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 overidden 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 isostacy. 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.

A. M. Quennell

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

cooling on the elastic thickness of the lithosphere, which should cause the downwarp and peripheral arches to broaden with time. Boillot also discusses the more controversial possibility that extension and thinning along continental margins can occur soon after continental rifting, by gravitational spreading of the still hot and relatively ductile continental crust towards the ocean basin. He does not, however, mention an important predictive test of this hypothesis: if it does occur, there should be a corresponding zone of compression (thrusting?) in the oceanic crust under the continental rise. Such a zone is not apparent in seismic sections across continental margins, but recent data from the NW European margin (Avedik *et al.* 1981) suggest that there are considerable difficulties in reconciling the structure of the upper crust with the amounts of extension required to thin the crustal section as a whole. A possible explanation is that the normal faults seen in seismic sections are growth faults, with considerably greater displacements at depth than near the surface. This, of course implies slow and prolonged extension: not the instantaneous stretch envisaged by McKenzie (1978). Incidently, Boillot does not explicitly discuss growth faults in this book, although they are implicit in his figures.

In Chapter, 3 Boillot elaborates on the sedimentary and structural evolution of rifted margins, including discussion of the successive stages in the evolution of a rift zone into an ocean basin. He also has an overly brief section on strike–slip margins, which he explains as oblique transforms forming along rifted margins. This seems to ignore the realities of major strike–slip margins such as those of western North America, where ridge–trench intersections and migrating triple junctions are involved.

Chapter 4 deals with the morphology and structure of active margins, and is a useful and up-to-date account. I found the section on the evolution of marginal basins a bit too brief to be clear to students. The sections on the back-arc structures in Cordilleran type margins are inevitably somewhat speculative, and there is a danger that students may take the 'models' too literally. One or two real cross-sections of Cordilleran margins would have been valuable here.

In Chapter 5, Boillot discusses the magmatic and metamorphic characteristics of active margins. He presents the essential magmatic information clearly, and wisely avoids dwelling on the increasingly inconclusive geochemical discussions of their origin. The section on metamorphism begins well, but is marred by his unwillingness to accept the real implications of blueschist facies metamorphism. He presents the data from experimental petrology, but suggests on p. 93 that blueschists can form at around 15 km depth. On p. 97 he reduces this to *less than 10 km.* This is unacceptable: not only does it make the distinction between metamorphic baric types meaningless; but if true, it would mean that most low-grade metamorphic domains and slate belts, and many of the deeper sedimentary basins, should show blueschist facies mineral assemblages.

In Chapter 6, Boillot discusses collisional orogeny. I found this chapter the least effective: the writing and organization become confused and haphazard, and a student would be unable to gain any idea of the structure of real collisional orogens. Much of the chapter concerns a comparison between Aubouin's (1965) geosynclinal theory and current ideas on the structure of continental margins. This is of considerable interest from a historical viewpoint, but is probably confusing for students being educated 15 years after the onset of plate-theory.

Some general comments. There are few documented examples, and those that are given are not always representative: the submarine canyons of the French Mediterranean margin, for example. When discussing gravity data, Boillot fails to distinguish between free-air, isostatic, and Bouguer anomalies. This confuses several discussions (pp. 9–10, 21, 65–66, and fig. 4.10). Many of the figures are reproduced with little modification from the literature and lack scales (e.g. figs. 1.5, 3.9 and 5.1), orientation (figs. 4.6, 4.7 and 4.8) or adequate explanation in the legend (figs. 4.4, 4.7, 4.8, 5.2 and 5.8). Problems with idiom and terminology are surprisingly rare, in view of the range of subjects covered, and the problems of translation. Some quibbles: 'friction (shearing)' presumably means strike–slip or transform on p. 12. On p. 16, 'more viscous' should be less viscous, or more ductile. Note 2 on p. 35 probably contains a misprint. 'Pitching' on p. 73 apparently refers to the direction of thrusting.

In summary, this is a remarkably useful text, summarizing an amazing amount of up-to-date information on continental margins at a level suitable for second-year undergraduates. At £4.95, it is priced within the reach of the most impecunious undergraduate: no small matter in these days of symposium volumes at ten times this price. Some parts are inevitably better than others: Boillot is at his best on passive margins, and where he is summarizing well established morphological and geophysical data. Scattered inadequacies in text and figures will, I hope, be eliminated in future editions.

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J. P. Platt

Thrust and Nappe Tectonics

McClay, K. R. & Price, N. J. (editors) 1981. *Thrust and Nappe Tectonics.* Special Publication No. 9, Geological Society of London. Blackwell Scientific Publications, Oxford. 539 pp. Price:

This report of a three-day conference on the subject of thrust and nappe tectonics, held at Imperial College, London, in April 1979, fixes in book form most of the papers read on that occasion. Much of the material is available, however, in a well-stocked library. Publication for those without access to such a library should be in a cheaper form than this hard-back book. It is surely true, but irrelevant I suppose, that a more comprehensive text could have been written by the same authors had the articles been designed to complement one another.

However, in spite of the unsurprising lack of coherence the collection is of considerable interest to anyone concerned with understanding thrust fault regimes. Some of the articles, notably that by Ramsay on the Helvetic Nappes as well as those by Price, Thompson, Brown & Hatcher should make useful reading for senior undergraduates in addition to more experienced geologists seeking an up-to-date review of thrust regions with which they are themselves unfamiliar. A companion review in the North American section (Brewer, Cook, Brown, Oliver, Kaufman & Albaugh) provides an introduction to continent-scale reflection profiling. In a way it is surprising that the North American regional descriptions are at the end of the book. Because modern views on foreland thrusting depend on a knowledge of Rocky Mountain and Appalachian structure, there was a good reason to put them first amongst the regional descriptions.

There are some useful points made in the four-page introduction provided by the editors as a commentary to the whole book. It is interesting, as they say, that the works of Hubbert are referred to relatively little. In fact they are listed after only four papers (there is a subject index but no author index). It is my guess that it is the theoretical works of Elliott (1976 a, b) to which most reference is made (cited 23 times in 20 articles), followed by those of Dahlstrom (1969, 1970 cited 15 times in 14 papers). It would be difficult to better a close study of these four papers together with another (Elliot & Johnson 1980), which was in press while the book was being prepared, as a basis for understanding foreland thrusting. I do not think that this book can compete successfully with them.

The two-page record of a discussion of the meaning of the word thrust and other terms, put together by one of the editors, is less satisfactory. While a thrust fault is defined as a map-scale contraction fault (dip irrelevant to definition), a contraction fault is allowed to shorten an arbitrary datum plane (again no attitude specified). Yet an Andersonian normal fault qualifies as it shortens a vertical datum plane. A 'duplex' is a thrust sheet (mass) which is bounded by a 'floor' thrust and a 'roof thrust', seeming to imply that all thrust sheets, except those carrying the earth's surface must qualify. "*Often* duplex structures are imbricated" (my italics) yet imbrication seems to me to be inherent in their construction. Certainly, no imbrication exists at the start, merely a ramp (Elliott & Johnson 1980, fig. 3). But then does a duplex exist until successively new ramps develop through the carriage under the upper thrust sheet of the detached fragments or imbricates? Or do I misunderstand the terminology or the definition?

The paper by Bally, in the section on the Mechanics of Thrusting, emphasising the importance of the limited degree of subduction of continental crust that he argues has taken place, is in the welcome form of an essay. So also is that of Smith on a possible link between foreland