

perhaps the author comes down too heavily against the operation of plate tectonics at these early stages in Earth history. The evidence here, particularly from palaeomagnetic data, is not yet sufficiently conclusive for plate mechanisms to be dismissed as a factor in the accumulation of the early crust. Again the concept of allochthonous terranes, with the possibility of large-scale transcurrent faulting, both during and after accretion, provides further degrees of freedom in the interpretation of the early mobile belts. Archaean orogenic belts will need to be reexamined in the light of this new model.

Each chapter is followed by a list of statements summarising its contents and a list of suggestions for further reading. A detailed reference list is given at the end of the book, followed by a comprehensive index. The text is profusely illustrated with line drawings throughout and the volume includes a large, coloured tectonic map of the world, suitable for the lecture room.

In spite of its comprehensive coverage and its excellent presentation, the main impression left after reading Condie's book is one of disappointment. The author fails to convey the sense of excitement which motivates most research workers as the developing concept of plate tectonics, with its many variations on a few simple themes, provides more and more convincing models to explain the complexity of orogenic belts, and permits the formulation of more coherent theories of crustal evolution. The author's view of plate tectonics, derived from a geochemical, rather than a structural or deformational standpoint, appears to be essentially static. Plate tectonics is a dynamic process describing events which are in progress at the present day. Potentially, from the evidence which it provides of the present interactions of crustal plates, we can deduce the processes by which one crustal type is altered into another, and can extrapolate these processes backwards through time to account for the present composition and structure of the whole of the Earth's crust.

Despite these reservations Condie's book clearly fulfills a need, and the success of the first edition has encouraged the publishers to improve the presentation of the second edition. No longer is it presented as camera-ready copy; line drawings are placed at appropriate positions in the text, rather than gathered together at the end of each chapter, and the author has been encouraged to carry out a thorough revision of his text with the introduction of much new material and updating of his references. Comprehensive coverage, attractive presentation and moderate price will surely commend this book to all students of the Earth Sciences.

A. J. Barber  
N. Breen

#### REFERENCES

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Scotese, C. R., Kambach, R. K., Barton, C., van der Voo, R. & Ziegler, A. M. 1979. Palaeozoic base maps. *J. Geol.* **87**, 217–277.

#### Geophysics, then and now

Bates, C. C., Gaskell, T. F. & Rice, R. B. 1982. *Geophysics in the Affairs of Man*—A personalised history of exploration geophysics and its allied sciences of seismology and oceanography. Pergamon Press, Oxford. 492 pp. Price: hardcover £30.00; softcover £12.30.

When I first picked up this book my initial impression was that I would be bored by page twenty and would have little inclination to read on through the next 400 pages. The book has a dull look about it. The cover is dull and the pages are cluttered with footnotes and quotations, all in very small print. The illustrations are mainly grouped into six sets of postage-stamp size photographs distributed at intervals throughout the book, unreferenced to the text, of generally poor quality and often of doubtful relevance. For example, in the group of illustrations between pages 286 and 287, the pages of photographs are not numbered, a diagram showing the evolution of sensors for underwater warfare was obviously prepared for publication at two to three times the size printed here and is for the most part quite illegible. Also in terms of relevance to the text (in the same group of photographs), who is Linda Benedict, Junior Surveyor on Seismic Party 1741 of Geophysical Service, Inc. and what is the happy snap of her at work outside Evanston doing on the same page as passport portraits of John Slaughter (Director, NSF), Manik Talwani (Second Director, Lamont-Doherty) and Bettye Athanasiou (Life Member SEG)?

However, despite its many shortcomings in presentation, much of this book makes interesting and entertaining reading. It contains a wealth of information concerning events which have happened within the lifetimes of the authors. Much of what they write must be in part based on first-hand experience and familiarity with the circumstances of events as well as the people involved. This account of the birth and development of modern geophysics during the past few decades is admittedly personalised but much of its merit derives from the way in which the authors succeed in telling their story as from the view-point of an insider, someone directly involved in the events that occurred.

The book commences with a very brief description of how the science and technology of geophysics developed from earliest recorded knowledge until the end of the First World War. The inter-war years are seen as 'geophysics coming of age'. Then follows a chapter on how many well-known and eminent geophysicists spent the war years. Interesting though this chapter is, there is little evidence for much advancement in conventional geophysics during this period; seismology and oceanography were given more attention. Immediately post-war, exploration geophysics became again a field of active research and renewed application in the search for hydrocarbons and minerals. Over the same period, the foundations were laid for major international cooperation in such enterprises as the International Geophysical Year (1 July 1957 to 31 December 1958). The 1960s are seen as a period of significant interplay between science and government and of course the beginnings of revolution with development of plate-tectonic theory. The final historical chapter covers the 1970s and early 1980s, a period of boom in exploration geophysics following great technical advances in seismic exploration technology. At the same time, however, there were complex economic and political changes occurring with environmentalism on the one hand and OPEC on the other, radically influencing both governmental and corporate policy in resource exploitation.

The broad history having been covered, the authors then give a well-documented account of geophysics as a business with a detailed analysis of the pattern of growth of many of the major contracting companies so well known today to the practicing geophysicist. Finally, and again in a very personalised way, the realm of geophysics is given added perspective by introducing the views of a number of eminent contributors, either as short statements of actions in their careers which had given greatest personal satisfaction, or as a series of *vignettes*, such as that by W. Harry Mayne: 'Conception of the Common-Depth-Point (CDP) Method of Seismic Surveying'.

With so much good material within it the book must be judged as a successful enterprise. I know I will use it often for reference and as a source-book. I would have preferred it to be shorter, better illustrated and with less devotion to oceanography, which in my opinion is given more eminence than necessary as an allied science to geophysics. I warmly recommend it to all involved in geophysical research and exploration.

R. McQuillin

#### Inside information

Bolt, B. A. 1982. *Inside the Earth: Evidence from Earthquakes*. W. H. Freeman & Company, San Francisco. 191 pp., 75 figs. Price: hardcover £16.90; softcover £7.70.

In this book, Bruce Bolt throws light upon not only the obscurities of the Earth's internal form and composition, but also the mysteries of earthquake seismology, which can often appear as impenetrable as the Earth itself. To many, acronyms such as U.E.O. (unidentified earthquake onset) and the codes for seismic arrivals, such as PKiKP (a p-wave refracted through the Earth's outer core, reflected from the surface of the inner core and refracted back to the Earth's surface as a p-wave), serve only to increase the impenetrability of the subject, leaving them with the feeling that as long as there are a core and mantle down there somewhere, that is fine with them and the Earth. It is Bruce Bolt's intention to make the subject plain to readers whether they be students or 'curious laymen'. He has set himself the difficult task of explaining qualitatively, often by analogy, an essentially quantitative science. In this he generally succeeds admirably, but he finds it difficult in early chapters to avoid clumsiness in stepping around certain topics which are dealt with in later chapters or cannot be treated at length where they arise. Certain basic information about seismic theory and excerpts from important papers are presented in 'boxes' aside from the main text, which makes 'hem easy to refer to. Subjects are cross-referenced well, and the figures are clearly drawn and annotated.

The first chapter concerns itself with early ideas about the Earth's internal constitution and the discoveries of the early pioneers of earthquake seismology, such as Oldham, Milne, Gutenberg, Mohorovicic and Lehman. The last section of this chapter is a somewhat opaque explanation of how waves can be represented in the frequency domain.

Chapter 2 is a straightforward and clear account of the nature and properties of seismic waves, which anybody new to the subject should find to be very helpful.

In Chapter 3 the techniques and problems of observational seismology are outlined. Figure 3.4 provides an illustration of one of the main laws of observational seismology, i.e. that during or shortly before an important earthquake, the operator will switch off the recorder to change the paper or tape!

The main seismological divisions of the Earth into the crust, mantle, outer and inner core, are described in Chapter 4, together with short accounts of the internal structures of the Moon and Mars. The finer scale structure of the Earth is dealt with in Chapter 5, which makes very interesting reading especially in the accounts given of different investigations, and the action of their sometimes conflicting results upon current theories and subsequent studies.

Chapter 6 covers a topic of which, in my experience, many geologists are completely unaware. That is the study of free oscillations of the Earth generated by large earthquakes. Here, in relatively few pages, is a clear description of what they are, how they are studied, and what information they yield about the Earth's internal structure and anelasticity.

In Chapter 7 are summarised the various strands of evidence relating to the physical properties of the rocks forming the different parts of the Earth's interior and the temperature distribution.

Fifty exercises in Chapter 8 provide a gentle test of the reader's understanding of the book, and prompt questions about the material that otherwise might not come to mind.

If a succinct description of the Earth's internal structure and composition is required, then this book is worth reading, but that is not the book's main strength. The most absorbing aspect of the book is Bruce Bolt's account of *how* the Earth's interior has been explored, giving us the inside information on seismology and seismologists.

G. Westbrook

### Metamorphic processes

Gillen, C. 1982. *Metamorphic Geology: An Introduction to Tectonic and Metamorphic Processes*. George Allen & Unwin, Winchester, Maryland. 144 pp. Price: hardback £12.00; paperback £4.95.

Whereas volcanic and sedimentary rocks may be seen forming on the Earth's surface at the present day, understanding the origin of metamorphic rocks, formed deep in the crust and exhumed only after millions of years of erosion, is conceptually much more difficult for beginning students of geology. Dr. Gillen's elementary textbook on Metamorphic Geology, designed to accompany G.C.E. 'A' level or first-year University (or Open University) courses in geology for students without previous geological background, will therefore be welcomed by both teachers and students. The author presumes that the student will at the same time be taking courses in other aspects of geology and will have access to a limited number of hand specimens, and possibly thin sections, of metamorphic rocks.

The book gives an overall view of the scope and significance of metamorphic rocks and metamorphic processes from first principles. Chapter 1 introduces the subject matter of the book, outlining the mineral composition, texture and field relationships of metamorphic rocks. Chapter 2 reviews the factors controlling metamorphism, including the environmental conditions within the Earth's crust; heat, pressure, pore fluids and the effect of differential stress; and describes how these conditions influence metamorphic processes such as crystal growth, diffusion and recrystallisation and suggests the possible relationships between environmental conditions and major movements of the Earth's lithospheric plates. In Chapters 3 and 4 the various types of metamorphic terrain are described in terms of the contact, dynamic and regional metamorphic associations; many of the examples being taken from the classic metamorphic terrains of the Scottish Highlands. In Chapter 5 the author describes how these types of metamorphic environments may be generated at plate margins or in regions of continental collision. He goes on to consider how these

processes may have varied through geological time and how these variations have influenced the development of the Earth's crust. The critical question here is the extent to which it is reasonable to extend present plate-tectonic interpretations back into the Precambrian. In his final chapter (6), the author explains how textural evidence can be used to recognise phases of recrystallisation, mineral growth and deformation which affected the rock since its origin as an igneous or sedimentary rock, reflecting the environmental conditions through which the rock had passed to reach its present metamorphic state.

The book is liberally illustrated with line drawings, maps, diagrammatic cross-sections and half-tones of rock outcrops, hand specimens and thin sections of metamorphic rocks. A series of short exercises are added to the end of each chapter, and the volume concludes with a useful glossary of terms used in the study of metamorphism and metamorphic rocks, suggestions for further reading and a list of excursion guides to areas of metamorphic interest in the British Isles. There is also a comprehensive index.

While the book is to be welcomed, it has some important deficiencies. The author has a staccato prose style and this, together with the printing of frequent keywords in bold type, detracts from the fluency of the text. The author frequently expresses his concern that the student should not be burdened with a plethora of new names and new concepts. This concern goes too far when important metamorphic minerals like glaucophane, prehnite, pumpellyite, lawsonite and jadeite are described, but not named, leading to the absurdity that rocks containing these minerals on Ernst's (1971) map of metamorphic zonation in California (taken from Miyashiro 1973) are all shown in the key as 'zeolite-bearing'. Although the book has pretensions to be an up-to-date exposition of current concepts in metamorphism and tectonics, the reader can detect a residue of older concepts such as orogenic cycles and the oversimplified view that orogenic belts develop from sedimentary basins.

Unfortunately, the book also provides many examples of careless editing: several figures lack scales; a detailed account of the Lewisian rocks of Northwest Scotland has no accompanying map; adjacent maps illustrating the extent of rocks affected by the Hercynian orogeny show different distributions in North America; Archaean rocks are described as 'all' metamorphic on one page and 'mostly' metamorphic on the next. There are also several obtrusive typographic errors.

Despite these shortcomings, the book is wholly admirable in its conception with proper emphasis given to the quantitative dominance of metamorphic rocks in the Earth's crust and to the importance of metamorphic processes in the evolution of the crust throughout geological time, drawing attention to the economic significance of metamorphic rocks where this is appropriate.

This short volume provides a valuable introduction to the study of the processes and products of metamorphism in their tectonic context and will provide an adequate basis for more advanced studies. It may be anticipated that demand for a second edition will enable the author to improve on the presentation of the first.

A. J. Barber

### REFERENCES

- Ernst, W. G. 1971. Metamorphic zonations on presumably subducted lithospheric plates from Japan, California and the Alps. *Contr. Miner. Petrol.* **34**, 43–59.  
Miyashiro, A. 1973. *Metamorphism and Metamorphic Belts*, Allen & Unwin, London.

### Maps and structures

- Roberts, J. L. 1982. *Introduction to Geological Maps and Structures*. Pergamon Press, Oxford. 325 pp. Price: hardcover £20.00, US \$40.00; flexicover £7.50, US \$15.00.

A characteristic which is probably common to all structural geologists is the ability to perceive geometries in three dimensions. However, not all geology students are intuitive in this respect and thus textbooks of structural geology and map interpretation have to emphasize the topic. The stated purpose of this new book is to bridge the gap between the two groups of texts by describing structures in general and then explaining how they may be recognised on geological maps.

The book is divided into eight chapters: an introduction, a chapter on sedimentary rocks and outcrop patterns, five chapters on structures and their effects on outcrop patterns, and a final chapter on structural features of cratons and orogenic belts.