

BOOK REVIEWS

A structured approach to understanding rock deformation

Park, R. G. 1983. *Foundations of Structural Geology*. Blackie, Glasgow. 135 pp. Price: hardcover £16.95; limp £7.95.

There is no need for this review to be prolix: Graham Park has written a concise, balanced text that should satisfy the structural needs of most first- and second-year undergraduates. *Foundations of Structural Geology* is up-to-date, well-written and scholarly; sources of illustrations being cited and journal articles being recommended for additional reading.

The structure of the book is based on the philosophy that to make the subject meaningful to students who may have had little field experience, it is necessary to start by describing phenomena before considering relatively abstract topics such as deformation mechanisms and rheology. Wisely, Park excludes detailed discussion of sedimentary structures, map interpretation and stereographic techniques; subjects elaborated in other texts or laboratory manuals. The fifteen chapters are grouped in three parts: *Part 1 Morphology* (1) faults and fractures, (2) folds, (3) foliation, lineation and fabric, (4) igneous bodies; *Part 2 Deformation* (5) stress, (6) strain, (7) stress and strain in materials, (8) determination of strain in rocks, (9) faulting, (10) folding, (11) emplacement of igneous intrusions, (12) gravity-controlled structures; *Part 3 Geotectonics* (13) major earth structure, (14) plate tectonics, (15) geological structure and plate tectonics.

Inevitably, because the book is an elementary text, the topics selected for discussion are largely predictable, but Park's packaging of gravity-controlled structures in a single chapter should encourage the reader to consider how other structural associations, comprising a variety of elements, could be interpreted as being the products of a set of linked processes. Likewise, the final chapter 'Geological structure and plate tectonics' is rewarding because specific examples of well-known associations are considered in their broader tectonic settings.

On a purely personal level I was delighted that Park includes sets of closely spaced fractures with foliations and recognizes fracture cleavage as a variety of cleavage (p. 18). However, I am not confident that many structural geologists would agree with him. Park relates fault orientations to stress and strain axes, and for the examples illustrated (fig. 9.3), the equating of σ_1 with Z and σ_3 with X axes is reasonable because the amounts of displacement on the conjugate sets are the same. It would, however, have been worth noting that where displacements on the fault sets are unequal Z and X rotate away from σ_1 and σ_3 , respectively. The book contains only a few relatively trivial errors, some possibly introduced at the production stage: for example the half-tone in fig. 3.6B matches its caption but not the text description (p. 26 line 5), and τ is attributed to the wrong axis in fig. 5.4A, but the correct one in fig. 5.4B.

The format and appearance of *Foundations of Structural Geology* are generally pleasing, especially the clarity achieved by the use of two colours in many of the line drawings. I do not hesitate to recommend Park's book to students; at £7.95 for the limp edition it is good value, and, perhaps more importantly, they are more likely to read it than some more 'weighty' but less concise texts.

P. L. Hancock

Structural geology of the planet earth

Bott, Martin H. P. 1982. *The Interior of the Earth: its Structure, Constitution and Evolution* (second edition). Edward Arnold, London. 403 pp. Price: hardcover £25.00.

The first edition of this book was published in 1971 shortly after what is now known as the plate tectonic revolution had made its major impact on geological science. In the last decade many advances have been made in the application of plate tectonic theory to a wide variety of geological problems, particularly in the field of global tectonics. Progress has been made also towards a better understanding of the

processes which occur within the Earth which are the driving mechanism of plate motion. To take account of such recent advances, this second edition has been largely re-written with much revision and addition of new material including a new chapter on continental margins and island arcs. Some chapters, though substantially unaltered in terms of subject matter, have been given new titles, the reason for which is not immediately obvious. The order in which some topics are covered has been changed in places and in my opinion the result is a better structured book. For example, discussion of global tectonics and continental drift is integrated into Chapters 2 and 3 on continental and oceanic crust, instead of being relegated to a chapter near the end of the book. This strengthens the early chapters and leads to a more logical development of the main theme of the book, which throughout places strong emphasis on the interpretation of the solid Earth in terms of geological observations made at its surface and such deductions as can be made from geophysical measurements.

It is interesting to note that the title of this second edition has been extended by '... its structure, constitution and evolution'. The first edition was titled simply 'The Interior of the Earth'. This change does not appear to reflect any real difference in content but does give the prospective reader a better indication of the scope of the text.

It commences with a chapter on the planetary structure of the Earth, its relationship with the Moon and planets of the solar system, and even extending to a brief account of currently held views on the origin of the universe. Then follow two chapters on crustal structure; continental and oceanic. When describing the continental crust, the author is very much at work in his own parish. Many of the examples of structural interpretation and illustrations are derived from papers he has written or co-authored. However, the danger of parochialism is judiciously avoided as locally studied structure is used only to elucidate the wider concepts under discussion. The chapter leads through to an interpretation of the composition and structure of the continental crust down to the *Moho* and concludes with continental drift and the origin of the continental crust. The composition of the oceanic crust is described as deduced from results of both geophysical investigations and DSDP drilling. Ideas on sea-floor spreading are developed via the Vine-Matthews hypothesis leading to establishment of a geomagnetic time scale dating the oceanic sea-floor. Ocean ridges, the origin of the oceanic crust and the nature of fracture zones and transform faults are treated in turn before a rather brief exposition on plate tectonics. As the literature abounds with lengthy expositions on plate tectonics, I regard the author's self restraint here most laudable.

Chapter 4 on the mantle removes the geologist reader some distance from the familiar ground of observable rocks and Earth surface geological processes, but the subject has particular relevance to an appreciation of global tectonics in general and the nature of continental margins and island arcs in particular, as described in Chapter 5. This new chapter, though only 28 pages long gives a very comprehensive account of the nature of passive and active margins, island arcs, subduction zones and marginal basins. Included here also are short sections on microcontinents and sedimentary basins of the continental interior, these being described as subsidence features akin to those which occur at passive margins. Recent ideas on the formation of such basins (Sleep & Snell 1976, McKenzie 1978) are mentioned but without critical analysis other than to say 'They still remain controversial...'. A fuller account of these controversial ideas would surely have been included had their present impact been appreciated at the time this book was written.

Chapters 6 and 7 on the core and on terrestrial heat flow are not, as one might expect, loaded with mathematical treatment of the essentially geophysical subject matter. Evidence on the structure of the core is clearly presented and it is in this chapter that the origin of the Earth's magnetic field is discussed as well as its history in the geological past. In his introduction to the chapter on heat-flow the author states 'The study of thermal processes within the Earth is one of the most speculative branches of geophysics'. However, it is equally important to appreciate as he states later 'The subject is a particularly important one because the process of heat escape from the Earth is probably the cause, directly or indirectly, of most tectonic, metamorphic and igneous activity'. The chapter treats the subject fully and is particularly valuable in its review of much that has been published over the last few years on heat flow experiments and the mechanism of heat escape through the lithosphere.

The penultimate chapter is titled 'Rheology of the crust and mantle' compared with 'Fracture and flow in the crust and mantle' in the first edition. The original title more accurately describes the chapter's contents in that fracture as well as flow mechanisms are described in the new edition, including a section on brittle deformation. The main theme, however, is deformation of the lithosphere by creep mechanisms and flexure. Stress release by fracture and energy release through earthquakes is described and finally there is a short section on the viscosity of the mantle.

As a conclusion to this book, the author gives us a well-balanced review of current ideas on the mechanism of global tectonics. The historical development of various hypotheses are all included; contracting Earth, expanding Earth, the convection hypothesis, hypotheses dealing with the mechanisms of plate motions and continental splitting.

How accessible is this predominantly geophysical treatise to geologists with an interest in solid Earth processes and structural mechanisms but whose background is not strongly mathematics or physics orientated? The author set out to capture such an audience and in my opinion has succeeded even if at times he assumes a detailed understanding of geophysical techniques for the fullest appreciation of results being quoted. As a reference book it is likely to be valuable to the majority of working geologists and geophysicists. It is well illustrated and clearly written with a comprehensive reference list appended for each chapter.

R. McQuillin

REFERENCES

- McKenzie, D. 1978. Some remarks on the development of sedimentary basins. *Earth Planet. Sci. Lett.* **40**, 25–32.
 Sleep, N. H. & Snell, N. S. 1976. Thermal contraction and flexure of mid-Continent and Atlantic marginal basins. *Geophys. J. R. astr. Soc.* **45**, 125–154.

Volcanic reading

Decker, R. & Decker, B. (editors and introductory passages) 1981. *Volcanoes and the Earth's Interior* (Readings from *Scientific American*). W. H. Freeman and Co., San Francisco. 141 pp. Price: hardcover £14.95; softcover £6.95.

This 141-page volume is a further collection of general review articles previously published in *Scientific American*, following a related theme. There are 10 articles of which the oldest was published in 1975 and the youngest in 1982.

I. *Volcanoes and Plate Tectonics*.

- (1) M. N. Toksöz. The Subduction of the Lithosphere (1975).
- (2) K. C. Macdonald & B. P. Luyendyk. The Crest of the East Pacific Rise (1981).
- (3) K. C. Burke & J. Tuzo Wilson. Hot Spots on the Earth's Surface (1976).

II. *Volcanic Products: Lava, Ash and Bombs*.

- (4) D. L. Peck, T. L. Wright & R. W. Decker. The Lava Lakes of Kilauea (1979).
- (5) L. R. Kittleman. Tephra (1979).
- (6) R. Decker & B. Decker. The Eruptions of Mount St. Helens (1981).

III. *Volcanic Windows into the Earth's Interior*.

- (7) P. J. Wyllie. The Earth's Mantle (1975).
- (8) K. G. Cox. Kimberlite Pipes (1978).
- (9) R. K. O'Nions, P. J. Hamilton & N. M. Evensen. The Chemical Evolution of the Earth's Mantle (1980).
- (10) R. B. Smith & R. L. Christiansen. Yellowstone Park as a Window on the Earth's Interior (1980).

The title of the book provides the prospective reader with a good indication of the contents of this series of papers. The articles cover the products of volcanic activity, mantle process generating volcanic activity and the evidence from volcanism for mantle petrology and geochemical evolution. As there is a related theme between the articles, and each one was originally published in *Scientific American* as a stand-alone article, it is inevitable that there should be considerable repetition on basic features such as the outlines of plate tectonics or the controls of volcanism.

The first section 'Volcanoes and Plate Tectonics' contains three good articles, especially that by Macdonald & Luyendyk which describes a portion of the East Pacific Rise near the Gulf of California. This provides fascinating reading and links different scientific disciplines with the description of hydrothermal activity which reaches a

temperature of 350°C, carries sulphides and has associated with it an unusual biological community. This is followed by a clear description of geophysical evidence for magmatic activity just beneath the ridge crest. Burke & Tuzo Wilson's 'Hot Spot' article also provides interesting reading. However, some of the features described, such as the number and location of hot spots and their importance in the initial generation of a spreading ridge are not universally accepted. This perhaps highlights one of the failings of *Scientific American* reviews in that they are presented as factual accounts and areas of controversy or alternative arguments are not always highlighted.

The second section covers 'Volcanic Products' and includes an article by Peck, Wright & Decker on lava lakes. A well-documented account of lava solidification is provided for these unusual environments. An inevitable account of the Mt. St. Helens' eruption is included and covers ground that is available in other similar publications.

The final section includes an article by Wyllie on the 'Earth's Mantle'. This is the least innovative of the articles, and is largely a basic description of physical properties of the mantle and their interpretation which is standard material in many text books. Cox's article on kimberlites is based largely on mineralogical evidence while O'Nions, Hamilton & Evensen examine the evolution of mantle as determined from isotopic ratios. This article is a very clear and concise treatment of an involved subject. It is in contrast to some appalling terminology used by Smith & Christiansen in their article about the Yellowstone Park volcanics. This is evidenced in their description of the simple difference in SiO₂ content between rhyolite and basalt with the sentence 'Where more than 72 percent of the rhyolite consists of silicon dioxides only 50 percent of the basalt consists of them'. However, this is only a minor point as in general the articles are well written and at a level attractive to both professional and interested layman. One point that would improve presentation and understanding of the text would be the numbering of the diagrams and appropriate reference to these in the main text. It is annoying to read a section of text and then overleaf to find a diagram making that text so much easier to follow. Why *Scientific American* persists in this practice is difficult to understand.

In conclusion, therefore, this series contains well-written and presented articles that offer up-to-date interpretations and theories. It should prove a good, reasonably priced, investment for both the non-specialist and interested layman.

D. Robinson

Mammoth lakes: geological unrest

Rinehart, C. D. & Smith, W. C. 1982. *Earthquakes and Young Volcanoes along the Eastern Sierra Nevada at Mammoth Lakes 1980, Lone Pine 1872, Inyo and Mono Craters*. William Kaufman, Inc., Los Altos, California. 63 pp. Price: softcover £4.50.

This small book describes earthquake and volcanic activity along a 250-km length of the eastern fault boundary of the Sierra Nevada in California. It is a book that is written for the interested layman, with general descriptions of the 'Pacific Ring of Fire' and measurements of earthquake intensity using the Richter scale.

The major earthquakes in the region at Mammoth Lakes in 1980 and Lone Pine in 1872 are described in journalistic fashion and old newspaper illustrations and headlines are reproduced. The major attraction to the geologist will prove to be the excellent photographs of the fault lines, scarps and uplifts of the area.

The recent volcanic alert, issued by the U.S.G.S. for the Mammoth Lakes region, will have heightened geological interest in the area. The geological tourist would therefore find this book a useful purchase with its excellent photographs, maps and brief description of the volcanic geology. In general, however, there is little of interest to the average geologist, not visiting the area, to attract their attention.

D. Robinson

Splitting continents

Illies, J. H. (editor) 1981. *Mechanism of Graben Formation*. Elsevier, Amsterdam. 266 pp. Price: hardcover US \$65.75, DFL. 135.00.

J. Henning Illies, the editor of *Mechanism of Graben Formation* and the foremost authority on the Rhine graben, died in the summer of 1982 and thus sadly this volume must be his epitaph. Illies' short