With the exception of the quality of a few illustrations and a very few typographical errors, the book is well produced and edited. On the basis of the topics discussed in the first eight articles it is worthy of a place on the library shelves of geology departments, but remember it has appeared as Vol. 117, No. 6 of *Pageoph* if your institution subscribes to that periodical.

Whereas *Earthquake Prediction and Seismicity Patterns* is a collection of original research papers *Earthquakes and Volcanoes* is a book intended for earth science students or scientists from other disciplines. In common with other books in the series 'Readings from Scientific American', *Earthquakes and Volcanoes* is a selection of offprints held together by introductory linking passages, in this instance by Bruce Bolt. The book comprises 154 pages, the majority of them containing one or more illustrations (some in colour), and all of them of the customary high standard maintained by *Scientific American*. The clarity of the writing is so uniformly excellent that I can only assume that professional subeditors are involved in the production of each article.

The book contains eleven short articles divided into three sections (dates of original publication in parentheses).

I. *Earthquake Properties*

1. D. M. Boore, 'The motion of the ground in earthquakes' (1977).
2. F. Press, 'Resonant vibrations of the Earth' (1965).
3. F. Press, 'Earthquake prediction' (1975).
4. D. L. Anderson, 'The San Andreas Fault' (1971).

II. *Earthquakes and Earth Structure*

5. P. Molnar and P. Tapponnier, 'The collision between India and Eurasia' (1977).
6. B. A. Bolt, 'The fine structure of the earth's interior' (1973).
7. T. H. Jordan, 'The deep structure of the continents' (1979).

III. *Volcanoes and Heat Flow*

8. H. Williams, 'Volcanoes' (1951).
9. H. N. Pollack and D. S. Chapman, 'The flow of heat from the earth's interior' (1977).
10. M. N. Toksöz, 'The subduction of the lithosphere' (1975).
11. D. P. McKenzie and F. Richter, 'Convection currents in the earth's mantle' (1976).

In addition to all the articles having appeared in monthly issues of *Scientific American* some of them have also been included in previously published 'Readings' on other but related themes. Because the articles were originally published in a separate issue of the parent periodical the authors of each post-1968 paper were obliged to introduce the reader to the broad outlines of plate tectonics before passing to their special topics. Inevitably this has resulted in some repetition now that the papers have been collected together in a book. A few minor but irritating errors may be a consequence of over-hasty compilation when the articles were assembled for reprinting in book form. For example, in the extreme right-hand part of the figure on page 48 two points on the map are labelled D^1 and D^1 although in the caption they are referred to as D^1 and D. In addition B^1 and B which appear on the same map are not mentioned in the caption. In the table of subduction zones in Toksöz's article the page number of a related figure is given as 8, whereas in this collected edition it is 130. Jordan's otherwise excellent article is slightly marred by some barbarous jargon.

Perhaps the least satisfactory parts of the book are Bolt's introductions to the three sections. They are in the form of a series of questions posed by a hypothetical enquirer, and a series of answers largely derived from the following articles. Although the answers are admirably concise and up-to-date, the questions are somewhat contrived. They read more like examination questions than the type of query which an interested layman might ask of a seismologist.

On the basis of the authority of the contributors, the clarity of their accounts and the generally high standard of book production, I have no hesitation in recommending this modestly priced book to students and to scientists not involved with earthquake research.

P. L. Hancock

An Unconventional View of Cleavage Genesis

Davies, W. 1980. *On Slaty Cleavage and Structural Development in Lower Palaeozoic Wales.* University College of Wales, Department of Geology Publications, No. 8. 26 pp., 11 plates. Price: soft-cover £1.00 (free to libraries and persons known to be interested).

The series of publications from the Geology Department of the University College of Wales at Aberystwyth, commenced in 1972 with a long paper by Nancy Kirk on her then heretical views about graptolites, which at the time were unacceptable to the editors and referees of many journals. Davies' paper is the 8th publication in the series but the first on a structural topic; it is likely to be as controversial as its forerunners. Davies presents his own completely revolutionary ideas on the development of Wales during the Early Palaeozoic and integrates them with some novel notions on slaty cleavage genesis in Caledonian Wales. The author invites comments and questions from readers in the hope that their contributions will form the basis of a published discussion of his ideas.

In the first part of his paper Davies critically examines currently held views about the structure of Caledonian Wales and the value of the classical hypothesis of its geosynclinal evolution. He refers to the difference between observed and inferred thicknesses of Lower Palaeozoic successions, stating that whilst a thickness of at least 10000 m was suggested by O. T. Jones only 600 m can be observed at any one point. Thus he questions concepts based on what he believes was Jones' thickness over-estimate, and attempts to explain the evolution of an Early Palaeozoic basin containing no more than 1000 m of strata (excluding volcanic rocks). Unlike O. T. Jones, who attributed the low metamorphic grade of the rocks to burial during the Early Palaeozoic, Davies proposes that the metamorphism could be related to burial beneath between 2.5 and 5 km of Carboniferous, Triassic and Jurassic strata. This is where I believe the author introduces an inconsistent approach. Although he wishes to reduce the thickness of the Lower Palaeozoic succession to that which can be observed he is nevertheless content to postulate burial beneath successions for which there is no *direct* evidence of their ever having been deposited.

In place of the classical geosynclinal hypothesis and modern plate tectonic models for the sedimentary and deformational evolution of the basin, Davies suggests that the sediments were deposited in an intracratonic basin some 200–400 km wide with a palaeoslope of not more than 1°. He also proposes that the structures can be better explained by a general uplift of the Precambrian basement. It might have added to the author's argument if he had explained how he thinks the thick, dominantly andesitic and rhyolitic pile of the Snowdonia Volcanics came to be erupted in an intra-cratonic environment, since most other workers regard such volcanics as being characteristic of an island arc environment.

Davies continues his argument by analysing the geology of several subareas and proposes penecontemporaneous gravitational sliding of sediments, rather than orogenic deformation, as the origin of the Caledonian structures. He regards the structures as being the result of large-scale sheet sliding of sediments down basin slopes; folds and cleavage developing where the leading edge of the sliding mass came to a halt. In these circumstances, he argues, the attitudes and styles of the folds would depend on whether movement was checked in a severe (his word) or uneven manner. He postulates that cleavage formed in a stress field generated by the sliding and assisted by dewatering of the sediment pile. The wide variation in cleavage trend in North and Mid Wales he attributes to different directions of mass sliding. Davies also discusses the possible effect of the Snowdon Volcanics on cleavage attitude, and concludes that the weight of the volcanics forced the soft sediments concentrically outwards from beneath the volcanic pile.

In the second part of his paper Davies discusses a possible mechanism of slaty cleavage formation in Wales, again emphasising the role of soft sediment deformation. He describes the variety of cleavage styles and presents some comments on strain values as determined from deformed fossils and reduction spots. This section of the paper is well illustrated by stereopairs of scanning electron micrographs showing examples of cleavage textures in Welsh Lower Palaeozoic slates, and in a slate from the French Alps. Davies again concludes that deformation occurred before lithification and considers that his concepts could be applied outside Wales. However he does not tackle the problem of explaining the genesis of cleavage in some of the retrogressively metamorphosed minor intrusions which are referred to in the older literature as "greenstone schist" or "chlorite schist". It is difficult to envisage dewatering or soft sediment sliding as a significant mechanism of cleavage formation in these settings.

Judging from the quantity of papers published about the dewatering hypothesis, many, if not most, structural geologists, will disagree with Davies' conclusions. His interpretation of the Welsh Lower Palaeozoic sequence is also likely to meet with substantial opposition. Nevertheless both he and his department must be congratulated for their courage in

presenting and publishing such unorthodox views which deserve notice. Controversy, even if generated by ideas which are generally held to be incorrect, may lead to a worthwhile reappraisal of the observations. It is hoped that contributions will be made to the discussion publication since Davies has left quite a number of questions unanswered in his paper. I look forward to reading the discussion document.

D. E. Roberts

Using Explosions

Al-Sadi, H. N. 1979. *Seismic Exploration.* Birkhauser, Basel. 220 pp. Price: hard-cover sFr49, DM54, US $29.50.

Seismic techniques, in particular seismic reflection, have long been the major geophysical methods employed for subsurface structural exploration in the petroleum industry. In recent years the reflection method has become increasingly important in academic studies as new techniques, such as those used by COCORP in the United States, are employed to provide information on the structure of the lower continental crust, hitherto a complete unknown, with many surprising and interesting results.

H. N. Al-Sadi's book is a relatively short (220 pages) and comprehensive account of the techniques used in modern seismology, concentrating on the manipulation and processing of seismic waveforms. The first two chapters deal with the general theory of wave propagation and elastic waves, and are followed by two chapters on the mathematical analysis of waveforms and their manipulation in both time and frequency domains. The techniques of reflection and refraction surveying are then covered and the book concludes with a discussion of digital processing of seismic reflection data.

The coverage is soundly based in mathematics and all techniques are fully presented. Consequently this is not a book for casual reference since full knowledge of preceding chapters is necessary for the understanding of any specific points in later chapters. The book serves as an excellent text for advanced undergraduate and postgraduate students of geophysics. It is, however, a shame that the author does not provide more examples of the use of the techniques he so ably describes.

P. Kearey

Ethiopian-Somalian Geology

Merla, G. *et al.* 1979. *A Geological Map of Ethiopia and Somalia* (1973) *at* 1:2 000 000. (plus an explanatory text including 22 black and white illustrations and 37 colour illustrations and a 1:3 000 000 map of major landforms) Consiglio Nazionale delle Ricerche, Italy. Distributed by Pergamon Press, Oxford. 117 pp. Price: US $60.00, £27.50.

Thirteen and more years ago, the Ethiopian region was a blank on the map to English-speaking geologists, judging from the blank in their literature. The British were occupied in Kenya, notably its classic sector of the African Rift Valley. Americans came lately to Arabia, to the Precambrian basement of southwest Arabia in particular. But the intervening region remained uninvestigated, perhaps because there were no cultural links with British or U.S. universities or geological survey departments. (I except some valiant researches in ex-British Somaliland).

All that has changed utterly. Plate tectonics beckoned two large French–Italian and German interprises to Afar at the end of the 1960s, and a new-born and terrible beauty was revealed in all its volcanic and tectonic starkness. Articles on Ethiopian–Somalian geology now frequently appear in English-language journals, and several new 1:250 000 and 1:500 000 maps of Afar geology help focus our attention on this active 'triple junction'. Farther south, across the Horn of Africa, petroleum prospects have attracted U.S. oil companies to make deep-crustal surveys of the hugely subsided coastal zone of southern Somalia.

And yet, another and much neglected tide of learning is flowing since the beginning of the century. Meticulous and adventurous researches stemming from Italian university geology departments have been published and argued over down the decades—in Italian journals. This prolific work led, in 1933, to Giuseppe Stefanini's publication of a 1:2 million geological map of the Ethiopia–Somalia region, accompanied by 195 pages of commentary. As a pioneering and now classic work, it was superseded during the travails of World War II (in 1943) by Giotto Dainelli's monumental *Geologia dell'Africa Orientale*, a work of three volumes (1843 pages) and one volume of maps crowned with a revised 1:2 million geological map. Whatever criticisms might be levelled against Dainelli's work, in particular wearisome duplication of factual detail, it has certainly never received just recognition from the scientific community. Its wartime appearance, and the growth of a monoglot, English literature, effectively muffled it.

Apposite to a century of largely ignored geological research in Ethiopia and Somalia, is the following passage from the work under review (p. 10): "The Italian reader cannot help feeling shocked by the manner in which Italian papers are quoted by foreign authors. An exceedingly faulty orthography, misquotations, erroneous information, and more often sheer neglect are common ... The importance and priority of Italian contributions to Ethiopian and Somali geology being a well-known fact, a little effort and use of dictionary could be expected". Could be expected? Alas, the English language is a ruthless and disdainful supremacist. This is tacitly acknowledged by Professor Giovanni Merla, a student of Stefanini, in this 'third edition' of the 1:2 million geological map, and accompanying 95-page commentary. The language employed is no longer Italian but English.

The University of Florence team led by Merla had the new map completed and printed in 1973, six years before the commentary with which it is now united. The map shows nearly three times as many lithological subdivisions as did its 1933 and 1943 predecessors, though compared with Dainelli's map, the colourings are of darker shade so that clarity is lost. The text, drastically curtailed by comparison with Dainelli's memoir, is written in very readable English with occasional and charming Italian grammatical style.

Ten chapters commence with an 'Introduction' and 'Summary of the Geological History', both by Merla himself. The first comprises a terse account of previous geological maps and, such is the pace of modern Ethiopian research, there is a necessary section devoted to corrigenda to the 1973 map. The second chapter essentially highlights Merla's abiding interest in processes of regional uplift, and platform and basin subsidence, rather to the neglect of other topics. Thus, the pre-Mesozoic evolution of the region is not mentioned here. The crustal nature of Afar is debated without reference to the crucial seismic profiling made by Berckhemer *et al.* (1975, in: *Afar Depression of Ethiopia*).

The Precambrian 'basement' is discussed in Chapter 3 (again by Merla) in terms of a two-fold classification into high and low-grade metamorphic rocks. But this lithological discussion is largely superseded by the work of V. Kazmin, both in journal articles and in a geological map of the Ethiopian Empire, published in 1973 by the Geological Survey of Ethiopia. Neither in Kazmin's nor Merla's work will the structural geologist find much of detailed interest, reflecting a wide-open field entered only by the pioneering mapping of the late Dr. W. H. Morton and students of Professor R. M. Shackleton. A brief appendix (by P. Canuti) on the ?Ordovician glacial sediments of northern Ethiopia unnecessarily duplicates a previous discussion (by Merla) in Chapter 1.

The Mesozoic and early Tertiary marine sedimentary sequence (Chapters 4 to 6) forms one of two topics central to this new work. Merla (Ethiopia) and A. Azzarolli and Canuti (Somalia) provide an excellent review of recent changes and present status of formation ascriptions. Also discussed are time-space facies variations that express transgression—regression cycles, superimposed in some areas with continuing basin evolution. Rather crude cross-sections illustrating this vital topic are scattered as Figs. 6 and 14. Complementary sections and isopachyte maps for the Somali region can be found in Barnes (1976—cited in Merla's bibliography).

'The Volcanites' is title to the longest chapter, 7. It relates to the boldest, most ambitious feature of the new map, a detailed subdivision (by E. Abbate & M. Sagri, based on the work of B. Zanettin *et al.*) of the Tertiary volcanic rocks of the plateaux. The result, which would greatly have interested Dainelli, is not altogether a happy one, although the authors frankly acknowledge the formidable problems they have faced. Despite the plethora of available radiometric ages, conveniently tabulated here in an appendix, correlation both across the Ethiopian rift valley and N–S across the Ethiopian plateau is so difficult that five independent provincial stratigraphies are set up. The corresponding five different sets of colours on the map add a prerequisite of decipherment to discernment.

Within each province, extrapolation of volcanic formations for hundreds of kilometres beyond studied type-areas, on the assumption of a sub-horizontal and continuous stratigraphy, makes no allowance for probable lenticular development of separate, low-angle basaltic shields about observed dike-swarm axes. One glance at the histograms of radiometric ages presented in Fig. 7 (p. 52) is sufficient to show that either the bulk of these ages, or else the adopted stratigraphic scheme, is seriously in error. Out of numerous instances I select only one, the