

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.

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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.

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REFERENCES

- Ernst, W. G. 1971. Metamorphic zonation 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.