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TECHNIQUES, PROBLEMS AND USES OF MEGA-GEOMORPHOLOGICAL MAPPING

Clifford Embleton
King's College
University of London
United Kingdom

At the closing session of a conference organized by the British Geomorphological Research Group (BGRG) in London in 1976 (Embleton et al., 1978), G.H. Dury attempted to look into the future of geomorphology. His final argument was, essentially, that projections of current trends and rates of growth are, in the longer term, meaningless, because scientific advance does not occur as a smooth curve of progression but as a step function, a series of revolutions. Looking back on the last 150 years or so of scientific geomorphology, it is possible to identify the principal revolutions that have marked its advance - the uniformitarianism of Lyell, the glacial theory of Agassiz, the cyclic theories of Davis and Penck, the climatic geomorphology of Büdel, and so on. The effects and significance of three other 'revolutions' are still being evaluated: the revolution in the measurement of geological time, the technological revolution in global remote sensing, and the concept of plate tectonics in geology.

In the early decades of the twentieth century, geomorphology was dominated by theories of cyclic landform evolution and by an historical approach. The emphasis was on landforms, especially at medium to large spatial scales; the ergodic hypothesis, with its substitution of space for time, was usually assumed. Long time-scales were employed, and relict elements, sometimes of great age, were commonly recognised in present landscapes.

Dissatisfaction with the speculative and unscientific nature of much of this type of geomorphology, an increasing desire to place geomorphology on a more rigorous and quantitative foundation, and the advent of the computer, caused a swing away from historical geomorphology in the 1950's. The emphasis of geomorphology shifted to studies of processes, both in the field and in the laboratory, and to theoretical modelling of these processes. In order to make the investigations manageable, geomorphologists concentrated more and more on smaller spatial scales and short temporal scales. Many became obsessed with micro-geomorphology, with first-order drainage basins, beach profiles, single hillslopes.

The great changes that were then taking place in geology passed almost unnoticed, or were regarded as rather irrelevant. After all, the radiometric dating revolution was hardly of interest to those studying contemporary hillslope processes, and plate tectonics and sea-floor spreading were worlds away from stream channel processes. The advent of satellite surveys and the development of remote sensing techniques were of no importance to such objects of geomorphological study. At last, however, the 1980's are beginning to show a response by geomorphologists to these new concepts and techniques, and a re-awakening of interest in historical geomorphology, large-scale geomorphology and the study of landforms. To quote Ollier (1981), "over the next few decades, geomorphologists must forget their trivial catchments and see megaforests instead of trees."

The term mega-geomorphology itself is quite new - we used it in 1981 for the title of another conference in London organised by the BGRG (Gardner and Scoging,1983). Mega-geomorphology is on the same scale as plate tectonics, biological evolution and macro-climatic change. It is not concerned, as Ollier says, "merely with a little bit of sculpturing on the top of the geological column". Its time scales are measured in millions of years, its forms are studied as continental or macro-regional assemblages. Techniques of radiometric dating and remote sensing are essential to its study.

Mega-geomorphology and remote sensing

The most important techniques for the study of mega-geomorphology are without doubt those that fall under the heading of remote sensing, utilising surveillance from artificial satellites and enploying sensors that range across a large part of the electro-magnetic spectrum. For the first time in the history of geomorphology we have a direct method for identifying global or macro-scale morphostructures. Remote sensing has many advantages over traditional ground survey (Verstappen, 1977a, 1977b) - unprecedented speed and accuracy, a uniform density of information over the whole mapping area and uniform reliability. Problems of ground access or difficulty of terrain are side-stepped, and there is an unrivalled capability for recording complex geomorphological patterns such as those of dune fields, tropical karst, ocean waves, glacier surfaces or thawing permafrost. It completely obviates the need for the traditional procedures of scale reduction, cartographic generalisation and data selection that are responsible for introducing inaccurate or biased depictions of landfoms. Additionally, remote sensing from frequently orbiting satellites is ideally suited to studies of landform dynamics: sequential imagery gives instantaneous and repeated views of such rapidly changing phenomena as flooded areas, depositional coastlines, snow cover or proglacial areas.

At the same time there are problems. The most important is that a completely new basis for interpretation is needed. For any successful geomorphological interpretation of remote sensing data, it is essential that the analysis be carried out by a geomorphologist, preferably someone with field experience of at least parts of the area being investigated, with an understanding of the geomorphological process systems operating in the area at present, and if possible with background knowledge of the paleo-geomorphological evolution of the area. These needs cannot be too highly stressed. If the area is largely unknown in terms of its geomorphology, mapping by remote sensing must be accompanied by an adequate programme of fieldwork, at least sampling parts of the terrain, and if necessary also analysing soil and rock samples in the laboratory.

The geomorphology of Europe

Before satellite remote-sensing data became widely available, a project was commenced for the geomorphological mapping of Europe. The Commission for Geomorphological Survey and Mapping (see Embleton, 1981) was set up by the International Geographical Union in 1968, under the chairmanship of Professor J. Demek, then of the Institute of Geography in Brno, Czechoslovakia. The Commission included representatives from nearly all countries of Europe, as well as the Soviet Union, and a few from other areas. The Commission has now been in existence for 16 years, Professor H. Th. Verstappen succeeded to the chairmanship in 1980, while I have recently taken over as chairman from Verstappen. Two main projects have been organized by the Commission, one completed in 1984. the second planned for completion by 1986-87. The first was to compile a systematic text on the geomorphology of Europe, nows published (Embleton 1984). The second was to prepare and publish a geomorphological map of Europe, as far east as the Ural Mountains, in 15 sheets at a scale of 1:2.5 million, to complement the existing geological and Quaternary maps of Europe at the same scale. A detailed legend for the mapping was established and subsequently revised (Embleton, Maresova and Matousek, 1983, 6th revision), and careful coordination between some 30 geomorphologists in various countries including the Soviet Union was achieved. The first sheet (number 10) was published in 1976; after various delays due to political and financial difficulties, the publication of further sheets is now proceeding. All the geomorphological information is now complete, and all the cartographic work finished. Four more sheets are to be published by the Czechoslovak Academy of Sciences, in conjunction with UNESCO, in 1985. and the remainder will follow in 1986-87. The Commission has, at the same time, published several manuals of geomorphological mapping at various scales to explain the procedures of data collection and compilation (Demek, 1972; Demek and Embleton, 1978; Kugler, 1982; Russian and Chinese editions have also been printed - Bashenina et al., 1976, and Chen Zhi-ming, 1984).

The Geomorphological Map of Europe is based wholly on ground survey. The original data were compiled on larger scales, and there was then a process of successive generalisation and scale reduction to 1:2.5 million. Because of cartographic limitations, some data were selected and other data discarded. All these procedures inevitably introduce a subjective element, coloured by individual perception or particular geomorphological theories. There were many problems of correlation, such as the disagreements on the locations of Quaternary moraine systems running across East and West Germany, whose first mapping showed some remarkable displacements at the actual frontier!

Remote sensing and the geomorphology of Europe

When the project to compile a geomorphological map of Europe was first formulated, remote sensing data were either unavailable or the resources for their analysis were not availabled (i.e. in eastern Europe). Th authors of the map of Europe are fully aware of its imperfections - variations in accuracy, level of detail and cartographic deficiencies. However, an immense amount of field experience lies behind it, and it is this experience that could be utilised if a project to re-map the continent were undertaken, based on remote sensing from satellite data. It was noted earlier that perhaps the single most important problem in compiling a new map from remote sensing is that of checking the data against ground truth. In the case of Europe, however, at least an approximation to the ground truth is already available. To make progress in any aspect of global mega-geomorphology, we need an information store on global landforms, which must include the geomorphological mapping of whole continents (as well as submarine areas). The most logical starting point would be Europe, which would then provide the necessary further experience for mapping other areas. It may be noted in passing that, in recent contacts with Chinese geomorphologists, great interest has been expressed in the mega-geomorphological mapping of their country, which their Academy of Sciences is keen to promote.

To undertake a new map of the mega-geomorpholoIgy of Europe will require considerable financial backing, access to satellite data and expertese in analysis.

The uses of mega-geomorphological mapping

The prime function of all types of geomorphological mapping is as a visual information store. At the smaller mapping scales, say 1:2.5 million or less, it has the ability to display the spatial relationships of mega-morphostructures. Broad patterns and distributions, sometimes not previously apparent, can be perceived, from which inferences can be made about the locations of major geomorphological boundaries and about the regionalisation of forms. In turn, this provokes questions about the origins of these phenomena and the setting-up of hypotheses.

A second important function is in the field of research coordination, as became readily apparent during construction of the geomorphological map of Europe. Not only do geomophological phenomena have to be viewed in a wider spatial context, but the discipline of mapping within an agreed international framework and the need for agreeing temporal and spatial correlations often forces the geomorphologists concerned to re-examine their basic concepts and approaches.

Thirdly, small-scale geomorphological maps can play a useful educational role. Comparisons with other physical maps (geology, soils, vegetation, etc.) show the complex integration of all elements of the natural environment. For geographical teaching purposes, the landform map is superior to a simple topographic map, provided it is well designed.

Finally,the importance of geomorphology to the interpretation of remote sensing data needs to be stated. Much traditional geological photo-interpretation, for instance, is based on analysis of landforms and drainage patterns, prior to field checking. The experienced geomorphologist with his training in the perception of spatial elements in the landscape and his conceptual appreciation of process and landscape evolution through time, can much more easily and reliably appreciate terrain types depicted on remote-sensing imagery than the analyst without such a background.

Conclusion

This paper is in the nature of a plea for a programme of global geomorphological mapping based on remote sensing data. This is a necessary step in bringing together the rapidly evolving concepts of plate tectonics with the science of geomorphology. Geomorphologists must bring back the broader spatial and temporal scales into their subject, and abandon their recent isolation (at least in western countries) fiom tectonics and geological history before the Quaternary. It is suggested that a start be made with a new geomorphological map of Europe, utilising the latest space technology.

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