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Session: Weathering and Soils

Convenors: COLIN PAIN (\*) & STEFANO CARNICELLI (\*\*)

STEFANO CARNICELLI

WEATHERING AND SOILS

The symposium title, «Weathering and Soils», clearly reflects the two-sided issue geomorphology faces, with respect to the processes and products of climatic and biological action on earth surface materials. Lying near the border between geology and physical geography, geomorphology progresses under the stimulus of two convergent necessities. The more physical one is the understanding, and as much as possible the quantification and forecasting, of the components of the overall evolution of the earth surface. The more geological necessity is the reading of that portion of the geological record that is of direct interest to geomorphology, that is the record of past geomorphic processes.

By the process point of view, weathering is a fundamental issue; it strongly conditions, and indeed in many cases makes possible, basic geomorphic processes like erosion, infiltration and mass movement. Pedogenesis, in this context, is an extension of the weathering concept; more complex than weathering, it is as much or more influential on geomorphic behaviour of land surfaces.

The products of weathering and pedogenesis, soils and weathering horizons, are integral parts of the geological record, than of the accessible information about the history of the earth, and of its surface in particular.

The contributions to the symposium well reflect this two-sided, but convergent, issue; some of them are more focused on one side, some on the other, some more do tackle the problem of synthesising the two points of view, but all contribute significantly to this complex but fascinating picture, as parts of the work geomorphology does to improve its overall knowledge base.

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(\*) Minerals Division, Australian Geological Survey Organisation,  
PO Box 378, Canberra ACT 2601, Australia.

(\*\*) Dipartimento di Scienza del Suolo, Università di Firenze, Piazzale  
Cascine 15, 50144 Firenze.

PROCESS STUDIES

Judging by symposium contributions, weathering in itself is one of the processes most considered as a research theme. Among the contributions dealing with it, a notable trend is a high interest in the early stages of rock weathering and accompanying processes. These studies often show to be spurred by practical implications, as the conservation of man-made objects of the more diverse types, while several are of a more strictly research nature. Practical applications add to the end value of geomorphological research, and they don't necessarily represent a constraint to the scientific value of the results. This is plainly demonstrated by the work of Takahashi & alii, that, while primarily concerned with bridge maintenance, brings substantial support to the concept that weathering is a necessary prerequisite for hard rock erosion, even when mechanical stresses are high. Another contribution in this sense comes from the work of Waragai, who found an interesting way to show how, in rock shattering, exfoliation predominates over chemical and physico-chemical weathering only under very specific circumstances. The significance of physico-chemical processes linked to change of moisture conditions is also stressed by the works of Meiklejohn and Mottershead & Pye. A fascinating case of complex interactions between weathering, wind erosion and water erosion in the initial building of a regolith is offered by Vieira.

Methodologies used vary widely, including tools such as detailed monitoring of physical conditions, use of sophisticated proximal sensing instruments and simple mechanical measurements. The importance of these last can hardly be overlooked; the contributions by Mottershead & Pye and by Hachinohe & alii show them to be cheap and highly repeatable, and they bear on a very focal issue, i.e. the reduction of rock's resistance to physical stresses.

Seen by a pedologists' point of view, such interest on early weathering stages can only be welcome, as it appears

that there is still a lot to understand about the ways unconsolidated surface mantles develop. The properties of such mantles are now acknowledged by pedology to influence soil formation potentially more than the properties of the bedrock itself.

Other geomorphological processes are issues for intensive studies; in this symposium, this means soil erosion, but also the fresh and implications-rich issue of chemical transports through landscapes.

Of great interest is the concentration of soil erosion studies on processes up to now considered either of lesser importance, with respect to the mainstream of water and wind erosion, and/or difficult to study. So, Oostwoud Wijdenes & *alii* bring us new knowledge on the long suspected anomalies induced by tillage on coarse materials behaviour in slopes. Their advances might foster reconsideration of recent slope deposits, and has major practical implications for soil conservation. Other two contributions, from Nafaa and Vittorini, deal with the problem of «catastrophic» erosion, i.e. those erosion processes that remove large amounts of materials in single events, well spaced in time. Further than catastrophic, such processes also tend to be chaotic, in the sense that their behaviour is inherently non-linear and scarcely lends itself to classical measuring and modelling instruments. These characters made, in the past, for an underestimation of their importance, but ideas are changing rapidly and the weight of catastrophic erosion in land surface modelling and soil destruction is becoming more and more acknowledged. The contributions show well how progress is being made in the knowledge of the factors controlling these processes. The linkage between catastrophic erosion and more linear processes of erosion and soil formation is becoming better known, so that they are less and less seen as abrupt, isolated events. The importance of weathering in influencing geomorphic processes, even on unconsolidated sediments, is stressed again by Vittorini, and hopes for a better forecasting ability are fostered.

Chemical transports in the landscape are a highly significant issue in a world dominated by environmental concerns, but also basic processes of landscape evolution. Both aspects are tackled by the contributions presented, among which that of Bukowska-Jania & *alii* sets in the major stream of basic geomorphic processes quantification.

At the border between process- and landscape-oriented studies, the contribution from Mezôsi & Szatmari well represents the kind of applied, and very important, studies to which better geomorphic knowledge is expected to contribute deeper and richer bases.

## LANDSCAPE STUDIES

Geomorphological research exploiting soils and weathering horizons as part of the geological record is a well-established sector. Its object has been seen as rather on the

«pure research» side, but this view has shifted rapidly since climatic changes have started coming to the fore in the interest of politicians as well as of the scientific community. Contributions on this issue have been numerous and varied, and the portrait of current research is highly significant.

In terms of aims and approaches, the most consistent trend is to address such researches directly to the reconstruction of past geomorphic processes; this includes both analysing the nature of past erosional cycles and tracing geomorphic surfaces existing in past landscapes. This is a natural evolution, given the emergence of new sources of chronological and paleoclimatical data, that tend to supersede the classical role of paleosols in paleoenvironmental reconstruction. Such shift in primary issue should not be considered diminutive, but rather of potential benefit for geomorphology as a whole, as better knowledge of past processes can only be of help in the interpretation of present ones.

Another consistent and interesting trend is to widen the object of investigation from paleosols as a whole to single weathering or pedological horizons. Extending from the classical, and still well alive, interest on laterites and other indurations, this is a welcome advance on several accounts. Single horizons, especially the deep ones or those with a higher than average mechanical stability, are more likely to survive erosional/depositional cycles than whole soil profiles; this means that the ability to use single horizons increases the extent of the accessible record. Deep horizons are generally little involved in bioturbation and other soil surface processes. The contributions presented indicate that this can be more of an advantage in interpretation, a sort of «noise reduction» that makes the essential information clearer, as shown by the works of Ben Brahim & Thiry, Patyk-Kara & *alii*, Migon and Whalley & *alii*. The last cited papers show how this approach can bring new knowledge even from the much studied glaciated regions. The interest in lower parts of truncated soil and weathering profiles should not be generalised to the point of neglecting surface horizons; actually, the symposium has seen how significant contributions still come out from paleopedological studies of whole profiles, such as those of Melis and Muggler & Buurman. The realisation of the possibilities inherent in studying them must anyway be kept in mind when weighing the value of the evidence they represent.

By the methodological point of view, two trends are clear. The first one is towards integration of different observation scales. Authors like Ben Brahim & Thiry or Melis demonstrate clearly the benefits that can derive from combined use of evidences from microscopical analysis, macroscopical observation, landscape-scale analysis and regional stratigraphic correlation. A second trend is towards expansion and improvement of the absolute and relative dating techniques used. It is apparent how much ingenuity is being displayed by researchers in looking for new ways to measure the age of weathering horizons, and results may be highly rewarding on the background of

the rapidly growing mass of dated paleoenvironmental information

As a general word, it must be remembered that not only the research using innovative methods is useful in this field. The record to be studied is huge and mostly unexplored, and any new research is a valid addition to the wide and complex mass of knowledge from which the story of the earth's surface is to be reconstructed.

As expectable, the symposium has also seen contributions dealing exclusively, or pre-eminently, with genesis, geography and utilisation of soils. These researches may superficially appear of minor interest for the average geomorphologist, but the interest in them is actually very justified on several grounds.

As a basic, soils are useful components of the geologic record as much as they are known in their genetical and geographical relationships; studying the soils of the present is the best way to improve such knowledge, and then studying soils in themselves actually turns out as a useful contribution to geomorphology. With similar significance, soil variability is a factor controlling land surface behaviour with respect to most geomorphic processes. More generally, multi-scale, landscape oriented research, as shown by other contributions, can only be as valid as good and harmonised knowledge is for every single component observed or observation scale.

Another potential usefulness of such research comes from a pedologist's working experience. It is part of such experience that comprehension of relations between soils, climate, deposits and geomorphic processes, the essence of soil cover spatial analysis, hardly comes without generating some progress in geomorphological knowledge. Sometimes this information is lost, as pedologists tend to consider it as a tool rather than as a result, but this should not be allowed to continue. Such exigency just underlines the need for more interdisciplinarity in the study of landscape, the good potential of which has been shown by some contributions such as that from Vieira.

## SUMMARY AND CONCLUSIONS

The synthesised outcomes of a symposium with a broad scope like this tend to show more emphasis on the methodological side, and the Weathering and Soils symposium makes no exception. Indeed, the stimulus for methodological discussion was of the best order.

A methodological issue that clearly comes out is the multiplicity of scales at which work on weathering and soils can be usefully led, and the benefits that can be acquired by integrating the methodological approach over the widest range of scales. This turns out as a paradigm of the necessity to reach convergence between the process oriented and the land surface-oriented approaches, the first one more addressed to micro, and macro-scale studies and the second towards landscape, and regional-scale ones. It is not surprising that contributions that do tackle the difficulties of multi-scale approach appear to give widely interesting results. This should not, however, detract from the value of more specialised approaches; multi-scale studies can only be decisive when knowledge at the various scales involved is adequate; the issues to be solved at single-scale level are such that single-scale studies are to maintain their necessity and value for the foreseeable future.

Other, not less important, methodological issues have emerged. The thrust to improve knowledge about early stages of weathering and quantification of weathering processes is well apparent, as are the new opportunities for using all kinds of weathering features as part of the geological record, and the growing possibilities for dating such features and using the results for geomorphological interpretation.

Some interesting points have been anyway made also on non-methodological issues. Among these, the most evident for the writer are the new insights on the pre-glacial history of glaciated areas, the growing articulation and structure of knowledge about catastrophic erosion and the hints about the complexity and multiplicity of regolith-building processes.