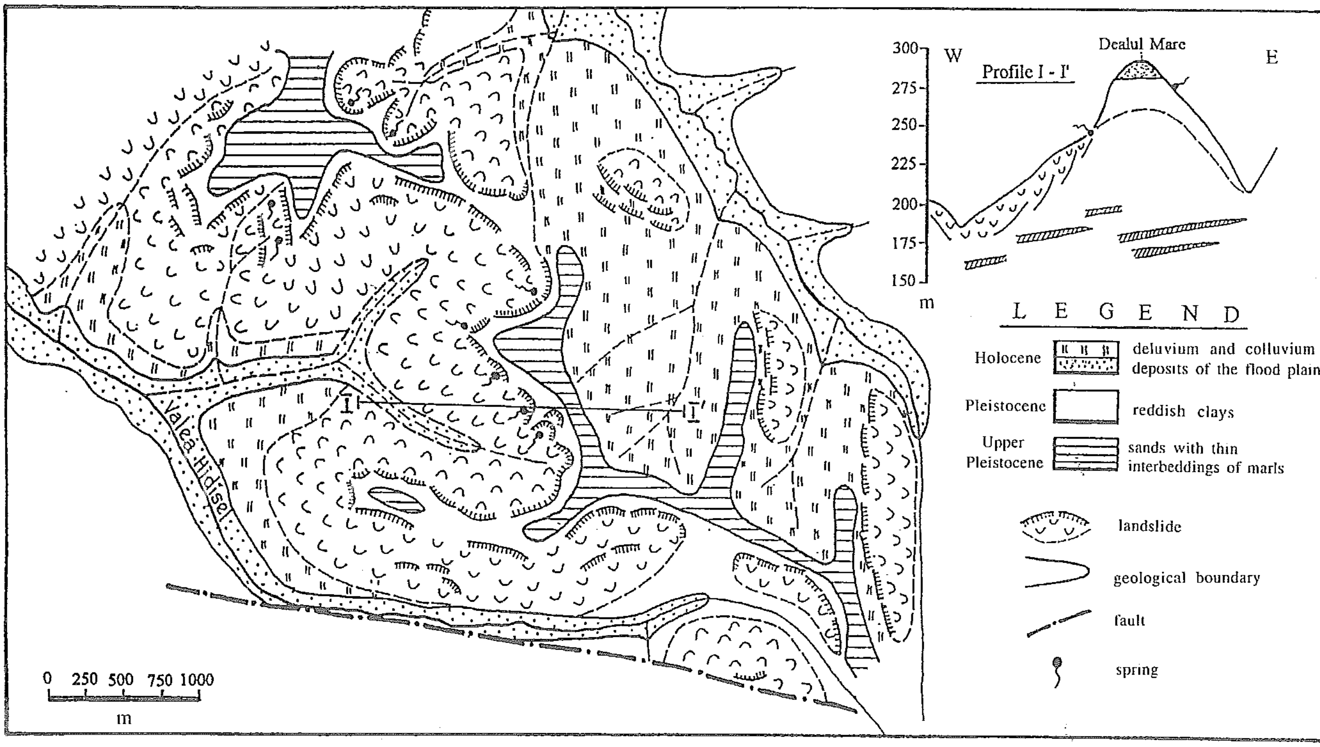

FIG. 5 - Slopes affected by landslides on the upper part.

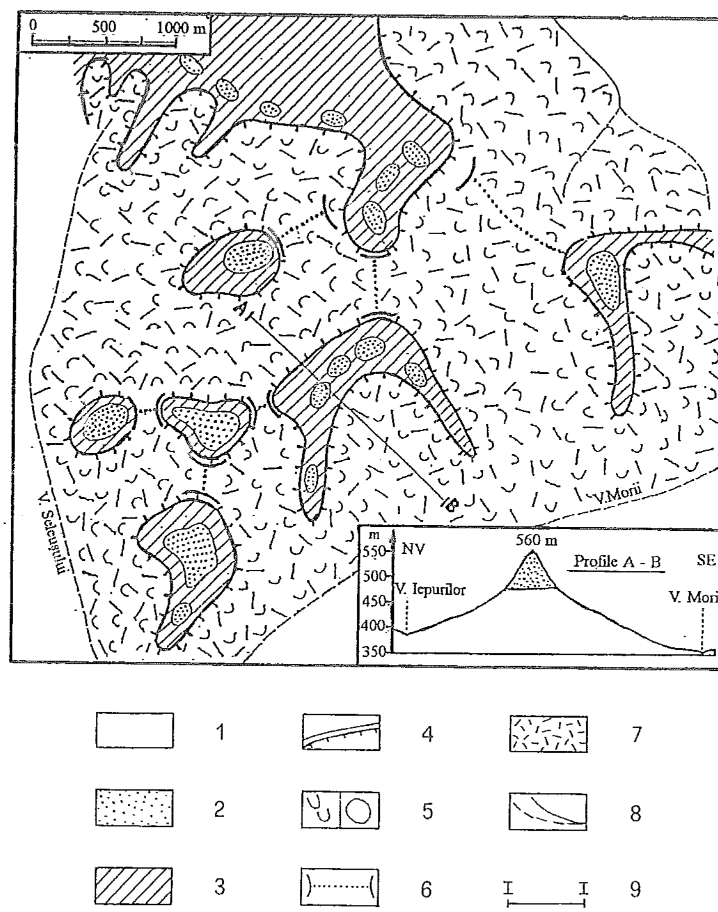

FIG. 6 - The intersection of the slopes due to landslides with remaining outliers on the interfluves: 1) mares, clays; 2) sands; 3) interstream area; 4) cuesta; 5) landslip; 6) saddle; 7) glacis; 8) stream; 9) profile.

The complex slopes

The slopes of the Transylvanian Depression are marked by many «morphological thresholds» (surface of terraces, structural steps, overhanging glacis). Between these thresholds the subystems of the slope have their own evolution. The lower thereshold would function as a local basic level for the slope sector situated in its upper part. The irregularities on slope lead to the dissipation of energy in the steeper sector and its concentration in the concave sectors. Hence, disturbances in the water flow and in the movement of materials on slopes, relative to these morphological thresholds. The slope surface appears as a dynamic field of dispersion and concentration of forces and resistances (MAC, 1988 a, b).

Two situations can be distinguished:

a) *deluvial deposits* - formed mainly by pluvio-denudation, solifluxion and creeping cover the small «irregularities», in such a way that the initial step-like slope changes into a more or less uniform, with a glacis aspect.

b) in the case of prominent thresholds, parallel stripts appear, formed of deluvial deposits divided by steep slope sectors devoid of deluvial deposits or covered by a thin soil layer (ICHIM, 1981).

As a result of the denudation of the more prominent sectores on the one hand and of the accumulation of deluvia on the lower threreshold, on the other hand, there a long slope results with the aspect of a slightly rippled glacis, formed of a series of ablation or erosion, transport or accumulation sector, which recur several times.

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