Book Reviews / Critique

Book Reviews

Earth's Earliest Biosphere, its Origin and Evolution

Edited by J. William Schopf
Princeton University Press
562 p., 1983, $95.00 US; cloth,
$42.50 US; paper

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The purpose of this volume is twofold: (1) "to provide an integrated, up to date assessment of current evidence relating to the timing and nature of major events in the early history of life", and (2) to present the results of a research project of the "Precambrian Paleobiological Research Group" (PPRG), a group of geoscientists formed around J.W. Schopf at UCLA.

The book comprises fifteen chapters by twenty-one authors and spans the whole range of subjects that have paleobiological interest, from speculative articles, such as "Prebiotic organic syntheses and the origin of life" by S. Chang *et al.*, through factual accounts, such as "Isotope inferences of ancient biochemistries: carbon, sulfur, hydrogen and nitrogen" by M. Schidlowski *et al.*, to assessments of the biologic or non-biologic origin of microfossil-like objects by J.W. Schopf and M.R. Walter (for the Archean) and by H.J. Hofmann and J.W. Schopf (for the Early Proterozoic). The printing is superb, the volume is well illustrated, and all articles make interesting reading.

The volume succeeds well as an overview of previous research. It is, of course, the overview of one school of thought only: the reader should not expect to find much reference to the growing evidence for fairly high Archean oxygen levels. In table 3-1, W.G. Erust repeats the legend that detrital uraninite and pyrite are distinctive of Archean crustal rocks, whereas the typical Archean placer is, in fact, a banal sand with pyroxene and Fe-Ti ores; detrital uraninite and pyrite occur in specific (and rare) settings only. Nor should the reader expect discussion of new ideas such as that the interface between oxidizing and reducing environments provided in the surroundings of marine hydrothermal springs might have been important for the origin and early evolution of life.

The volume is much less convincing as a report of a research project. For example, the discussion of "Archean stromatolites: Evidence of the Earth's Earliest Benthos", by M.R. Walter, remains superficial because not one of the samples stems from a stratigraphic section that has been measured bed by bed; neither the lateral and vertical variation of stromatolite morphology, nor the precise environment in which they grew, are known. Thus, the basic data that would permit discussion of the ecology of the stromatolite-forming organisms are lacking. In a similar vein, J.W. Schopf and M.R. Walter compared the Warrawoona microfossils with modern micro-organisms, without biometric statistics; such a comparison is not convincing unless it is supported by statistical data.

All samples investigated by the PPRG are listed in Appendix One. I was surprised that all information on the stratigraphy and sedimentology of the samples was second-hand. Consequently, the authors have no positive evidence, for example, that the sulfide of the Isua rocks studied has a sedimentary origin. This is a serious weakness of the methodology because it casts doubt upon the number of interpretations of the chemical data. It is the opinion of this reviewer that sophisticated chemical analyses, as performed by number of authors of this volume, should be done with geologically well controlled material, not with grab samples.

Glacial Deposits in North-West Europe

Edited by Jurgen Ehlers
A.A. Balkema Publishers
470 p., 1983, $48.50, cloth

Reviewed by N.W. Rutter and N. Catto
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North-west Europe has served as a focal point for the investigation of glacial deposits since the initiation of the study of Quaternary geology. In recent years, research has gradually become directed towards sedimentological investigations. *Glacial Deposits in North-West Europe* presents a broad overview of sedimentological research currently in progress, while illustrating both the stratigraphic framework and some of the practical applications of the investigations.

The volume is divided into five sections dealing with deposits in Norway, Sweden, Denmark, West Germany and the Netherlands. Each section begins with a brief description of the glacial history of the country which serves as a convenient framework for integrating specific sedimentological studies. The papers which follow accurately reflect the main trends of sedimentological research in the individual nations. The six papers from Norwegian workers primarily are concerned with till lithology, glaciation and deglaciation chronology, marine clays, and sedimentation on the Norwegian continental shelf. Eleven papers from Swedish scientists deal with till sedimentology, moraine types and genesis, drumlin morphology and stratigraphy, ice flow directions and streaming, and the use of tills for mineral prospecting and construction. Glaciofluvial and varved glaciolacustrine sediments also are discussed. The nine contributions from Denmark include discussions of kinetostratigraphy and ice thrusting, till lithology and fabric, the incorporation of foraminifera and other fossil material into tills, and glacial mapping.

Workers from West Germany contributed eighteen papers dealing with a wide variety of topics. In addition to investigations of till lithology, fabric and genesis, and stratigraphic studies, reports on glaciofluvial deposits, subglacial valleys, paleosols, patterned ground, and the deposits of the German Bight of the North Sea are presented. The volume concludes with eight papers from the Netherlands concerning glacial stratigraphy, till lithology and sedimentology, ice-pushed ridges, and glaciofluvial and glaciolacustrine deposits.

The organization of the papers serves to emphasize the stratigraphic and geographic aspects of the work, somewhat at the expense of sedimentology. However, this organizational scheme is a convenience to the worker who is not entirely familiar with north-west European deposits. Fortunately, many of the topics discussed in each national section are similar enough to facilitate comparison and the development of a ready appreciation of the variation among sediment types throughout the region.

The volume is profusely illustrated, and the contributions for the most part are very readable. Although some papers are strictly of local or regional interest, others should prove intriguing to Canadian Quaternary scientists. The organization and the general absence of background material, however, make the volume unsuitable for use as a student text. We recommend *Glacial Deposits in North-West Europe* to Quaternary professionals, especially those interested in till sedimentology, lithology and genesis.

Great Geological Controversies

By Anthony Hallam
Oxford University Press
189 p., 1982, $22.75

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Amid the monotonous and, even if inspired, usually uninspiring drone of the speakers at geological meetings, there are just a few individuals who are always worth going to hear, since – even though one might disagree with their ideas – one knows they will give an entertaining and stimulating address. Among such persons are Stephen Jay Gould, Adolf Seilacher, Beverly Halstead and the author of this book, Anthony Hallam. They specialize not in the usual self-protective equivocations or obliquities of phrase, but in downright statements of ideas in a fashion that one cannot fail to comprehend. Though one might be irritated or even angered by what they might say, one will not be bored! Hallam writes (p. v):

> I like to classify scientists that I know into arm-wavers and nit-pickers – arm-wavers are better at dreaming up ideas, nit-pickers better at finding fault with them. Most of us, of course, are something of a mixture. Perhaps it is not too cynical to suggest that we tend to be arm-wavers when assessing our own ideas and nit-pickers in evaluating those of our colleagues, but we all recognize the value of fruitful interaction between the two types.

I would unhesitatingly identify Hallam as an arm-waver, and I honour him for it.

Good general histories of geology have been few. Adams' *The Birth and Development of the Geological Sciences* is a mine of information on the early stages of our discipline, but does not attempt to survey the last two centuries. Zittel's *History of Geology and Palaeontology* is full of detail, but virtually unreadable. Geikie's *The Founders of Geology* is lucid enough, albeit imbalanced; but surely it has been the Fentons' *Giants of Geology* – whatever its unreliability in detail – that has come closest to being enthralling, to stimulating an interest in the history of our discipline among those previously without such interest.

The exhiliration I have derived in the past from Hallam's lectures, and the intriguing title, made me wonder whether we had here a more modern and more authoritative successor to the Fentons' book. The title indicates a measure of selection, admittedly, but the Fentons were selective also; they chose to focus on particular contributors to the growth of geology, while Hallam has selected the particular controversies in which many of those figures were involved. Fair enough; then let us see how this theme is handled.

The first of the five controversies he has chosen for consideration is that between "Neptunists, vulcanists and plutonists". In this, a careful and readable account is given of Abraham Gottlob Werner's ideas and influence. However, in his interpretation of Werner's life and influence, Hallam relies too heavily on Cuvier's *éloge* and takes too little account of the very different picture emerging through the work of Ospovat in the U.S. and Seddon in Australia. There are some strange errors. Hallam cites the suffix used by Werner for his divisions in a non-existent singular form, *Gebirg* (p. 3), whereas, whether as a mining or as a topographic term, this should be the plural form *Gebirge* (the singular is *Berg*). Robert Jameson is misnamed "Jamieson" throughout and Johann Gottlob Lehmann as "Lehman". I wonder also whether Steno's work was "totally ignored by Werner", as Hallam states (p. 6) or simply unknown to him; is there evidence that Werner *was* aware of it? Nevertheless, there are some memorable phrases, as when Hallam notes cogently (p. 21) that

> A satisfactory dialogue is always difficult to conduct between people with totally different preconceptions.

In general, Hallam presents the opposing cases lucidly; his summation on the Neptunists' ideas (p. 24) seems to me especially percipient. However – and perhaps through inadvertence, since this work is extensively quoted in the next chapter – the influence, in the propagation of Plutonist ideas, of John Playfair's *Illustrations of the Huttonian Theory* (1802) virtually escapes mention, a serious deficiency in an otherwise good account.

Hallam's second theme is the confrontation between "catastrophists and uniformitarians". The account here is lucid and judicial, Charles Lyell's contributions being treated much more fairly and reasonably than in Mott T. Greene's recent *Geology in the Nineteenth Century* (1982). An interesting point is made when Hallam notes (p. 41) that

> Preoccupation with the Deluge was of much more concern in Britain than on the Continent, perhaps partly because some of the leading figures, such as Buckland, Conybeare, and Sedgwick, were clergymen.

There *were* early works in other countries, of course – those of the Dane Frederik Klee, best known in its French translation (*Le déluge,* 1847) and of the French Abbé Edouard Lambert (*Le déluge mosaique,* 1868) being examples; in the United States the topic has been considered from as early as 1836 (F. Fellowes, *Sacred History of the Deluge)* to as recently as 1966 (Whitcomb and Morris, *The Genesis Flood*). Nevertheless, it does seem that, in orthodox scientific thinking, no nation took the biblical event so seriously as did the British.

Surprisingly, no mention is made of Sir Richard Owen's attack on Lyell's science in 1851. It is disappointing also that Hallam has given so small a consideration either to the later opponents of uniformitarianism, such as John Murray III whose pseudonymous book ("Verifier" 1877, *Scepticism in Geology*) caused some ripples of disquiet in its time, or to such contemporary advocates of catastrophism as the highly influential, if markedly unscientific, Immanuel Velikovsky.

The third controversy to be tackled by Hallam is that concerning "The Ice Age". This chapter begins extremely well, with such almost forgotten contributors to the recognition of past glaciations as Perraudin

and Venetz being given proper honour, while the difficult relationship between Jean de Charpentier and Louis Agassiz is clearly expounded. To William Buckland is given due credit, here and on a later page (p. 156), for being prepared to abandon an energetically-expounded hypothesis when confronted with evidence that it was wrong; Sir Roderick Murchison, in contrast, would never admit an error, however flagrant! Hallam does not mention Ignatius Donnelly's late and eccentric theory that the drift deposits were a product of meteorite impact (*Ragnarok*, 1883) – perhaps understandably, since it convinced no one! However, I do feel that such energetic proponents of the concept of ice ages as John F. Campbell (whose anonymous two-volume exposition *Frost and Fire* appeared in 1865) and so unregenerate an opponent as Sir Henry Howorth (*The Mammoth and the Flood*, 1887; *The Glacial Nightmare and the Flood*, 2 vols., 1893; *Ice or Water*, 2 vols., 1905) merited mention, at very least.

Chapter 4 begins with a tiresome, if all too commonplace, mis-statement. Though Archbishop James Usher of Armagh (here mis-spelled "Ussher", presumably through confusion with the surname of the English stratigrapher W.A.E. Ussher) did indeed calculate the year of creation as 4004 B.C., it was not he but John Lightfoot of Cambridge who, as Edward T. Brewster puts it, "by methods comprehensible only to a theologian" (*Creation, A History of Non-Evolutionary Theories*, 1927, p. 108), identified creation week as 18th to 24th October, with the creation of Adam (not of the earth, as Hallam states) at 9 a.m. on October 23rd (not the 26th, as Hallam states). Despite such a bad beginning, the summary of the development of an absolute geochronology contained in this chapter is good and lucid, though surely the work of Lennart von Post's team of Swedish scientists on the counting of varves and the studies of carbon dating also merited mention?

Chapter 5, "Continental drift", seems to be an updated epitome of Hallam's own book *A revolution in the earth sciences* (1973) rather than an entirely fresh piece of writing. Perhaps as a consequence, it is both the longest and, to me, least satisfactory chapter. An inconsistency of treatment is one problem for the reader. The first names of the principal figures in the story are given sometimes in full (e.g., "Dr. [later Sir Harold] Jeffreys" p. 123), sometimes partially, e.g., Harry Hess (Harry H. Hess), sometimes in abbreviated ("Alex du Toit" for Alexander Logie du Toit, p. 133) or incomplete ("Tuzo Wilson" for John Tuzo Wilson, p. 145) form, or sometimes only as initials ("B. Sahni and R. Good", p. 134). The reasons why Wegener's drift hypothesis was not taken more seriously by his contemporaries are discussed; but Hallam seems not to perceive that Wegener's contemporaries regarded him as just the selfsame sort of wild visionary as the Velikovskys and von Denikens of today! Tuzo Wilson is mentioned as an authority (on p. 145) before being introduced properly into the story (on p. 146). References to "the Jaramillo event" (p. 145) are not explained. It is stated (p. 140) that no sedimentary rocks older than mid-Cretaceous have yet been discovered in the ocean basins, whereas in fact sediments from the mid-Jurassic, up to 180 million years old, are known from near the Marianas Trench and the eastern North Atlantic (see J. Sclater *et al.*, *J. Geophys. Res.*, v. 186, p. 11535, 11540). Though this is an assessment of a controversy, the "dissenting voices" (p. 150) still being raised against plate tectonics are not quoted, as surely they deserve to be. The judgemental balance of the earlier chapters is forfeited; this one becomes an expression of opinion on, rather than an assessment of, a controversy.

In a final chapter, "General Considerations", Hallam gives a brief overview of his earlier chapters, considers the story he has told in the light of the concepts of scientific history advanced by such philosophers as Popper and Kuhn, and speculates concerning likely future lines of research in the earth sciences. He notes (p. 168, 169-170),

> More and more researchers are treading well-worn paths and having to work harder and in more detail to discover something of real novelty . . . I consider it highly unlikely that there will be any dramatic change in the immediate future

I wonder if he is right. I am inclined to think *not*, for I feel that a growing knowledge of other planetary bodies in the Solar System may well furnish new evidence for the better comprehension of our own Earth – the motion of its plates and, perhaps, the ultimate causes of major extinctions, ice-ages and periods of unusual tectonic activity. However, Hallam's assessment is an interesting one and deserves to be pondered.

Hallam states in his introduction that, in addition to attempting an analysis of the controversies he deals with, he wishes to

> . . contribute towards the transmission of some fascinating pieces of intellectual history to a wider audience. I have frequently been dismayed during my years as a university teacher by the common attitude of students, and even some colleagues, who know little and care less about how the modern subject of geology has come about.

Has Hallam succeeded in reaching out to this wider audience, then? If he has not, the format of the book is in part to blame; the dull greyish-green cover and the entire lack of illustrations combine to repel the casual browser among geological shelves. Hallam's aptly chosen quotations and lucid phrases succeed often in pinpointing an idea or a problem in a fashion that will stimulate discussion among those already interested in this topic. However, he has not achieved that special lightness of writing style possessed by the Fentons, by which they interested and informed even the merest tyro in the geological sciences.

Perhaps it is unfair for me to feel some disappointment on closing this book; perhaps, on the basis of my enjoyment of Hallam's lectures, I had expected too much; yet that *was* my reaction. Well, anyway, read the book for yourselves; the price is modest and it should both enlighten you and set you thinking.

Mapping Geological Structures

By K.R. McClay
Geological Association of Canada
Short Course No. 2, Part I
221 p., 1984, $25.00 per 2-volume set

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Mapping Geological Structures essentially comprises three chapters with a short introduction and three appendices. Chapter one is concerned with basic mapping techniques, chapter two is an introduction to structural geology and chapter three is concerned with the analysis of data collected during mapping. The book presents nothing new and offers no new perspectives and draws heavily on textbooks and articles for its illustrations.

Chapter one starts at the elementary level of listing equipment needed in the field, giving suggested map symbols and explaining how to measure geological structures. It gives some sound advice on such topics as the choice of compass, measurement of dip and dip direction rather than dip and strike, and the need to continually interpret the map while in the field.

Chapter two is the major part of the book, and comprises 153 pages of the total 194 plus 27 pages of appendices. It is an introduction to descriptive structural geology with tables listing the data that should

be collected during mapping and the purpose of such data collection. Classification is emphasized, and the level is sometimes more appropriate to the specialist (e.g., fold classification based on Fourier analysis) than to the field-mapper. In general, however, the chapter suffers from the problems of any such condensed text in that it contains a number of generalizations that can be misleading.

The third chapter is an introduction to structural analysis with the emphasis on simple areas, i.e., areas that have been deformed only once. For such areas the treatment is adequate, but for more complex areas deformed more than once, as generally encountered in Canada, it is inadequate. There is very little description of the methods of analysis appropriate to such areas and no discussion of the limitations of the methods. This inadequacy is acknowledged by the writer, who continually refers the reader to more comprehensive texts.

Appendices 1 and 2 give dip, apparent dip and thickness relationships and the final appendix is a clear, elementary introduction to stereographic projection of the type that can be found in several texts.

Given the time constraints on such a short course, the publication suggests that this course was quite ambitious and probably very good. However, the notes do not seem particularly valuable to me as a *stand alone* publication. They would not, for example, serve as an adequate text for an undergraduate education in structural aspects of the mapping of deformed areas.

Production leaves much to be desired. The photographs are good quality photocopies at best, and several diagrams are illegible, due to poor reproduction.

Metal Deposits in Relation to Plate Tectonics

By Frederick J. Sawkins
V. 17, Minerals and Rocks
P.J. Wyllie, Editor in Chief
Springer-Verlag
326 p., 1984, $38.00 US

Reviewed by Raymond Goldie
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In this book Professor Sawkins reviews the geology of deposits of non-ferrous metals. Each chapter is devoted to the ore deposits of a particular tectonic regime.

The book is up to date: it mentions, for example, the Olympic Dam/Roxby Downs, Red Dog and McLaughlin deposits, "black smokers" and suspect terranes. In fact, of the 880 papers to which Sawkins refers, a third were published in the 1980s!

The book is very idiosyncratic. Sawkins emphasizes deposits he knows well and deposit types which he can easily relate to plate tectonics. For example, copper-bearing breccia pipes merit seven and a half pages, almost as many as porphyry coppers and considerably more than two paragraphs and a diagram allotted to the Witwatersrand district! Another, more heartwarming idiosyncrasy is Sawkins' attention to Canadian deposits and to the work of Canadian geologists.

After Don Sangster's devastating critique in 1979, it is surprising to see anyone still trying to force ore deposits into a plate tectonic classification. In fact, Sawkins' classification of ore deposits is doubly shaky, for it juxtaposes one level of interpretation (the tectonic setting) on top of another (the genesis of the ore). The Carlin-type gold deposits of Nevada illustrate my point. Sawkins considers the mineralization in these deposits to be of mid-Tertiary age. He interprets the mid-Tertiary tectonic regime in Nevada to have been that of a "principal arc". The Carlin-type deposits are, therefore, of "principal arc" type. Now: of what use is this classification to a geologist who believes at least some of the mineralization in these deposits to be of Silurian age? (Sawkins bolsters his classification of Carlin-type deposits by referring to "the tendency of gold deposits to form in relation to principal arc magmatism". I'm tempted to mutter "circular reasoning!")

Sawkins mentions suspect terranes only briefly. What a pity: here is one area where plate tectonics can actually be of use to the economic geologist. The recognition of suspect terranes can enable one to identify the limits of metallogenic provinces, and to outline areas which may contain their extensions.

The book would have been improved had Sawkins consistently tabulated the range of size and grades characteristic of each deposit type. As Julian Boldy has pointed out (1977), the exploration geologist should have in mind not only the type of deposit but also the size of deposit being sought.

Because this book is so up to date, it is not surprising to find a few loose ends, such as material tacked on at the last minute and sections which properly belong elsewhere in the book. I counted numerous novel spellings (such as "hostrocks"), but less than thirty typographical errors. The diagrams are clear and consistent.

I recommend this wide-ranging, up to date book to anyone embarking on a survey of the literature of metallic mineral deposits. However, for a geologist who does not have time to chase references, the best comprehensive modern review of metallic mineral deposits is the 75th Anniversary volume of "Economic Geology" (with some supplementary articles to make up for the blind spots).

Mesozoic and Tertiary Geology of Southern Africa

By R.V. Dingle, W.G. Siesser and A.R. Newton
A.A. Balkema Publishers
1983, 384 p., 1970 figs., $39.50 US; cloth

Reviewed by L.F. Jansa
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This book undoubtedly provides the most comprehensive review of the Mesozoic-Cenozoic geology of southern Africa. The area covered includes South Africa, Namibia, Mozambique, Botswana, Lesotho and the Falkland Plateau. The authors also incorporate geology of the adjacent continental margins and the deep ocean basins.

Each of the seven chapters is profusely illustrated with stratigraphic columns, geologic cross-sections, maps, graphs and tables. Chapter one gives a brief introduction to the post-Paleozoic, regional setting of South Africa and a current view of the plate tectonic evolution of southern Gondwanaland. The authors critically assess the available data and point to several contentious issues in the plate tectonic interpretation of this part of the globe. These include the origin of shallow ridges, such as of the Agulhas Plateau and the Mozambique Ridge; the position of the ocean-continent crustal boundary, and the contradictory evidence regarding the predrift position of the Falkland Plateau. The author's conclusion that du Toit's (1937) Gondwanaland reconstruction is proving to be essentially correct, despite additional data and constraints provided by oceanic magnetic lineations, demonstrates the power of land geology and is a tribute to du Toit's genius as a geologist.

Chapter 2 is a detailed description of Triassic to Lower Jurassic rocks present in two major intracratonic basins, the Karoo Basin and a basin centred in Botswana. A non-South African geologist appreciates clarification of complex Karoo Supergroup stratigraphy, which encompasses the Permian to Early Jurassic. Though the authors consider the Permian-Triassic boundary in the above basins as reasonably well established from tetrapod fauna, according to Waterhouse and Stapleton this boundary

might be stratigraphically in the upper Late Permian. According to Dingle *et al.*, the Cape orogenesis (to which chapter 3 is devoted) occurred during the Middle Triassic. If we agree with Waterhouse, then the tectonic event occurred near the Permian-Triassic boundary. The Triassic-Jurassic boundary in South Africa is also poorly defined on the evidence of fossils and is based on absolute age dates of lavas (approximately 190 m.y.).

Chapters 4 and 5 outline the lithostratigraphy and biostratigraphy of the Middle to Upper Jurassic and the Cretaceous around the continental margin of southern Africa. The authors stress the contrast in sediment basin shapes resulting from variations in taphrogenic and epeirogenic styles and crustal subsidence. During the Middle Jurassic the depocentres shifted from mid-continental positions to the continental margin. This was accompanied by horst and graben development. This taphrogenic phase is considered by the authors to be contemporaneous with the onset of drift in the southern Atlantic. The base of the post-taphrogenic period is placed in the Early Albian, when margin subsidence became more uniform. Euxinic conditions in the southern Atlantic terminated at this time and normal marine conditions were established.

The economic potential of the Tertiary, such as the occurrence of glauconite, phosphatic rocks, diamondiferous sediments and oil exploration, is treated in chapter 6. Apart from the Kalahari Basin where only continental deposits accumulated, the Tertiary outcrops are restricted to the coast, shelf and slope areas. The stratigraphic discussion incorporates results of deep sea drilling, occurrence and origin of phosphatic rocks on the southern and western shelves off South Africa and the description of duricrusts, common in the Kalahari Basin. The chapter includes an excellent summary of Tertiary paleogeography and sea level fluctuation.

The final chapter, chapter 7, briefly reviews Mesozoic-Cenozoic igneous activity, which was intermittent from the Triassic into the Tertiary. The seven igneous events recognized by the authors are related to the various plate tectonic processes in South Africa. It is understandable that the best summary of paleogeography, paleoceanography and sea level changes is provided by the authors for the Tertiary; however, similar summaries in previous chapters are much less informative and less complete. The reader is thus left with the tedious job of plotting data from various basins, a task which could have been done better by the authors. The absence of such summaries does not facilitate an understanding of the complex Triassic-Jurassic evolution of southern Africa. A minor weakness is the improper use of adjectives with stages. In most cases the authors use Lower and Upper (for example Lower Albian) for both geochronology and chronostratigraphy, instead of using Early and Late where time is concerned.

A major feature of the book is the wealth of good illustrations throughout. I would prefer to see more photographs, particularly of field exposures and rocks, and a use of normal lithological symbols in the stratigraphic columns rather than a bar scale, but that is a personal preference. One or two figures have minor shortcomings, for example, Figure 192 has some abbreviations which are not explained in the caption. But these are trivial matters. The text is well written and the printing is of good quality.

The book represents a major advance in our knowledge of the Mesozoic-Cenozoic systems of southern Africa, and represents a great achievement for its authors. It fills a void in the literature and may serve as a standard for other similar compilations to follow. The book is reasonably priced and should be bought by students of Mesozoic-Cenozoic geology, stratigraphy, marine, petroleum and exploration geologists, and university libraries.

Structural Geology of Stratiform Lead-Zinc Deposits: Case Histories

By K.R. McClay
Geological Association of Canada
Short Course No. 2, part II
150 p., 1984, $25.00 per 2 volume set

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These notes were prepared for a Geological Association of Canada short course given in Vancouver in January, 1984 on "Mapping geological structures" (part I) and on the structural geology of a number of stratiform lead-zinc deposits (part II)). Part II, which is discussed in this review, briefly examines the geology of the Mt. Isa, Sullivan, Tom and Cirque deposits; it emphasizes their structural setting, structural controls, and ore fabrics and textures. The notes include the results of the author's own research on these deposits, and presents some previously unpublished work, but in keeping with most short course notes, generally reviews material previously published. The text is well written, free of errors, and adequately illustrated, although photographs are not well reproduced. References are kept to a minimum, but are sufficient to allow the interested reader to delve more deeply. The notes are aimed at the non-specialist, or a user audience – geologists involved in the exploration or development of a sulphide deposit – but as well provide excellent introductory and background material for a novice researcher.

Chapter 2 reviews the tectonic, stratigraphic, structural and metamorphic setting of the Mt. Isa deposit. It briefly describes the two main deposit types that occur in the host Urquhart Shale Formation, silver-lead-zinc lenses in dolomitic shales and copper orebodies in recrystallized "silica dolomite". The major section of the chapter describes, in fair detail, various fold structures and related fabrics, and the effect of bed thickness and competency on the style of deformation. In the final section, the author briefly reviews evidence for his conclusion that most, if not all, the observed folding is tectonic in origin.

Chapter 3 outlines the geology of the Sullivan deposit, a 160 million tonne Pb-Zn-Ag deposit in Proterozoic metaclastic rocks in southeastern British Columbia. This chapter is essentially a condensed version of a recently published paper by McClay in *Economic Geology* (1983, v. 78, p. 1398-1424). The regional setting, as well as local deposit geology, are reviewed, followed by a more detailed structural analysis that describes several phases of folding or faulting that affect the Sullivan deposit. The author concludes that nearly all folds observed in the sulphide layers result from tectonic deformation rather than from soft sediment or synsedimentary slumping, a view that must still be considered controversial.

Chapter 4 deals with the Tom deposit, a 10 million tonne stratiform Pb-Zn-Ag-barite deposit in Devonian shale in the Selwyn Basin in the Yukon Territory. Considerable new and previously unpublished data are presented, as well as a review of the regional geological setting, the stratigraphy and the mineralization of the deposit itself. As in the two previous chapters, descriptions of observed structures, petrofabrics and textures are a major section in the chapter, well illustrated with plans, sections, stereoplots and photographs. McClay concludes that although some diagenetic textures are preserved, the ore is significantly recrystallized and the observed structures are tectonic in origin.

The geology of the Cirque deposit, a recently discovered barite-lead-zinc deposit in Devonian carbonaceous shales in northeastern British Columbia, is reviewed only briefly. The last two sections in the chapter

describe both depositional/diagenetic and tectonic ore textures.

Chapter 6 is essentially a review of a paper by McClay and Ellis (1983, *Mineralogical Magazine*, v. 47, p. 527-538) that discusses deformation and recrystallization of pyrite in a number of deposits that range in metamorphic grade from subgreenschist to upper amphibolite facies.

Chapter 7 reviews briefly "the aims of structural analysis of stratiform lead-zinc deposits", the distinction between tectonic and synsedimentary structures, the identification and development of ore textures and fabrics, and sulphide rheologies. it concludes with a discussion of the implications of structural studies of ore deposits to genetic models and mineral exploration.

These short course notes are a good introduction to, and summary of, methods used in studying the structural geology of lead-zinc deposits (as well as other massive sulphide deposits). The notes are exemplified by case histories of deposits studied by McClay, and contain reviews and summaries of articles published in journals or texts that may not be readily available to a large audience. The notes will make a valuable addition to libraries of companies or individuals involved in the study, exploration or development of mineral deposits.

Trace Elements in Coal Volumes I and II

By Vlado Valkovic
CRC Press, 1983
Volume I, 210 p., $75.00;
Volume II, 281 p., $96.00

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Trace elements in coal are of major importance: they may catalyze or retard reactions during combustion, gasification or liquifaction (e.g., Fe, Ti), some are pollutants (e.g., Hg, As, Se, Sb), and others may be of economic importance (e.g., Ga, Ge). Considerable research has been directed towards resolving the origin, distribution, recoverability, environmental effects and methods of analysis of trace elements in coal. Much of the research is, however, hidden away in government publications or journals unfamiliar to most earth scientists. In *Trace Elements in Coal* Vlado Valkovic presents a comprehensive summary of elements in coal and, perhaps most importantly, reveals the residing place of a great deal more literature on the subject than most of us would have believed existed. *Trace Elements in Coal* is a two-volume set but could have easily (and more cheaply?) been published as one volume. Volume One includes two chapters: (1) Coal, – origin, classification, physical and chemical properties; and (2) Trace elements in coal. In Volume Two there are three chapters: (1) Coal utilization; (2) Environmental considerations; and (3) Methods of Analysis.

Volume one, chapter one, provides useful background on the origin and distribution of coal deposits and some of the chemical and physical properties of coal. Such diverse aspects as the electrical conductivity and pore structure of coal are examined in sufficient scope that no prior knowledge of coal is required, and the text can be easily followed by the non-specialist. Unfortunately, the subject matter is treated unevenly and those subjects discussed with which I am familiar include a number of significant errors. For example, factors influencing coal rank are only briefly mentioned and the reader is left with the incorrect impression that anthracite forms in response to folding. In chapter 2 the mode of occurrence of trace elements is discussed with reference to organic and inorganic affinity and this is followed by a cataloguing of the occurrence, concentration and significance of each element. For some elements, such as osmium, this requires a short sentence, whereas for other elements, such as mercury, two pages of text are devoted to documenting, in addition to its mode of occurrence and abundance, its fate during combustion and analytical methods.

In the first chapter of Volume Two Valkovic describes in some detail the importance and fate of elements (not just trace elements) during combustion of coal, with particular reference to partitioning of the elements into fly ash, slag or bottom ash and volatiles. Included in this chapter is an overview of desulfurization and recovery of such elements as Al, Ge, Ti, and U. The first chapter concludes with a brief summary of coal liquifaction and gasification technologies, but here Valkovic fails to emphasize the importance of the elements and simply reviews state-of-the-art coal conversion technology. Notably absent in this chapter is a discussion of the importance of elements in metallurgical coal and coke. The major part of the chapter, a section entitled Environmental Considerations, is devoted to air pollutants from coal-fired plants, but mention is made also of sludge, bottom ash and disposal of residues. Included in this section is an outline of the measures used to clean coal in order to reduce pollutants, with particular emphasis on sulphur and nitrogen emissions. Additional problems associated with emission of radionuclides, and the potential impact of coal conversion technology are discussed together with a very brief, and somewhat inadequate, section on biological and health aspects of coal use.

The last chapter, Methods of Analysis, is the subject for which Valkovic is best known, with several books on trace element analysis to his credit. In this chapter the common and some not so common methods of analysis are outlined. Regrettably, there is little discussion of the pros and cons of the different analytical methods for the elements, and the section "Comparison of Different Methods" is inadequate for anyone wishing to select a method of analysis.

The merits of *Trace Elements in Coal* are many. The volumes are an excellent summation of the elements in coal (not just trace elements) and are by far the best compilation to date, and thus represent a very valuable contribution. Sufficient background information is provided so that the non-specialist will have little trouble following even the most technical aspects discussed. One of the greatest values of the volumes is the excellent collection of references, but unfortunately the numerical system of in-text referencing is used. The most negative aspect of *Trace Elements in Coal* is that much of the text comprises paragraph after paragraph of what was discovered by research at a particular coal-fired plant or on a particular coal seam, and Valkovic does not draw conclusions or summarize what all these results mean; the readers are left to draw their own conclusions – no easy task in some sections. Minor annoyances include the inconsistent use of units (i.e., C and K) and scientific notation, and the occasional poorly constructed sentence.

Anyone seriously interested in elements in fuels or pollutants in general should have access to *Trace Elements in Coal.* The volumes are not casual reading, but do contain a wealth of information that can be understood by the non-specialist. For those who consider trace elements important but not particularly exciting, these volumes offer no surprises.