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Book Reviews / Critique

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Book Reviews

It Began With A Stone. A History of Geology from the Stone Age to the Age of Plate Tectonics

By Henry Faul and Carol Faul
John Wiley & Sons, New York
270 p., 1983; $29.50, paper

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To attempt to write a general history of geology has long been a task to cause even the hardiest geological historian to quail. Significantly, it has been attempted only rarely. Sir Archibald Geikie's *The Founders of Geology* (1897) was perhaps the earliest approach to such a history; though by design somewhat selective, this gives a fair overall picture of the developing science. Karl von Zittel's *Geschichte der Geologie und Paläontologie* (1899; English translation, 1901) comes closer to being comprehensive than any other work and, although virtually unreadable, remains a valuable source. Horace B. Woodward's concise *History of Geology* (1911) is an infinitely more palatable account, effectively extracting much of the meat from Zittel; while Frank Dawson Adams' *Birth and Development of the Geological Sciences* (1938) is remarkable and profound, but reaches only as far as the early nineteenth century in its survey of that development. Several other works exist but have seen no English translation; for example, Stanislas Meunier's *L'évolution des théories géologiques* (1911) and Helmut Hölder's massive *Geologie und Paläontologie in texten und ihrer Geschichte* (1960). The most readable text in English of relative recent date has been Carroll Lane Fenton and Mildred Adam Fenton's *The Story of the Great Geologists* (1945; republished in revised form as *Giants of Geology*, 1952). However, this is a compilation from secondary sources, in which some of the interpretations are sadly outdated.

A new overview of the whole history of geology is thus long overdue. However, with each passing year, each new development and every new light or handful of mud thrown upon earlier interpretations, the writing of such a book has become ever more difficult. It is a pleasure, therefore, to review so excellent a work as this and to know that we have, not just a modern and equally readable successor to *Giants of Geology*, but also a much more wide-ranging and thoroughly researched work. Interestingly, this is again produced by a husband-and-wife team; but, sadly, Henry Faul has not lived to see its publication, for the book was only completed after his death. It serves as a fine monument to an exceptionally erudite and very humane geologist.

There has been a tendency for North American geological historians to see the development of their science through americocentric spectacles, giving a fair treatment of European work up to 1850 but thereafter considering work done outside the US as, in general, unimportant. (Kirtley F. Mather's *Source Book in Geology 1900-1950*, published in 1967, is an especially regrettable manifestation of this attitude). It is good to find that the Fauls present a picture in which the work of US geologists is neither exaggerated nor downplayed. Nor do they concentrate unduly on any particular aspect of geology; in this sketch of our developing discipline, at least up to the end of the 19th century, the whole scene is in general very well delineated.

From that time, however, the balance is lost (perhaps because Henry Faul did not live long enough to adequately complete his survey?). The evolution of the dangerous-seeming heresy of Continental Drift into the proclaimed doctrine of plate tectonics is sufficiently well treated to keep happy those many geologists who view the latter concept as central to modern geology. In contrast, virtually nothing is said about the development of sedimentology, metamorphic petrology, geochemistry, photogeology, palynology and micropaleontology, paleoecology or petroleum geology, while the numerous major developments after 1900 in most pre-existing fields likewise escape attention. It is fairest, therefore — despite the title — to regard this as a history of geology to around 1900 and to assess it thus.

On that basis, as I have written already, *It Began with a Stone* merits high praise. In a work of so broad a compass, it is inevitable that there are weaknesses. The Fauls have little patience with the cataclysmic theories of geology, once so influential but now seen to be intellectual dead-ends. They do give a brief account of Burnet's concepts, but Whiston's and Whitehurst's theories of the earth are dismissed cursorily and even Cuvier's theory of the revolutions of the globe, historically important though it was, is not recounted in any detail. Thomas Beddoes' work on granites and basalts (1791), which contains the earliest suggestion that granites might be of metamorphic origin, escapes mention, while Henry Sorby's pioneer studies of the formation of sediments, the development of slaty cleavage and the nature of meteorites are not discussed. The statement (p. 122) that Mantell's description of *Iguanodon* was "the first scientific presentation of one of the large dryland reptiles later described...under the name *Dinosauria*" is downright wrong; William Buckland both discovered *Megalosaurus* before Mantell's find was made and described it in print before his work was published. There are statements of opinion that can be controverted. The Fauls' assessment of Abraham Werner's achievement (p. 95) is very different from that of some other writers, Alexander Ospovat in particular; their claim that Robert Jameson's lectures were "interesting and popular" accords ill with Charles Darwin's judgement that they were "incredibly dull"; and few Alpine geologists would agree that Jean André de Luc's work is "now largely forgotten" (p. 109).

The handling of the names of scientists mentioned is irritatingly inconsistent. Sometimes only the first of two Christian names is specified (e.g. "John Henslow", p. 124), whereas on other occasions both are given. Those scientists blessed with a string of Christian names fare indifferently; all of Lamarck's names are mentioned (though not his title of Chevalier) on p. 135 whereas, on the previous page, none of Cuvier's baptismal names are given, only the name "Georges", which he assumed after his brother's death. The second, Giles, of Dau-

beny's three Christian names is omitted (1852). The very frequent error of turning Archbishop James Usher's surname into "Ussher" is repeated (p. 116) — is this a result of confusing him with the nineteenth-century English stratigrapher William Ussher? — and Ignaz Venetz's first name is mis-spelled (p. 142). The usage of "microbiology" on p. 196 is incorrect; it is the study of microbes, not of microfossils. Typographical errors are commendably few; I noted only five (on pages 82, 128, 138, 182 and 187), a small number indeed in so complex a text. These minor points can all be set right in the second edition, for this book deserves to go through many editions!!

Its numerous positive points include a lucid account of Islamic scientific attainments and failures, the trumpet statement that "Geology was born in Italy", a clear and succinct account of the origins of geodesy and the early work on the earth's magnetism, and a good explanation of the true significance of Charles Lyell's visits to North America. It is salutary to be reminded that Lazzaro Moro, not Giovanni Arduino, devised the stratal designations "Primary" and "Secondary" and to be told of Alexandre Brongniart's attainments in stratigraphy (though his brother, pioneer paleobotanist Adolphe Brongniart, passes unmentioned).

The most important things about this work are its lucidity and its balanced view of the development of our discipline. Buy it and recommend it to your students; if there is any other history so good in a long while, we will be fortunate indeed!

Hydrodynamics and Sedimentation in Wave-Dominated Coastal Environments

Edited by B. Greenwood and R.A. Davis, Jr.
Elsevier Science Publishers, Amsterdam
474 p., 1984; $100.00 US, cloth

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Over the past decade, there has been a proliferation of sophisticated research on modern nearshore and coastal-zone sedimentation. This is reflected in the several published symposia volumes now available on the subject. Wave-dominated beach and nearshore environments have received most of the research effort, and this book could rightly be termed "state-of-the-art" with respect to that effort. The entire volume is reprinted from the journal, Marine Geology (v. 60, no. 1-4). It is a compilation of 22 papers (although in the preface the editors say there are 23) presented at a symposium entitled "Coastal Environments Dominated by Waves", and convened at the Eleventh International Congress on Sedimentology, Hamilton, Ontario, in August 1982. The Editors of this volume, B. Greenwood and R.A. Davis, Jr., were also the principal organizers of the Hamilton symposium.

The main objective of the Hamilton symposium was to provide a forum in which to discuss the relationships between hydrodynamics and sedimentation in both modern and ancient wave-dominated coastal environments. The highlights of this volume are the excellent papers dealing with those relationships in modern environments. The first eight papers emphasize the links between wave dynamics and sedimentation, both from a theoretical viewpoint and in actual case studies of specific beach and nearshore depositional systems. The next six papers are concerned with bed forms and sedimentary structures, the most noteworthy being those by R.C. Shipp (on the depositional sedimentary structures in the barred nearshore system off Long Island, New York), and A.D. Short (on beach and nearshore facies sequences of southeast Australia). Papers 15 through 20 deal on a macroscale with coastal depositional segments in terms of morphological style and resultant evolution of characterisitc stratigraphic sequences. Provocative studies in this category include a paper on the gravel beaches of the British Isles (R.W.G. Carter and J.D. Orford), and a comparative analysis of Holocene barrier-beach stratigraphies from Nova Scotia, the Mississippi Delta, and eastern Australia (Boyd and Penland). The last two papers (by W.R. Dupré and P.A. Allen) are excellent examples of the interpretation of shallow-marine rock sequences relative to the ancient wave conditions under which they formed.

Preface aside, the volume is well-structured and edited by two individuals who are at the "cutting edge" of their field of expertise. It is, however, a book meant for the specialist who is interested in the study of hydrodynamics-sedimentation of modern coastal environments. With the exception of specific papers referred to above, this book will be of limited value to the non-specialist earth scientist who is concerned primarily with the interpretation of ancient sequences. I suspect "ancient-rock" purists and resource geologists will find the price of the book prohibitive compared with far less specialized volumes presently on the market. Nevertheless, I would urge every avid coastal researcher to either purchase a copy, or ensure that his or her institution library has one available. It is certainly the best volume published on this topic to date.

Variscan Tectonics of the North Atlantic Region

Edited by D.H.W. Hutton and D.J. Sanderson
Blackwell Scientific Publications, Palo Alto
270 p., 1984; $60.00 US, cloth

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The book provides a good view of the overriding problem of European geology — the definition, composition, and meaning of the Variscan Orogen. This orogen includes some of the longest studied, most closely examined, and most discussed features of the earth's crust. The orogen is defined here as a broad zone of deformation which lies between central Europe and the southern British Isles, and which continues southward to fringe the northwest coast of North Africa and the east coast of North America. The time of deformation spans Middle Devonian to Early Permian time. Thus the Variscan as defined here would include the Hercynian, Mauritanian, Alleghanian, Acadian, and in some papers, the Caledonian orogenies! In general, the authors see the evolution of this complex as a single, simplistic Wilson-cycle — Late Precambrian or Early Paleozoic rifting followed by closing that progressed through Paleozoic time from northeast to southwest. There are some excellent review papers here as well as others that offer some fascinating research questions and speculations.

The publication is an extension of papers given in September 1982, at a meeting of the Tectonics Studies Group of the Geological Society of London. The purpose of the meeting was to concentrate on the northern margin of the orogen around the North Atlantic between central Europe and Alabama, and in particular the nature of the so-called Variscan Front. The margin is important for a number of reasons: (1) definition should be easy and so permit strike correlations and comparisons; (2) pre-convergent geometries and convergent vectors might be distinguished; and (3) recent studies especially geophysical, have given new insight on orogenic margins of both sides of the Atlantic. The front is important because of: (1) the long dispute in Europe over both its reality and its nature; and (2) its putative continuation into North America.

The intended audience of the book is mainly the research geologist, broadly defined, in the fields of sedimentary tectonics, deformation, or geophysics. Such a collection of papers is meant to help foreign geologists overview presently disrupted parts of the orogen, to offer to local geologists syntheses of current geological ideas, and in general to suggest questions which might be answered

by continuing research. A general problem is that papers of this sort are very quickly dated, in part because of the emphasis on interpretation rather than on basic data.

The papers are organized geographically starting in the east, in central Europe and finishing in the west, in the southern US. Each sector is introduced by a substantial review article, followed by one or more regional, geophysically-based papers, and then ended by more detailed contributions. Some sectors are concluded with "idea" papers that pose questions and speculations. This orderly scheme is interrupted by inclusion of recent work on the Massif Central and the foreland of Britain and Ireland. There are six papers on mainland Europe; seven on Britain; four on Ireland; and five on North America.

I found the first third of the book, dealing with mainland Europe, to be the most valuable. For a non-European who has been consistently confused by the Variscan Orogen, the best contribution may be by Weber, who begins the sector on mainland Europe. The first of many Variscan events is the now traditional rifting in early Paleozoic, or late Precambrian time. This "Caledonian"(!) event involved almost simultaneous granitic intrusion, bimodal volcanism, granulite facies metamorphism, and continuous sedimentation (in part similar to the Acadian event in the Meguma terrane of Nova Scotia). Weber places this rifting on top of a rising, hot mantle, and expulses water from the resulting granulites to form calcalkaline granites that first invade the upper crust and then are deformed to produce orthogneisses. The "Acadian" event began in the Early Devonian with folding, large-scale thrusting, and metamorphism of the basement, and concluded in the Late Devonian with extensive erosion. This was the major event in the Variscan basement. Although crustal shortening continued through the Carboniferous in the interior zone, the weakly metamorphosed external zones of the Variscides were first folded during the Carboniferous; however, deformation was mainly brittle, producing varieties of mylonites as shears coincident with the former rift zones. Ramping resulted in uplift of basement blocks that in turn shed turbidites into intervening lows. Weber uses two Andrews-Sleep cells in the lithospheric mantle to account for heat loss and convergence.

By far the most entertaining, revealing and stimulating paper is by S.C. Matthews, who concludes this sector. He notes that "solutions of the problem presented by the Variscides have been many, and consistently unsuccessful. Attempts to understand the nature of the problem have appeared less frequently". Sounds very familiar! He also compares the enthusiastic application of plate tectonics in the seventies to a form of Geo-Esperanto by which language and national barriers were discarded as well as the need for any previous knowledge of parts of the Variscan puzzle. We can apply this to the Appalachians too! Matthews argues that the Variscides are certainly not belt-like, and questions the often-quoted width of 2000 km. He is devastating on the Variscan front — calling it trivial, misconceived, and illusory in Europe, and of questionable use in North America. I also wonder about the export value of such terms as "Acadian" outside its native area, rather than "the Devonian event"; also "Caledonian" or even "Variscan". There are so many interesting and forthright comments by this iconoclast that his paper is a zinger.

Meissner, Springer and Fluh suggest that the entire orogenic belt consists of thin sialic platelets that were dispersed in either a shallow sea (Europe) or large oceanic area (the Appalachians). Shifting and interstacking of these platelets without subduction in Europe led to the orogeny.

Burg, Leyreloup, Marchand and Matte argue that in the northern part of the Massif Central inverted metamorphic zonation indicates significant crustal thickening, most readily explained by southward overthrusting onto the continental shelf of southern France. Quendardel and Rolin show that in the northwestern part of the massif, thrusting occurred at two times: toward the northeast in the late Caledonian (Acadian?), and toward the southeast in the Westphalian. Franke notes that in the Saxothuringian Zone of Bavaria, deformation was first toward the northwest and then the southeast, as do Mosher and Rast in New England.

The British sector is starred by a condensed but readable summary by Coward and Smallwood. Thin-skinned tectonics with thrust transport toward the NNW is emphasized. The original British lower crust and lithosphere should extend over 150 km beneath the English Channel and northern France. Four short papers identify low-angle thrusts which extend offshore to the south. The sector concludes with two papers describing Carboniferous east-west shearing in northern England.

David Sanderson describes the structure of southwest Ireland, considers several models, and then attempts to extend them southeastward across southwest England and Brittany. It is a very clearly written paper that gives good, thumb-nail descriptions of these areas. Interestingly, Sanderson favours thick-skinned tectonics at least in Ireland. Cooper and co-workers use balanced cross-sections to argue that in the Irish Variscides thrusts are equal in importance to folds, and caution that fault control of both basin margins and sedimentation has been over-emphasized. Max and Lefort, as well as Coller, suggest that the Irish Variscan front is basically a dextral shear zone during middle and late Carboniferous time. As such, the front may be one of a swarm of similar, parallel shears bridging Europe and America.

Nick Rast begins the North American sector with an interesting, five-fold division of the Late Paleozoic Appalachians that emphasizes platformal areas to the northwest and west, from Variscan-Alleghenian deformed belts to the southeast and east. Identification of the extrapolated Variscan front into Maritime Canada and New England is an important limiter here; note the comments by Matthews. Rast speculates that the Alleghenian overthrusting of the southern Appalachians might be traced northward so that all of the Meguma terrane of southern Nova Scotia might be allochthonous — wow! He also employs a gigantic sinistral strike-slip fault whose paleomagnetic basis has now become suspect. Lefort and Haworth identify a dextral shear northeast of Newfoundland that they believe to be the continuation, on a pre-Mesozoic fit, of the front; however, they emphasize that this boundary is not the northern limit of Variscan deformation. Mosher and Rast detail the similar sedimentary, deformational and metamorphic histories during Carboniferous-Permian time in Maritime Canada and New England. Brewer concludes the North American sector with a summary of COCORP data from the southern Appalachians and Ouachitas, and an interesting extrapolation to Europe.

In summary, the editors suggest that south- and southeasterly-dipping thrusts occur throughout the northern marginal zones, and that dextral slip was important not only in the late stages of the orogeny, but also possibly in early phases. Northwest- to southeast-directed collision was oblique in the central region, whereas in North America, closure was more normal to the northeast trend of the margin. The Variscan front could then be more definite in those areas dominated by thrusting, but more diffuse where transcurrent shear predominated. The present position of the front also depends on the gross level of erosion. Obviously thin-skinned tectonics are greatly favoured throughout the book.

At the same time as the Dublin meeting, the Caledonide-Applachian Orogen Project of the IGCP met in Atlantic Canada for its seventh annual conference. The long-term purpose of the project has been essentially the same as that of the Dublin meeting. At the same time as both of these meetings, Williams and Hatcher proposed that the Appalachians alone consist of at least 19 suspect terranes. One of the reviewers of our conference proceedings questioned our purpose in the light of the terrane concept of orogens. An incoherent assemblage of such blocks may make nonsense of any attempted long-range correlation of the orogen. Both Matthews and I hope that the "Variscides", broadly defined, is not a chaotic melange, but that along-strike correlation of zones is possible.

The editors are to be congratulated in producing a smooth, well-controlled and uniform product within three years of their meeting. I know that this is not easy, especially when

authors write in different languages. Undoubtedly much of their success is due to translations and smoothing by Mattheson, who unfortunately died before its publication. The illustrations are many, uniform and very clear, although more geographical maps would have helped the foreign reader. This book is an important contribution but is very expensive at 22 cents per page. Make sure that your library has a copy.

The Dark Side of the Earth

By Robert Muir Wood. With portraits drawn by Margaret Woodhouse.
Allen and Unwin, Winchester
246 p., 1985; $19.95 US, cloth

Reviewed by William A.S. Sarjeant
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That the last twenty years have seen a great change in our concepts of the earth and its structure is beyond dispute. During those years, Alfred Wegener's theory of the drift of the continents, long disregarded by most scientists and classed (alongside the works of such writers as Immanuel Velikovsky and Erich von Däniken) as pseudo-science, has received a fresh lease on life and become transformed into the new concept of plate tectonics — a beautiful scientific butterfly bursting from the rather ugly chrysalis in which it had lain for so long.

This dramatic revision in thinking has captured the imagination, not only of earth scientists, but of the public at large. Though the time since its occurrence has been brief, the intellectual turnabout involved has been charted already in several works. First of all came Anthony Hallam's *A revolution in the earth sciences* (Clarendon Press, Oxford, 1973) and almost simultaneously, Ursula Marvin's *Continental Drift. The evolution of a concept* (Smithsonian Institution, Washington D.C., 1973). Subsequently, William Glen added details to the story in *The Road to Jaramillo. Critical years of the revolution in the earth sciences* (Stanford University Press, 1982). Hallam reviewed the developments a second time in his *Great geological controversies* (Oxford University Press, 1983) and it was treated with also in Henry and Carol Faul's *It Began with a Stone* (Wiley, New York, 1983). Now the whole story of this revolution in concepts is presented anew in the work under review.

It is a readable book and charts quite well the course of the development of our present concepts; but alas! its author has constructed for himself a windmill against which he tilts so determinedly that the whole work is seriously distorted. The tone is set as early as page 2:

> "...the discovery of the Earth and the creation of Earth Sciences were consistently resisted by the geological establishment. Following a bitter struggle with the physicists over the age of the Earth, Geology failed to adapt to the new style of geophysical investigation. The decline of a science can be irresistible. Like a dynasty without the ambition of the first monarch, the creative force had become replaced by ritual and repetition. An alien science had been developing on the margins of Geology for almost a century. A generation after the Second World War this new scientific structure challenged and overwhelmed the old."

There you have it: the giant Geology falls to the bright lance of Geophysics (the capitalization is so consistent that it is clear that personification is intended). Then, from the recumbent corpse, there is a phoenix-like regeneration to produce that new and beautiful discipline, Earth Sciences.

Indeed, we must presume that the author, himself a geophysicist, genuinely perceives events thus; if he did not, he would be hard put to sustain so bizarre a view throughout 240 pages. Throughout, the geologist is envisaged as being an intellectually limited individual, incapable of theorizing or even of wide-ranging thought — a sort of scientific Neanderthal man:

> "As the hammer made contact with the rock, the continuity of the Earth's surface could not be forgotten; the most important epistemological problem in Geology, that of determining how the study should get underway, was met not with calm contemplation but with the smashing of the hammer. For once the smashing was completed, the problem vanished. Now in this rock, this sample, there is a discrete entity to be studied. The hammer itself has been borrowed from the blacksmith or the stonemason — who are creating objects for the use of man. The borrowed tool can only create according to its function: the size of the horseshoe or the stone-slate. The rock fragment became the object under study as if it were made predeterminedly discrete when it was simply a sculptured creation. Of available sizes from the dust grain to the continent, the geologist recreated the Earth according to the size of his own fist. The residual memory was at work. Stone Age man was reborn, busy manufacturing artifacts, at the beginning of the 19th century." (p. 9)

What a curious misinterpretation this is! Moreover, the author himself presents the very evidence that undermines it. As he demonstrates amply, though Wegener himself was a meteorologist, many *bona-fide* geologists were major contributors (direct or indirect) to the development of the modern concepts about the Earth's crust and interior that are now generally accepted. There was the Reverend Osmond Fisher, for example, who originated the idea of convection currents within the Earth (p. 29); Thomas Crowder Chamberlin who, as Muir Wood admits, was "the first respected scientist" to have "traversed the boundary into Astronomy and Cosmology" (p. 31); Grove Karl Gilbert, who perceived how asteroid impacts had scarred the moon's surface and who originated the concept of orogenies (p. 47-48); Frank Bursley Taylor, who proposed an American version of the theory of moving continents (p. 48-49); Richard Dixon Oldham, who first interpreted satisfactorily the nature of the earthquake waves (p. 64); Samuel Warren Carey, who was the major modern advocate of the concept of the expanding Earth (p. 116-117); Arthur Holmes, pioneer of radioactive dating of the Earth's ages, yet emphatically a field geologist (p. 91-92); Richard Field, whose vigorous teaching inspired his students to explore the ocean floor (p. 126); Harry H. Hess who, despite his work on submarine geophysics, was "foremost a petrologist" (p. 128); the Dutch stratigrapher and paleontologist Martin Rutten, who was the first to incorporate radio-isotope dates into a magnetic-reversal timescale (p. 148); and John Tuzo Wilson, originator of the concept of transform faults, who actually preferred the outdoor life of geology to the "repetitious and stuffy" practice of physics! (p. 131).

Of course, such figures were few in proportion to the number of workers concerned with detail. Is there any science, even geophysics, where the generalizers, the grand theorists, are not fewer than the persons tackling more limited tasks? To regard geology — personally I refuse to use that initial capital — as abnormal in this respect is nonsense! Yet throughout the history of our science, there have always been individuals looking from the particular to the general.

While admitting Alfred Wegener's error in believing the moraines of Europe and North America to have been once joined (p. 85), Muir Wood does not point out clearly the several other dubious evidences which, adduced by Wegener in favour of continental drift, forced paleontologists and biologists to view his theory with distrust. It is fair, I think, to compare Wegener with Robert Chambers, who advocated the idea of evolution in his *Vestiges of the Natural History of Creation* many years before Darwin published *On the Origin of Species*. In both instances, a fair critical consideration of the concept was impeded by its bolstering by unsatisfactory or unacceptable evidence. Muir Wood quotes with evident approval the conclusion in 1964 that "purely geological evidence cannot disprove drift" (p. 161). If geologists in general did not accept — indeed, did not even give serious consideration to — Wegener's theory before 1950, are they to be blamed when the three major lines of evidence in its favour

(paleomagnetism, the facts of submarine geology and the view of the Earth from space) were not available to them?

Yet let us consider those who defended, with varying degrees of vigour, the unpopular concept of continental drift during its hard years. We find US geologist Reginald Daly in the arena (p. 80), along with the English stratigrapher George Lamplugh (p. 75), the French structural geologist Emile Argand (p. 70) and the Dutch petroleum geologist W.A.J.M. van Waterschoot van der Gracht (p. 82-83). Indeed, foremost among its defenders was the geologist Alexander Logie du Toit of South Africa (p. 106-108). In contrast, among the most vigorous opponents of these developing theories we find John Joly, trained in civil engineering and experimental physics and only secondarily a geologist (even though described by Muir Wood merely as "Irish geologist", p. 89), who strove vociferously to prop up Lord Kelvin's false estimates of the Earth's age against the opposition of most geologists. We find the leading geophysicist of the United States, Harry Fielding Read, vigorously rejecting Wegener's ideas (p. 79); geographer Philip Lake spearheading British opposition to the theory (p. 75-76) and mathematician Harold Jeffreys proving its most enduring opponent (p. 76-77, 96).

Muir Wood's prejudices result in other distortions of which the reader needs to be aware. Lord Kelvin's calculations, accurate enough when one considers the evidence available to him from physics but unacceptable from the outset to geologists, are described briefly and in a fashion that implies the geologists to have been over-sensitive defenders of a fundamentally untenable position (p. 26). The theory of physicist George Darwin — a weird one in retrospect — that the moon had been spawned from the Earth, its scar the Pacific Ocean (p. 54-55), served as a second lesson to geologists that the concepts of physicists were not always to be trusted!

The statement that "After Lyell geologists shunned the study of earthquakes" (p. 195) is, of course, ridiculous. Geological work, during the 19th century, was concentrated in countries where earthquakes were rare. With so many other areas of research more immediately available to them, why should geologists in those lands give primacy to earthquake study? Yet in countries where earthquakes *were* regularly occurring, they did not neglect this topic. The work of the Irish physicist Robert Mallett was continued, not by other physicists, but by the geologists Thomas and Robert Oldham in India (p. 197). British geologist William Lothian Green was able to develop original concepts from his awareness and knowledge both of the volcanoes and the earthquakes of Hawaii (p. 20-23); and it was US geologist Clarence Dutton who made the major study of the 1886 Charleston earthquake (p. 46). Certainly, after John Milne's work (p. 156-157), the study of earthquakes did begin to pass into the realm of physics; yet, to this day, earthquakes have never ceased to be treated with in core geology courses.

Other distortions occur also. Let us consider a passage when Mr. Muir Wood is dismissing the idea of the expanding earth on the basis of Gauss' theorem concerning the property of surface curvature:

> "This Gaussian curvature is well known to all mathematicians and many Earth scientists, but geologists who champion the expanding Earth have refused to reason with it because they believe, along with their 19th-century forebears, that Geology should never be constrained by mathematicians. In this instance this means that Geology can hope to transcend the very properties of space." (p. 208)

Apart from its emotive conclusion, this passage makes two characteristic false assumptions; that the theory concerned has been championed only by geologists, whereas it has attracted many physicists and geophysicists also, and that geologists are necessarily trained in mathematics and aware of Gauss' concepts; of course, they are not.

Similarly, in a diatribe against the Geological Society of London, Mr. Muir Wood derisively lists the titles of the addresses by Presidents between 1964 and 1970 as treating consistently with lesser issues and ignoring the much more important continental drift question (p. 206). Of course these men lectured on other topics; the President is expected to lecture on a field of geology in which he has specialized knowledge and each President, quite properly, did so!

A number of minor errors should be noted. Mr. Muir Wood is unhappy with German citations: he converts Hans Conrad Escher von der Linth into "van der Linth" (p. 50, 51), omits the umlaut from Göttingen (p. 125), mis-spells "und" (p. 74) and "Entstehung" (p. 85) and does not capitalize German titles properly, even when they are italicized (e.g. p. 68, 212). He refers to the Danish explorer Lauge Koch as "Lange Koch" and implies that he died in the 1920's (p. 86), whereas Koch lived until 1964. However, proof-reading has been good; I noted only three errors (on pages 76, 115 and 150).

When Mr. Muir Wood instances the changes of names of geology departments that began in the 1960's as an admission that the malign giant Geology had been overthrown, I feel he is missing the point. Yes, the new ideas of Earth structure and long-term behaviour did cause the neglected daughter science of geophysics, hitherto an unwelcome adoptee of physics, to be taken back into the maternal home; but the retitled departments were also embracing parts, at least, of several sister disciplines — geography, atmospheric and stratospheric physics, even aspects of astronomy. Geology remained the core of these restyled departments and continues to do so; it has not been disavowed, only supplemented. Muir Wood's claim that the American Geophysical Union has come "to dominate the Earth Sciences" (p. 206) ignores the fact that the Geological Society of America and the American Association of Petroleum Geologists have not only much larger memberships, but also much broader concerns, which geophysics (yes, even the new geophysics!) form only one — and that not the most commercially important.

As for his "G-éloge" (p. 223), this is arrant nonsense! Are we indeed losing "the expert whose knowledge consists of the ability to name a plethora of fossils, minerals and identify the stratal age"? No, of course not; his skills remain fundamental to every company concerned with exploration for minerals and to every geological survey striving to reconstruct subsurface geological structures by the accurate correlation of strata. Why should Mr. Muir Wood feel that those "skills are denigrated in the new overviews of the Earth scientist involved in geological work or indirect geological mapping"? The comment is meaningless, except as an expression of prejudice. When he asks "What Earth scientist would wish to spend years compiling an accurate and detailed map of one small region?" he seems not only to be unaware that this remains the only method by which any region may be properly known and its economic potential determined, but also to forget how many major deductions of earth structure have developed from such detailed studies.

This is a well-written book even if, among its major figures, only Alfred Wegener truly comes alive. It gives good, brief summaries of many episodes of early and recent geological history; for example, Pellegrini's work (p. 37-38); the background to global seismology (p. 155-158), the relevance of the moon initiatives (p. 185); the significance of the Mohole fiasco (p. 187-188) and the sad collapse of the International Geological Congress in Czechoslovakia after the invasion (p. 214). It is attractively illustrated by drawings of the principal protagonists in the story. The documentation is sound and the indexing thorough. Yet, in the last analysis, the author's prejudices are so pervasive that only readers who share them (other geophysicists, presumably!), or are strong-minded enough to ignore the flavour they give to the text, will be able to read it with profit and pleasure.

Memoirs of an Unrepentant Field Geologist. A Candid Profile of Some Geologists and Their Science 1921-1981

By F.J. Pettijohn
University of Chicago Press
260 p., 1984; $29.50, cloth

Reviewed by William A.S. Sarjeant
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Francis J. Pettijohn has made massive contributions, both to the investigation of the Precambrian strata of the northern United States and eastern Canada and to the development of sedimentology — or, as perhaps he would yet prefer to see it called, sedimentary petrology. His textbooks, in particular, have opened the doors to the latter discipline for many prominent geologists. Since Pettijohn is perhaps the first sedimentary petrologist to set forth his reminiscences at length, this autobiography must inevitably be of great interest to all concerned with the history of our discipline.

However, you must not expect that this book will enable you to come to know its author at any personal level. This work is as impersonal in tone — and, in all fairness, as lucidly written — as any of Dr. Pettijohn's textbooks. So little does he reveal about his life outside geology that, for example, we do not learn the name of his wife, the date of their marriage or whether it produced any children. Even when describing in detail the canoe odyssey in Ontario that was so pivotal in guiding his career, he avoids to a remarkable degree, recording the emotions it must have aroused in his breast. Interest and concerns outside science are so rarely mentioned that one wonders whether the author *has* any extra-scientific concerns. Perhaps not; perhaps his life is indeed wholly concentrated in geology. Indeed, his achievements make this seem probable enough. Nevertheless, for those of us who like to learn something about the personality and character of the giants of our science and who relish the memorable anecdote that brings them to life, this work must be in some measure disappointing.

About the development and teaching of geology during his career and about the character and achievements of his academic colleagues, Dr. Pettijohn is much more forthcoming and frank. He gives a good picture of the geological courses presented, and the geologists responsible for those courses, at the institutions with which he was associated, the University of Chicago and Johns Hopkins University in particular. He shows why fallow periods occurred, how phases of expansion originated and why they ended. Even if his hands are decently gloved, he does not pull his punches in attacks on, for example, the Newhouse regime at Chicago and the pattern of courses it produced, lamenting (p. 203)

> "...Newhouse's decision not to fund, even in a very small way, field excursions but to buy a calorimeter costing ten times as much, and a general "putdown" of field studies as "something we are trying to get away from". The rush to be fashionable led many other schools down the same path to a greater or lesser degree. Stratigraphers, paleontologists, and mineralogists were replaced by isotope chemists, spectroscopists, geochemists and the life [sic]. They dropped field courses and many other "traditional subjects" such as map reading and plane table surveying. They became, as Ernst Cloos described it, like a doughnut — a lot of exotic fields round the periphery and nothing in the middle."

Elsewhere (p. 243) Dr. Pettijohn asks

> "Where does this leave all the avante garde geology? The mass spectrometers and the study of radioactive and stable isotopes, the microprobe, and spectrographic analysis and trace elements? These are the new and most expensive tools, which require the services of a chambermaid and mega-budget to support — tools that produce mountains of data from a shoebox full of samples gathered on a weekend collecting trip, data that a computer must record and digest. They enable us to see things we cannot see with the naked eye, but tools for observation is still all they are. They are not an end in themselves or a solution to any problem. We tend to forget that."

His attitude is one that many Canadian geologists will, I am afraid, dismiss as "old hat" and unworthy of consideration; why, if research is expensive, it *must* be worthwhile! Cost, for many scientists today is as much a yardstick of importance as salary is of success. Yet, as Pettijohn notes (p. 243-244)

> "...the day has not yet arrived when one can ship [chip?] off a sample and send it to the laboratory to learn the age, temperature of formation, or environment of deposition. We still have to depend on our field boots, hammer, and eyes."

Although the quotations above contain one undoubted and one probable misprint, typographical errors are few in this work, though sometimes those few tend to be distracting (e.g. "what the priorities wee", p. 198; see also pages 192, 206, 238, 245). Dr. Pettijohn's writing style in his biography is as admirably lucid as in his textbooks; and, again and again, one encounters the memorable and challenging phrase, as when he observes (p. 139) that "A good geological map endures while theories come and go." Or when he asks (p. 17) "Why, oh why, can't geology be taught where geology is and not in the lecture hall?"

He gives particularly good pen-portraits of some of his associates, for example, William C. Krumbein (p. 176) and Paul D. Krynine (p. 178). On Harold C. Urey, he observes (p. 200) that

> "...he had a real, wide-ranging curiosity about geology. Urey was the only one who...came into your office to inquire, to learn, to try out a new idea. There was a never-ending freshness about his approach to problems. The real creative mind is, I believe, one that can link seemingly unrelated things in a new way. Urey had this ability, coupled to a fertile imagination that provided the stimulus."

It is creditable also that Dr. Pettijohn is able to admit his own failings — an undue faith in the idea that the natural processes of sedimentation left "...a textural imprint on the sediments — a fingerprint as it were — that would enable us to identify the environment (or agent) of deposition." (p. 175)

All in all, this is an interesting and thought-provoking work. That the personality of its author remains veiled is surely by design, not by any chance of style; but, even if this book tells us only about Dr. Pettijohn's scientific actions and ideas and little about himself, it does help to chart the currents of geology during this century and the sediment of research results that those currents have produced.

Past and Present Vegetation of the Far Northwest of Canada

By J.C. Ritchie
University of Toronto Press
251 p., 1984; $35.00, cloth

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This book is an account of the modern plant communities and the Quaternary paleoecology of the North Yukon and the adjacent Mackenzie Delta region. The modern vegetation of boreal forest in the south and tundra in the north is associated with a steep gradient of decreasing winter snow cover and decreasing summer temperature. The eastern half of the area was covered by the Pleistocene continental glacier, whereas the more mountainous west was unglaciated and together with Alaska was linked with Siberia to form the landmass of Beringia during times of low sea level. Thus the area served both as a refuge for organisms during continental glaciation and as a route for interchange of plants and animals, including man, between Asia and North America.

The seven chapters are accompanied by appendices of botanical data, methods and C-14 dates together with 28 plates that illustrate landscapes, permafrost features and plant communities. Chapter 2 on the physical setting provides an important compilation and discussion of climatic data and permafrost features together with a summary of the physiography and geology. Chapter 3 on the vascular plant flora summarizes the various hypotheses put forward to account for species distribution but Ritchie concludes that these can only be tested by experimental studies or paleobotanical studies.

Chapter 4 on the modern vegetation contains an interesting compilation of Beringian vegetation zones. Forest commmunities separated by the Bering Strait are dominated by different tree species, whereas tundra communities have many dominants in common. This suggests that when Siberia and Alaska formed a continuous land mass, trees were absent and have migrated into the area from remote continental refuges after the formation of the Strait. For the Northwest, 21 communities and their associated landscape units are described.

Chapter 5 on vegetation history interprets the largely macrofossil Tertiary record from Alaska and the Arctic Islands; the pollen record from Mackenzie Delta sediment indicates that early Tertiary warm temperate forests yielded to boreal vegetation during the Pliocene. Despite vigorous attempts to core sediment of lakes in the unglaciated Yukon, the oldest lake sediment is a disappointing 30,000 years and thus the early and mid-Pleistocene is recorded in only four river bluff or coastal cliff exposures. The Porcupine River section shows that pine pollen was more important in the early and middle Pleistocene than it was in the past 30,000 years.

For the late Pleistocene and Holocene, Ritchie draws largely on his own published fossil pollen data and those of his immediate colleagues. Lake sediment pollen diagrams are interpreted as percentage cover using correction factors (R values) derived from the correlation of the modern pollen rain and vegetation. Until 14,000 years ago, the unglaciated west supported sparse herb tundra, except for marshy tundra in the lowlands. With glacial retreat 14,000 years ago, herb tundra expanded and shrub tundra appeared. From 11,000 to 7,500 years ago, woodlands replaced tundra over much of the area, tundra communities grew luxuriantly and mires began to develop. Modern communities began to appear at 7,500 years ago and latitudinal treeline retreated southward to assume its present position 4,500 years ago.

Chapter 6 on paleoenvironmental reconstruction presents various hypotheses to explain the vegetational history; these include climate, other environmental factors such as large mammal grazing, pollen representation and plant migration dynamics linked to refuge location and seed production and dispersal. The ecology of spruce, poplar, larch, dwarf and tree birches, *Typha* (cat-tail) and *Myrica* (gale) are considered in detail. He concludes, that during the period 24,000 years ago, the climate was colder and drier than present with no exact modern analogues but resembling that of Banks and Victoria Islands in the mid-Arctic. A warming trend, to a peak of July temperature 3-5°C above the present, was reached around 10,000 years ago; this is consistent with Milankovich theory. A cooling trend began at 8,000 years ago with modern climate established about 4,500 years ago.

Chapter 7 addresses the ecological relationships of the reconstructed vegetation with the "grassland" large mammal fauna represented by bones of mammoth, horse, bison, saiga antelope, dall sheep, muskox, caribou, elk, etc. Few bone collections are from a secure stratigraphic context with isotope dates and associated fossil pollen analyses. An exception is Bluefish Cave where bones of extinct or extirpated large mammals dated 15,500 to 12,900 years B.P. are associated with a tundra pollen assemblage. The modern putative analogue, Banks and Victoria Islands, supports relatively large herds of muskox and caribou. To test the hypothesis that the late-glacial landscape could have supported the fauna, Ritchie maps the area around the cave into various tundra types based on elevation. Then using plant productivity and animal consumption values, he shows that the tundra landscape around the cave could have supported the diverse fauna in small herds at low density. Thus "grassland", in addition to being unsupported by paleobotany, is not required by the mammals. Further, he points out that the grazer-browser habitat diminished by a factor of five at 11,000 years ago, supporting habitat change as a cause for extinction and extirpation.

Computer Applications in Petroleum Geology

By J.E. Robinson
Hutchinson Ross Publishing Company, New York
164 p., 1982; $23.25, paper

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During the mercifully brief period when I worked for a major oil company in 1971-72, I discovered that my boss would leave me alone to waste my time any way I wanted so long as a computer print-out was unfolded on the desk in front of me. Later, in the Geological Survey of Canada, I had a lot of fun playing with a terminal linked to a big computer downtown. It was possible to produce reams of "data" and all kinds of maps from a minimum of input. Eventually I decided that it was all a bit of a game and not really helping me to understand the geology or find a new oil well. In fact, I became so cynical about it I even wrote an article for Geoscience Canada (1975, v. 2, p. 193-195) that stirred up a few angry replies (some of them unpublishable).

Now along comes this book that spells out in detail every one of my doubts and concerns, yet shows how to make the most of the computer without turning into an obsessed hacker. This is strictly a practical treatise geared at working petroleum geologists in Canada and the United States. It describes the characteristics of the major well data files in North America, the type of information stored, the problems with this information, and what can usefully be done with it. The book is distinctly user-friendly in that there is a minimum of theory and virtually no mathematics. It is therefore aimed mainly at the experienced geologist with little computer training (an increasing rarity these days), who accepts a job with an oil company and finds a PC sitting on his desk. Or perhaps a graduate student who notices her friends disappearing into this humming, stuffy little room upstairs, for hours on end and wants to know how she could usefully join in without retaking basic calculus. In other words, this is for

people who are surrounded by computer expertise and want to know how to take advantage of it.

The book starts with a "series editor's foreword" by D.R. Merriam that does little to impress the potential buyer. It seems to claim, in the very first sentence, that the recent revolution in the earth sciences is due largely to quantifications in geology brought about by adaptations of the computer. This might make a good subject for a Pyroclasts diatribe. Next, there are several grammatical errors, including the statement that publication of this first book in the series "has taken longer to fruition than anticipated".

Chapter 1 briefly describes the nature of geologic data, and Chapters 2 and 3 are practical guides to commercial data files in North America. Chapter 4 suggests some preliminary ideas on how much of this information can usefully be manipulated by the computer, and Chapter 5 discusses digital well-log and seismic files, neither of them in the mainstream of geological (as opposed to geophysical) usage. Chapter 6 introduces map projection and well location procedures. Chapter 7 explains in a non-technical way how computers make contour maps from three-dimensional data such as thickness, elevation, porosity, sand/shale ratio, etc. As a sedimentologist concerned with trying to recognize trends, such as linear sand bodies, I was delighted to read "the computer mapping program does not consider basic geology. It does not know that stream valleys tend to be continuous, that folds have preferred directional trends. It cannot extrapolate grain from densely sampled areas to poorly sampled areas, yet an astute geologist can force all this information on the computer". *This* is the kind of honesty we want to hear, not a derivation of yet another algorithm that could render even plate tectonics obsolete if only you dumb geologists out there could come to grips with modern techniques.

Chapter 8 describes map analysis techniques such as trend surface analysis and filtering. Some difficult terminology creeps in here, and the author does not use the few illustrations very effectively to get his points across. Some subsidiary techniques are dealt with briefly in Chapter 9, including hydrodynamic maps, cross sections, and integration of seismic data. Chapter 10 discusses how to compare different maps with each other, and Chapter 11 deals with multivariate analysis techniques such as entropy, multiple regression and factor analysis. The combination of brief, non-technical description with few illustrations does not work very well for complex procedures such as factor analysis. Finally, Chapter 12 introduces the fast-expanding field of digital well-log analysis.

There is a lot of wisdom and useful advice in this book. It should be useful for beginners trying to talk to experts in order to find out what they can do with their data.

The Continental Crust: Its Composition and Evolution

By Stuart Ross Taylor and Scott M. McLennan
Geoscience Texts
Blackwell Scientific Publications, Palo Alto
312 p., 1985; $23.00 US, paper

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Some of the elements that make a good, general interest geoscience book are: (1) it can be read and *understood* without total familiarity with the subject; (2) it is of interest to a broad cross-section of the geological community; (3) it provides new insights into a field or a body of knowledge; (4) it is useful as a source of data and as an introduction to the related literature; (5) it be affordable, concise, well-produced and illustrated; and (6) it be suitable for use at the undergraduate or graduate level as a supplementary or main text.

In *The Continental Crust: Its Composition and Evolution*, subtitled an *Examination of the Geochemical Record Preserved in Sedimentary Rocks*, Stuart Ross Taylor and Scott McLennan have succeeded in satisfying all of these elements.

The authors have attempted to produce a synthesis of our present state of understanding and knowledge of the bulk composition of the earth's crust, both at present, and throughout the history of the earth. This may seem to be a dry subject of esoteric interest, but, as outlined by Taylor and McLennan, is a subject of concern to most geologists, and one which can provide insights into various geological processes throughout earth history. They focus mainly on their own research, which is heavily biased toward studies involving trace element geochemistry (particularly the rare-earth elements (REE)), especially in sedimentary rocks. They succeed because they provide an overview and compilation of over 20 years research work which is not familiar to many geologists, despite its potential significance, and they use this compilation (useful in its own right), to constrain our knowledge of the composition and evolution of the crust through time. In addition, they provide many insights into the problems of estimating crustal composition, and how these estimates can be interpreted in terms of global tectonic history. They also present some new models of crustal formation to explain their observations and insights, and, even if incorrect, these add measurably to the debate concerning Precambrian crustal development.

The book is organized into twelve chapters, and four short appendices. Each chapter is concluded by a succinct one-half to full page summary of its contents and conclusions. Chapter 1, "Some Perspectives" outlines some of the questions that arise about the crust, and some basic data that are important in any discussion of the crust. Chapter 2 concerns itself with "The Present Upper Crust", which illustrates its uniqueness, and reviews a number of approaches for determining its composition, focussing mainly on the use of REE data in sedimentary rocks to estimate crustal composition. It is interesting to note the consistency between the results determined by several different methods. Here, and in several other places in the book, it is striking to see that in a number of areas regarding the composition and structure of the continental crust, some consensus is beginning to be reached. Also in Chapter 2 is a section on the geological influences on the geochemistry of sedimentary rocks, a subject generally only briefly and poorly covered in sedimentology texts, despite its importance. Although brief, it is a concise review, and shows that with proper sampling and appropriate care in the laboratory, a wealth of information can be obtained through the study of the composition of sedimentary rocks. The chapter concludes with the authors' estimate of the composition of the present upper crust, with the rationale for their chosen values clearly explained.

Chapter 3 examines the more difficult problem of evaluating "Models of Total Crustal Composition". It concerns itself with the problem of how continental crust is produced, focussing on the "andesite model" (and variations) which the authors feel adequately explains present-day continental crustal growth and a "bimodal, mafic-felsic igneous model" for the Archean. The authors outline the latter model more fully in Chapter 9, but basically have been led to believe, on the basis of variations in sediment composition with time, that continental crustal growth in the Archean was different than at present. It should be noted that it does not immediately follow that major tectonic processes on the earth (i.e. movement of horizontal plates) were different in the Archean. In fact, as outlined by the authors, evolution of the composition of the continental crust reflects an evolution in tectonic processes as well, but not necessarily fundamental differences. The chapter concludes with a proposed bulk crust composition, with the rationale for the chosen values, again, clearly explained.

Chapter 4 deals with the problem of determining the composition of "The Lower Crust". It tackles the problem by examining the constraints provided through geophysics, the study of granulite facies terrains, xenoliths, Nd and Sr isotopic studies, and electrical conductivity. Finally, a lower crustal composition is proposed, again, with its assumptions well-documented.

Chapter 5 deals with "The Uniformity of

Crustal Composition with Time", mainly through examination of the sedimentary rock record. It is clear that trace element, REE data, and Nd model ages indicate that a major change in sedimentary rock bulk composition, and hence bulk crustal composition, occurred near the Archean/Proterozoic boundary, the exact timing of which varied in different cratonic regions.

Chapter 6, "Greywackes: Their Provenance and Tectonic Significance" is a needed digression. Before the composition of Archean sedimentary rocks can be used to estimate Archean upper crustal composition, it is necessary to examine the major sedimentary rock type in the Archean — greywackes. First, the tectonic setting, petrography and geochemistry of recent and Phanerozoic greywackes are reviewed. Then, Archean greywackes are described, and the three groups compared. Significant petrographic and geochemical differences exist between Archean and post-Archean greywackes, indicative of a different provenance for these two groups. This in itself is a significant contribution, since it has long been stated that Archean greywackes are akin to modern greywackes. However, it is now apparent that petrographic and bulk-composition arguments do not support such a sweeping generalization.

In Chapter 7, "The Archean Crust" is discussed. It tackles the problem of estimating the composition of the Archean upper crust through the use of the sedimentary rock record. It should be noted that here, and throughout the text, other pertinent evidence, such as volcanic rock data, stratigraphy and so on are incorporated into the authors' discussion and arguments, so the book is not in the least one-dimensional. The chapter also succinctly describes various proposed models of Archean tectonics. The chapter ends with estimates of Archean upper, lower, and total crustal composition. In this estimate, as in the others, as much of the periodic table as possible is included, adding to the utility of these estimates.

Chapter 8, "The Archean-Proterozoic Boundary" discusses the problems associated with this boundary, both from a stratigraphic and a crustal composition point-of-view. The geochemistry of several early Proterozoic sedimentary rock sequences is described, as these sequences record the major change in bulk crustal composition outlined in Chapter 5.

Chapter 9 deals with "Models for the Origin of Continental Crust". Here the authors focus on the problems of how continental crust is generated and accreted to cratonic nuclei, and how granites are formed. They conclude that the generation of granitic magmas must occur in the lower crust. The problem and significance of anorthosites and crustal growth is also covered. In addition, the authors' model of the Archean crust and how it was formed, introduced in Chapters 3 and 7, is further elaborated. There is a certain amount of overlap between various chapters in the book, but, as the authors state in a footnote, "In writing scientific books, unlike novels, it seems impossible to avoid drawing on conclusions reached in later chapters". However, the authors have kept such overlap to a minimum.

Chapter 10 is titled "Growth Rate of the Crust" and covers the various arguments and evidence concerning the growth of the continental crust through time. They conclude that at least 70% of the present-day crust had formed by the end of the Archean. Chapter 11 deals with "Crust-Mantle Relationships", particularly since differentiation of the crust from the mantle, whenever in earth history, has a corresponding effect on mantle composition. This chapter is brief, in relation to its speculative nature. The chapter concludes with an estimate of average oceanic crust composition. Finally, in Chapter 12, the authors look at "Early Planetary Crusts" for additional insights into crustal development on the earth. The earth appears to be unique in having a granitic crust, probably the result of having significant amounts of liquid water on the earth's surface early in the planet's history.

Of the four appendices, the list of journal abbreviations used in the footnotes, as well as the REE normalizing factors used by the authors are the most useful.

I thoroughly enjoyed the book on a number of levels. First, it is an excellent presentation of the value of the study of the composition of sedimentary rocks, and the use of geochemistry in provenance studies. One of the reasons that this book has had to rely heavily on the research work of Taylor and McLennan is that very few other researchers have bothered with their approach, despite its potential. Having done similar work myself, I can attest to its utility, and the book not only shows its applications, but compiles a lot of the earlier work together in one up-to-date source.

Second, on a student level, it is useful because it is logically laid out. For example, Chapter 2 provides an excellent example of how geochemists deal with the problem of measuring upper crustal composition, by outlining the various methods, their strengths and weaknesses, and the underlying assumptions of all the approaches. In the end, the agreement between these approaches illustrates that it is possible to achieve some consensus in geology.

Third, the book provides some new insights into a number of problems related to the continental crust, including the nature of Archean sedimentation, Archean tectonics, and crustal growth in the Precambrian. Although one may disagree with the authors' models or conclusions, their arguments are well-presented, and the evidence they present has to be addressed in future or alternative models.

Fourth, although it does require a basic knowledge of geochemistry (3rd or 4th year undergraduate level) it does not require total familiarity with geochemistry to read and understand the book. Although part of Blackwell's "Geoscience text" series, it is not suitable in its present form for use as an undergraduate text (it could be used as a graduate level text), however, it could be used as a supplementary text in a number of fields, including sedimentology (geochemistry of sedimentary rocks, particularly Chapter 6 on greywackes), Precambrian geology (nature of the Archean crust, the Archean/Proterozoic boundary), geophysics (composition of the mantle crust-system), geochemistry (geochemistry of sedimentary rocks, use of Nd and Sr isotopic data, geochemical evolution of the earth), planetary geology (composition of planetary crusts, including the earth), and as an outline of scientific methodology. The up-to-date character of the book (many 1984, some 1985 references) enhances its utility.

Finally, the book is well illustrated, has many useful tables,and numerous footnotes, some of which are quite witty in their own right. Although the authors are based in Australia, world literature on the subject is well researched, and adequately summarized. This book is useful as a bibliographic summary alone.

At one time or another, every geologist has to deal with the problems posed by the continental crust. Even marine geologists have to deal with all of the detritus that works its way from land into their pristine basaltic basins. This book is an excellent buy at $23 US, because of the wealth of information it contains, its excellent synthesis of an enormous body of data on the earth's crust from its formation to the present, and the insights and models it provides into crustal evolution, particularly in the Archean. It belongs in the hands of Precambrian geologists, volcanologists, sedimentologists, geophysicists, geochemists, marine geologists, planetary geologists, students, and yes, even economic geologists.