

BOOK REVIEWS

Geomorphology in Depth

Ollier, C. D. 1981. *Tectonics and Landforms. Geomorphology Texts*; 6, Clayton, K. M. (series editor). Longman, New York, 324 pp., 218 figs. Price: hardcover £20.00; softcover £9.96.

The purpose of this book is to give a synoptic account of contemporary tectonics in relation to the twin discipline, geomorphology. It is somewhat anomalous that global tectonics, which is virtually dependent on indirect observation, should have travelled so much further in the last few decades than has geomorphology. The advances in the latter field, partly because of a revolt against the cyclical approach, have been dominated by studies of process rather than with the whole picture; almost amounting to an obsession with 'seeing the trees rather than the wood'. However, an element of realism is again entering the thinking of the geomorphologist. While, on the one hand, the physical geographer may find it sufficient to take for granted what may lie beneath the surface and how it came to be there, the geomorphologist cannot afford to do so any longer. There is a parallel here in the substitution of organic evolution for the pre-Darwin belief in an instant 'creation' of life. Geomorphology, perhaps because it is basic to the study of environment as a branch of geography, has tended to separate itself from the earth science disciplines. Professor Ollier has had a broad experience in a number of tectonic, geographic and climatic environments, and although his approach is geographical, he has produced a text which will go a long way in making good this gap in the knowledge of the geomorphologist. He attempts to 'marry' the two disciplines. In his introduction, he is concerned to emphasize the fundamental importance of the geological time-scale on the one hand, and, on the other, to point out that a scale of magnitude exists for geomorphic features. In this book the tectonic features discussed are those of first- and second-order size, but most geomorphology deals with only second- and third-order features. This could suggest that third-order tectonic landforms are of only subordinate importance, but in a later chapter, tectonic landforms are given the recognition which, in the eyes of many geologists, they deserve.

The importance of distinguishing in the field between tectonic and structural landforms should have been given greater emphasis. There are two reasons for this. Tectonic landforms are generally those initially formed endogenetically. Any superficial subsequent modification is by exogenetic process. Structural landforms, on the other hand, are erosional, exhumed by exogenetic agents from the solid earth, that is the surface expression of buried structures in rocks of differing resistance to denudation. Eventually the distinction is blurred (e.g. an eroded fault scarp can become indistinguishable from an erosion scarp).

Ollier defines (p. 2) 'tectonics' as "concerned with the form, pattern and evolution of the global major features, such as mountain ranges, plateaus, fold belts and island arcs". Whereas he believes that "structural geology concerns smaller structures such as anticlines, faults and joints". These definitions are surely unacceptable because they imply that tectonic means 'large' and structural means 'small'.

The chapter on continental drift and sea-floor spreading states the traditionally accepted views but makes some criticisms and asks awkward questions about fit and subduction which tend to make the plate-tectonician uneasy. Alternative restorations, especially of the southern and eastern hemisphere, are briefly described. Alternative hypotheses and detailed criticism is dealt with in a late chapter. His description of a transform fault, which somehow became separated from the later section on faults, is misleading, but most texts repeat the same fallacy. In Fig. 2.11 it is not made clear that the relative movement on the extensions of the fracture beyond the separated parts of the spreading axis is nil and is better described by the term 'scar'. The active transform fault is only that part which lies between separated parts of the axis. Why is the term 'transverse' fault introduced? One is inclined to ask—transverse to what? The unambiguous term 'wrench' for 'strike-slip' is not mentioned.

There follows an excellent brief description of layering within the earth. This could perhaps more usefully have preceded the chapter on

continental drift. Gravity and isostasy have a special importance in geomorphology, and these are discussed, rather beyond what is generally considered adequate for the geomorphologist. The chapter on plate tectonics, repeats in greater detail what has already been described. The difficulty in accepting the orthodox views in their entirety is not minimized. The complexities of volcanic injection and extrusion along the spreading 'sites', and comparison of these with 'hot spots', are barely touched on. The perpetuation of the term 'Andes type' for simple subduction is inconsistent with the views of Gansser, Katz and others referred to in a later chapter. However, the different classes of collision are well described. As is appropriate, the possible mechanisms for plate movement are only listed and not discussed. The geophysicists are almost as much at a loss for a consensus on this subject as they once were reluctant to accept continental drift as expounded by the geologist.

There follow excellent accounts of continental structures (shields and cratons, fold belts, rift valleys, triple junctions and aulacogens). The concepts of Carey on deformation in plan are given special attention as a prelude to a later chapter on the expanding earth theory.

Volcanoes and their associated landforms are briefly described. Such landforms are anomalous in relation to other landscape forms. They are undoubtedly primarily tectonic and endogenetic but owe their form to exogenetic constructional and degradational processes. They are as much tectonic in nature as, say, a volcanic plug intruded into a normal landscape.

Landslides, a product of gravity, are geomorphic features, and can hardly be classed as tectonic. However a question remains—at what scale are we to accept that movement under gravity becomes tectonic. This question arises from the author's later discussion of mountain building. Ice, rock and salt flow, acting either directly or indirectly under gravity, are discussed and this leads to the subject of rheidity.

The previous four chapters deal with subjects away from the theme of tectonics. There is a return to the main stream of geomorphology with a description and discussion of planation surfaces, a term carefully selected because it is non-committal with regard to origin. Ollier implies that the anti-Davis outlook, which in its extreme form denied the existence of terminal planation surfaces cut to base level, has been held most strongly by those who probably have never seen a planation surface (e.g. that in central Tanzania between the Eastern and Western Rift systems). Ollier deals adequately with planation surfaces, evidence for their presence now or in the past, their dating, and their subsequent disturbance by warping or faulting. He goes on to a study of topography as it is affected by structures revealed by lowering of the land surface, that is, structural landforms. He moves on, without a proper introduction, to tectonic landforms, the result of contemporaneous tectonism: surface warping, faulting and combinations of both. He gives examples from Australia and eastern Africa of disturbances of drainage patterns and ponding. He brings up the case of big rivers, a neglected subject, and stresses their importance as distinct second-order landforms, their morphological-tectonic relationship still a subject for investigation.

Geosynclines and the geosynclinal concept are dealt with at some length. The traditional pairing of miogeosyncline with eugeosyncline is critically discussed. Implications from plate tectonics and the classification of geosynclines based on the nature of associated plate boundaries are described. The nature and sources of infilling sediments for each type are important as are folding, metamorphism at depth, and igneous intrusion. Trenches associated with island arcs, which are the traditional sites of subduction zones, and the discovery of features indicating tension—faults and unfolded sediments—are considered in relation to current theory. The unresolved problems which these observations pose necessitate fresh examination. This must involve the study of subduction, associated vulcanism, and plate boundaries in general, their gravity and seismicity patterns, sedimentation and metamorphism. Hypotheses alternative to subduction are described and examples, mostly from the western Pacific, are used to illustrate Ollier's ideas.

The ocean floor (deep-sea and continental-margin) have component 'landforms' among which tectonic forms predominate. This is not brought out in the otherwise very useful tables and descriptions. Coasts

are classified and related, in tectonic terms, to continental (plate) margins, whether 'collisional' or 'trailing-edge'. Sea-level changes in recent geologic times, can be related to ice-cap growth and decline, and to tectonic causes for eustasy in earlier times. Discussion of the latter is of particular interest, involving changes in the shape of the ocean floor and hence the volume of oceanic waters.

Crustal movement as related to erosion of the land and deposition is described in terms of vertical tectonics. As in the case of most subjects the author gives only enough for the purposes of his argument, but nevertheless encourages the reader to read more widely.

There follows a short but stimulating chapter on the expanding earth hypothesis, well-documented with modern references. Earlier, Ollier mentioned unresolved inconsistencies in what has virtually become the orthodoxy of plate-tectonic theory. The four possibilities in global tectonics are a contracting earth, a steady-state earth, a steady-state earth with plate motion, and an expanding earth. For the expanding-earth model Ollier marshals fourteen items of evidence, some negative in relation to current plate-tectonic theory, and some positive. He does not specifically state, but appears to assume, that a degree of accommodation occurs so that there are relative movements of continents. These need not be simply along great circles, but also obliquely to the separating spreading sites, suggesting subcrustal transport. Possible causes of expansion are suggested, but, as was the case in the continental drift argument, the absence of knowledge of a mechanism can be overridden by evidence that it actually happens. An argument not included by Ollier is that the necessity to supply a mechanism for plate motion (e.g. convection cells, gravity slide, etc.) as listed in an earlier chapter, is automatically reduced or virtually eliminated if expansion is accepted.

The formation of mountains and plateaus is then discussed. The difficulty of the earlier hypotheses involving lateral compression, the tectogene, which belonged to the shrinking earth model, are described. Pinch-folding, related to an expanding earth, raises problems: the mountains are in the wrong place on the continents. Plate tectonics, virtually involving only horizontal movement, and continental collisions can be seen as a cause only in some cases. Ollier is inclined to favour vertical tectonics as the chief mechanism for mountain building and this naturally involves gravity and isostasy. Plateaus and mountains he regards as fundamentally the same in origin, with only mountainous regions suffering faulting during elevation. Presumably rift valleys are to be classed with mountains. Cymatogeny, or arching, to produce plateaus, has been suggested by King. The undation hypotheses of Van Bemmelen are mentioned. Resurgent tectonics, involving reactivation of old faults following earlier folding, uplift and planation, is favoured for older continental regions. The Alps, the Himalayas, the eastern highlands of Australia, the Andes, the Appalachians, and western North America are described, and their characters and genesis discussed in modern terms. It appears that no one model for their origin need be accepted.

The final chapter is in a sense an epitome of the conclusions reached. It has to be borne in mind that this book is intended primarily for the convenience of those geomorphologists who have come to realise that geology has moved forward. This book brings them up-to-date and in line with current thinking on tectonics and structural geology. Ollier emphasises that present-day landforms can have had a much longer history than recent approaches have assumed. As he suggests (and this, also applies in petrology and stratigraphy) the venue of the early development and education of an earth scientist colours his subsequent thinking (and his prejudices). A geomorphologist from a continental interior might be astonished at the over-emphasis given to the study of slopes. The book is also for the geologist who should appreciate that geomorphology is not 'concerned only with a little bit of sculpturing on top of the geological column'.

Geomorphology must be seen as 'on the same time-scale as continental drift, plate tectonics and biological evolution'. A useful summary and comparison, 'paradigms of geomorphology', concludes the volume. Active process studies, climatic and dynamic geomorphology are all to be regarded as having their limited applications. The cyclical theories of Davis, Penck, King and others are given due honour. The limitations in the application of the principle of uniformitarianism is emphasized. From these considerations the author has arrived at the acceptance of evolutionary geomorphology. 'The earth's landscapes as a whole are evolving through time', paralleling the evolution of the earth. Ollier is apparently most concerned that not only landscapes, but also the processes which sculpture or build them, evolve with time, so that no static concept has any permanent place in geomorphology and tectonics.

For some of those coming with fresh minds to the subjects discussed in this book, the dispersal of discussion and controversy, on, say, plate tectonics, among a number of chapters may be a disadvantage. In this regard consolidation could have generally increased the quality. In

another sense this volume can also be criticised as being too much a collection of essays with too many breaks in continuity. This, however, does not detract significantly from the appreciation with which this first edition of this volume will be welcomed. Its appearance is most timely.

The book is well-designed and produced, has an ample and well-chosen list of references, diagrams which amplify the text, and an adequate index. It is eminently readable. The reasonable price makes its acquisition possible to the advanced student. It will consolidate his knowledge and can give him leads for further study. In addition it can be a valuable source book for an earth scientist.

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Continental Margins

Boillot, G. 1981. *Geology of the Continental Margins*. Translated by A. Scarth, Longman, New York. 115 pp. 86 figs. Price: softcover £4.95.

An interface creates instability which causes activity. The boundary between continental and oceanic crust is a zone of concentrated geological activity of all types. The great bulk of the world's sedimentation, much of its magmatic, deformational and metamorphic activity, and most of its currently exploited oil and mineral reserves, are located along or close to continental margins. Yet it is difficult for an undergraduate to get a clear picture of how continental margins form or evolve, and how their varied geological processes relate to one another. Specialist texts cannot present an integrated picture; and modern introductory geology texts deal with continental margins in the context of plate theory, and gloss over the dirty details that smudge the clean tectonic lines. There are now several ponderous symposium volumes dealing with continental margins: a wealth of information, yet few students (or anyone else for that matter) have the time thoroughly to fish their turgid depths. There is a clear need for concisely written text dealing with continental margins at an advanced undergraduate level, and this book fulfils that need.

Professor Boillot is Professor of Geology at the Université Pierre et Marie Curie in Paris, and is an experienced marine geologist. The book was originally published in French by Masson in 1978, and has been translated into excellent idiomatic English by Alwyn Scarth. As Boillot writes in his Foreword, a textbook on a topic where there is so much current research activity is in danger of being outdated almost before it appears in print. Remarkably, in view of its original publication date, this has not yet happened: Professor Boillot has a keen sense of the direction of current thinking. Most references are to papers published in the seventies; and a surprising number are from 1978 and 1979: these were presumably added to the English edition.

The other problem in writing a book on this topic is to know how much geological knowledge to assume on the part of the students. There are some inconsistencies here, but most of this book could be read without much difficulty by an undergraduate with a year of full-time geology education.

The book is divided into six chapters: an introduction, two chapters on passive margins, two on active margins, and one on collisional orogenic belts. Each chapter is headed by a pleasingly written narrative summary, and is divided into numbered sections which are listed in the contents. The Introduction provides a general description of the ocean basins, the structure of the crust and upper mantle, and a brief outline of plate theory. Much of this is concisely written and provides a useful summary, but most students using this book will already be familiar with the more elaborate and lavishly illustrated expositions of plate theory that are now standard in Introductory Geology texts. The paragraph on the continental crust emphasizes the now outdated concept of a 'granitic' and a 'basaltic' layer separated by a seismic discontinuity, and reproduces the continental crustal sections from the 1965 edition of Holmes' *Principles of Physical Geology*. These paragraphs need updating: Holmes showed 50 km-thick crust beneath the Great Basin of the western U.S.A., but it has been reinterpreted by Scholz *et al.* (1971) as 25 km-thick continental crust underlain by anomalously low density mantle. In this chapter, Boillot introduces the interesting possibility that the uppermost subcontinental mantle may be serpentinized, which, for example, provides a possible mechanism for crust-mantle decoupling during collisional orogeny.

Boillot's second chapter deals with the principal causes of subsidence along continental margins, and explains the effects of rifting, thermal cooling, and sediment loading. He includes a discussion of the effect of the elastic response of the lithosphere to loading: a broad downwarp flanked by arches. He does not, however, mention the effect of post-rift