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Book Reviews

The Nature and Timing of Orogenic Activity in the Caledonian Rocks of the British Isles

Edited by A.L. Harris
Blackwell Scientific Publications
 [for the] *Geological Society of London*
 Memoir Number 9
 53 p. plus 3 maps, 1985; \$55.00, paper

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This Memoir consists of three coloured maps accompanied by an explanatory text:

1. Caledonian Igneous Rocks of Britain and Ireland: Scale 1:2,000,000; compiled by G.C. Brown, E.H. Francis, P. Kennan and C.J. Stillman;
2. Time of Deformation in the Caledonide Orogen of Britain and Ireland: Scale 1:1,000,000; compiled by D. Powell and W.E.A. Phillips;
3. Grade and Time of Metamorphism in the Caledonide Orogen of Britain and Ireland: Scale: 1:2,000,000; compiled by D.J. Fettes, C.B. Long, R.E. Bevins, M.D. Max, G.J.H. Oliver, T.J. Primmer, L.J. Thomas and B.W.D. Yardley.

These maps constitute a British and Irish contribution to the series of thematic maps that were a primary goal of the International Geological Correlation Programme Project #27 "The Caledonide Orogen". These maps present the results of a major compilation effort, and as Britain and Ireland represent a complete cross-section of the Caledonide Orogen, they provide essential data bases for an understanding of the genesis of the Caledonide Orogen not only in Britain and Ireland, but in correlative areas up and down the orogen. Furthermore, the long history of detailed geological research in Britain and Ireland provides more complete data bases for the compilation of such thematic maps than is available in most other parts of the world. This allows greater insights into the genesis of this part of the Caledonide

Orogen which may be applicable to other orogens around the world. As such, these maps should be on the shelves of all geologists interested in the genesis of orogenic belts. The most unfortunate aspect of the maps is the lack of geographical place names on the base map and the absence of names of volcanic suites, plutons and of individual major structures referred to in the text, except for a few on the metamorphic map. This makes it very difficult for a reader unfamiliar with the detailed geography of Britain and Ireland to go from the text to the maps.

The igneous rock map uses the colours for the age of the rocks. The plutonic rocks are distinguished from the volcanic by lighter shades of colour, however, the distinction is difficult to see on the map: a superimposed pattern would have eliminated this problem. The other information on the igneous rocks, such as silica content, Streckeisen classification, essential minerals, age, affinity (tholeiitic, calc-alkaline, alkaline) and mode of occurrence are contained in coded information in notes around the map. Such a method of presentation makes it very difficult for the user to gain an appreciation of the regional trends without a great effort. This could have been achieved by time-and-space diagrams and time slice maps emphasizing other parameters. Unfortunately, this was not presented on the map or in the text.

Of the three maps, the time of deformation map best uses the cartographic options to display the information. On the time of deformation map, the colours are reserved for the time of first deformation with subsequent deformation indicated by coloured dots. Black lines show individual structures, patterns are used to distinguish pre-, syn- and post-tectonic intrusions and the age of volcanic suites, and isotopic ages are plotted directly on the map. The accompanying text provides a more thorough analysis of the compiled data than the other two sections. It makes good use of columnar diagrams to summarize the constraints on the times of deformation in each zone. The main criticism is the lack of an integrated synthesis to show the regional changes from zone to zone and across the whole orogen. An apparent lateral change in the onset of the

deformation occurs between the Southern Uplands and the Longford-Down Massif. However, the change is abrupt and occurs across the Irish Sea: could this be an Irish-Scottish national boundary fault?

The metamorphic map shows the grade of peak metamorphism in colours with polymetamorphic areas indicated by coloured dots. Some isograds are plotted along with some key mineral localities and patterns to indicate pre- and post-metamorphic igneous rocks. An inset map shows the age of the main metamorphism in colour. The combination allows the reader to clearly see the regional trends in the metamorphic grade with time. If this had been supplemented by time-and-space diagrams in the text, it would have provided a superb synthesis of the metamorphic data, however this latter aspect is sadly missing. In fact, the brevity of the text leaves much to be desired.

Finally, a synthetic chapter relating the information on the three maps and their significance in terms of the genesis of the orogen would have been a natural conclusion. Nevertheless, the data bases for the British and Irish Caledonides are now available for the reader to construct their own synthetic models, and to allow comparisons with other parts of the Caledonide Orogen and other orogens around the world.

Magma and Magmatic Rocks: An Introduction to Igneous Petrology

By E.A.K. Middlemost
Longman, London
 286 p., 1985, \$37.50, paper

Reviewed by D.B. Clarke
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For many established igneous petrologists, the name Eric Middlemost is associated with thorough review articles about igneous processes and igneous rocks. In *Magma and Magmatic Rocks*, Dr. Middlemost directs his reviewing talents to the entire igneous spectrum, and the processes that are responsible for it.

The first two chapters deal with the origin, properties, movement, emplacement, eruption, and differentiation of magmas. The next two chapters are concerned with classification and distribution of magmatic rocks. Then ten chapters, averaging 14 pages each, generally cover the occurrence, modal mineralogy, texture, geochemistry, and petrogenesis of: basalts, andesites, trachyte-syenite, dacite-rhyolite, granitic rocks, anorthosites, ultramafic rocks, alkaline rocks (including lamprophyres), kimberlites, and carbonatites. The last chapter is a somewhat philosophical treatment of the importance of magmatism in the solar system/cosmos.

As "An Introduction to Igneous Petrology", the book has both strengths and weaknesses. On the positive side, the text is very readable despite its many grammatical and editorial errors. It is informative, balanced in its presentation, and matter-of-fact in its treatment of the various petrological groups. To its credit, the book offers multiple working hypotheses in the petrogenetic sections, and does not advocate any particular school of petrogenetic thought. On the negative side, however, the author clearly believes more in the power of the written word than in the illustration, and more in the importance of the table of modal or chemical data than in the variation diagram. For example, the chapter on granites has seven tables but no figures of any kind, neither maps, cross-sections, variation diagrams, phase diagrams, nor cartoons. In fact, in the ten chapters on the various rock types, there is a total of only five figures, three of which are in the chapter on basalts. For a book directed at the "TV Generation", this type of approach is either a deliberate challenge to the student to put the *logos* back into petrology, or it is a serious misreading of the market. [There are two, two-page inserts of colour plates (ten field shots and twelve photomicrographs),

but these do not compensate for the lack of illustrations elsewhere in the hectares of unbroken text.] Another difficulty with the book is that it does not give enough recognition to the important contributions of experimental petrology (phase relations, geothermometry, geobarometry), trace element geochemistry, and isotope geochemistry for the substantial contributions they are making to the solution of petrogenetic problems. In other words, the approach belongs somewhat to "the old school" of modal mineralogy, textures, major element geochemistry, norms, and folkloric descriptions of suites from classic localities.

Magma and Magmatic Rocks is a useful reference book for a practicing geologist; comparably thorough companion volumes for metamorphic and sedimentary rocks would be highly desirable. However, as a textbook for an introductory course in igneous petrology, it does not communicate effectively either the practical field and petrographic skills, or the current excitement of isotope geochemistry and plate tectonics, to the novice petrologist.

Earthquake Prediction

By Kiyoo Mogi
Academic Press, Toronto
 355 p., 1985; \$117.95, cloth

Reviewed by Lalu Mansinha
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On February 4, 1975, an earthquake of magnitude $M=7.3$ struck in Liaoning Province, around the city of Haicheng, China. This was a historical event. For the first time, a major earthquake had been predicted; the populace had been warned and protective measures taken. The successful prediction gave added optimism and impetus to the research program in earthquake prediction already underway in Japan, the United States and the Soviet Union. For a while, there was the feeling that earthquake prediction was within reach.

The physics of the earthquake process is conceptually quite simple. Tectonic plates slide past each other along boundary faults. At any given time, the plate motion appears to be blocked around certain regions. Because elsewhere the motion continues, the plates deform in the vicinity of the blockage. The amount of deformation increases

with time until at some point rupture ensues. The plates jerk past each other, causing the earthquake.

The major effort in earthquake prediction is in identifying the blocked regions and deploying a network of instruments to detect the level of accumulated strain. The strain may be monitored through several direct and indirect effects. Unfortunately no single measure of strain has turned out to be a reliable predictor of an impending earthquake.

The technical perfection of the detection of precursors is but one aspect of earthquake prediction. There are social and political considerations. It is reasonable to expect occasional failure to forecast, both in time and space, of a number of earthquakes. Strategy to prevent cynicism in the public must be well thought out. There is also the question of protective measures. In a regimented society evacuation is a choice. After a few failures, it is not clear that the citizenry in a free society will evacuate the urban areas. Possibly the only true method of minimizing injury and loss of life is to campaign for stronger, earthquake resistant structures. Well policed tightening of the building codes is necessary.

The book by Professor Kiyoo Mogi provides a readable and authoritative survey of the present state of earthquake prediction. But the concentration is on the technical aspects of the problem. About a third of the book is general introduction to the physics of strain accumulation and the physical effects through which they can be measured. In spite of the general sounding title, the remainder of the book is devoted to case histories and the current state of ongoing regional programs in Japan. Still, the book is both informative and interesting.

Success of the research effort in prediction is not yet in sight. The prediction of 1975 Haicheng earthquake appears to have been an isolated success. The vagaries of prediction is illustrated by the failure to predict the 1976 Tangshan, China, earthquake. Estimates of casualties due to this earthquake vary, from 250,000 to 750,000, making it one of the most destructive earthquakes of modern times. In the United States, no precursors were observed prior to the 1979 Coyote Lake earthquake in central California, which occurred near a zone with extensive instrumentation. This has resulted in a sense of wariness and pessimism.

The style and the level of the book will appeal to the non-specialist. For the earthquake seismologist it can be a handy reference. The book is a must for institutional libraries. At over a hundred dollars it is a bit pricey for individuals. Parts of the book can serve as a text for graduate and undergraduate courses on earthquake seismology.

Mantle Metasomatism

Edited by M.A. Menzies and
C.J. Hawkesworth
Academic Press, Toronto
472 p., 1987; \$131.00, cloth

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Although most people would, no doubt, regard diamonds as the most valuable objects to be found in kimberlite pipes, there are other inclusions which, in the world of theoretical petrology, may, on occasion, generate almost as much interest and excitement as diamonds — these are the fragments of the upper mantle which have been entrained in ascending kimberlites (as well as in other alkaline mafic lavas) and are now present at the surface as xenolithic blocks. These high-pressure, ultramafic rocks have attracted much interest since it was first realized that they are, in fact, samples, otherwise unobtainable, of the Earth's mantle. Detailed petrological studies have since shown that they contain mineralogical and chemical evidence of metasomatic events which have, apparently, taken place within the mantle; study of this metasomatism has intensified during the last decade and important questions, such as its possible role as a precursor to continental rifting and/or basaltic magmatism are now being discussed. This volume is a collection of eleven papers by some of the workers currently active in investigating the process and its possible consequences. Although the contributors are all from the academic world, many of their names will be familiar to geologists who have been involved in diamond exploration during the last ten or fifteen years, since they are also known for their work on the economic aspects of the geology and mineralogy of kimberlites.

The volume is divided into three parts. Part I consists of two papers in which some of the theoretical and experimental constraints on the generation and movement of metasomatic fluids and magmas within the mantle, are reviewed. F.J. Spera discusses the mechanism and dynamics of the ascent of alkaline magmas and metasomatic fluids through the lithosphere, while D.H. Egglar reviews experimental data related to the possible role of low density fluids in mantle metasomatism.

Part II contains seven papers in which results of petrographic, mineralogical and geochemical studies of xenoliths recovered from kimberlites and alkaline volcanic rocks from many classic localities in Africa, Europe and North America, are presented. These papers, which contain abundant whole rock,

trace element, isotopic and mineralogical analyses, as well as meticulously detailed petrographic descriptions and illustrations, will surely become a standard source of fundamental information concerning these intriguing rocks. Most of the contributors distinguish between modal metasomatism, which has resulted in the actual replacement of early mineral phases by later, hydrous minerals, and cryptic metasomatism, in which incompatible element enrichment of the rocks has occurred without visible petrographic changes; abundant evidence of the reality of both types is recorded. The possible role of mantle metasomatism as a precursor of alkaline magmatism is alluded to by several of the contributors while both F.E. Lloyd and J.B. Dawson discuss the possibility that metasomatism, involving the introduction into the upper mantle of light oxides such as K_2O , H_2O and CO_2 , might, locally, decrease the density of the mantle and cause regional uplift and rifting. This mechanism might also help to explain the close relationship in time between uplift and strongly alkaline magmatism.

Part III consists of three papers which review recent data on the isotopic and trace element composition of recent volcanic rocks of purported mantle origin and discuss whether any aspects of their geochemistry can be attributed to mantle metasomatism. The consensus is that available evidence is not yet strong enough to establish such a link; more work must be done on both the xenoliths and the extrusive rock before the relationship, if any, between metasomatism and magma generation in the mantle can be fully understood.

Overall, this is an excellent update on developments in an interesting field of petrological research. The book is well produced and edited (typos are practically nonexistent) and the illustrations, both geochemical plots and photomicrographs, are, with a very few exceptions, lucid and pertinent. One of the contributors, F.E. Lloyd, uses black and white drawings, rather than photomicrographs to illustrate petrographic features and demonstrates, as Harker did many years ago, that such drawings can be even more effective than photographs in illustrating textures. Two notable omissions are firstly, the lack of any contributions from Russian petrologists, who have done a great deal of work on xenoliths in kimberlites, and, secondly the lack of an abstract along with each paper. The first of these may have been beyond the control of the editors, but the lack of abstracts is more difficult to understand. Abstracts are especially useful for the non-specialist who wishes to keep abreast of significant developments in this field without ploughing through pages of detailed results and discussions; however, the hefty price attached to this volume may ensure that it seldom falls into the hands of a non-specialist!

Geology of Sedimentary Phosphates

By Maurice Slansky
Elsevier Science Publishing Co., New York
210 pages; 1986; \$45.00US, cloth

Reviewed by R.L. Christie
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The original version of this book, *Géologie des phosphates sédimentaires*, appeared in 1980, published as a Mémoire of the BRGM (Bureau de Recherches Géologiques et Minières), France. Project 156, Phosphorites, of the International Geological Correlation Programme (IGCP) had begun in 1977, and within a short time many of the world's phosphate researchers had formed a close community through the improved communication engendered by the project. Slansky's first slim "mémoire" (95 pages), concise but covering the important practical aspects of sedimentary phosphates, was a most useful introduction for researchers new to the field, or in need of an authoritative review. The new book, first published in English in 1986 by North Oxford Academic Publishers Ltd. in association with BRGM, is much more than a revised version of the original, however. As the author himself remarks, the international co-operation obtained through Project 156 resulted in a substantial increase in knowledge and understanding, and the new version reflects this through a more comprehensive treatment of many aspects of phosphorites.

Phosphorite, or marine sedimentary phosphate rock, is the world's main source of phosphate for agricultural fertilizers; this material has become an essential one for developed agricultural countries because of the ever-increasing demand for food, and for developing countries because of their need to free themselves from dependence upon the costly international fertilizer market or from the uncertainty of food production on marginal agricultural land. Phosphorite is not a rare rock; the problems lie in prospecting for an ore that is easily overlooked, and in finding this ore, high in bulk but of low unit value, near the localities where it can be used, or treated.

The heart of Slansky's book is Chapter 5: Mechanisms of Phosphate Sedimentation and Phosphatite Accumulation. It is here the reader finds the "literate" part of the book, where nuances and the author's intuition enliven the subject for the reader. The other chapters are essentially thorough, but terse, notes on basic aspects of sedimentary phosphates, so of course do not provide a satisfying "read" — not a disadvantage in that no book in a specialized field is meant to be read from beginning to end!

A brief review of evident sources of P (continental, from leaching of soils; oceanic, with ultimate source unknown – volcanic supply appears later), is followed by answers to the great question: how did those vast quantities of arenite-grade phosphorite in the major deposits form? Slansky draws on his extensive experience and wide reading to discuss, first, environments and locations for phosphate formation, then the possible styles or manners of formation. As might be expected for such a variable and complex rock, phosphorite evidently can be derived through more than one route: the "gel, dehydration, crystallization, replacement" theory of Baturin (published in 1969 and later) is discussed, as is the model of Burnett (1974) and others of direct precipitation from interstitial water in muds. Which factors — e.g., CO₂ production, Ca availability, pH, Ca/Mg ratio — are critical is still not clear.

Slansky's favoured model, however, is clear and convincing: the biogenic element in the origin of phosphorite is more than simply that of biological concentration of P from ocean water (e.g., through phytoplankton). Living and recently living organic matter extends throughout the phosphorite story: humic acid, bacteria, and enzymes appear at many levels. Of apatite precipitation within the marine ooze, Slansky (p. 119) suggests "The formation of a phosphate grain seems ... to begin by the coating of an appropriate surface with humic acids ... precipitation of phosphate is ... triggered by the acids themselves and not directly by the surface ... phosphate pellets [may] form around no more substantial a seed than a humic acid molecule, or a group of such molecules".

This book, even in its more expanded chapter (5), has not the detailed reasoning of, for example, papers in Nriagu and Moore's 1984 "lexicon" volume. But Slansky's book is a review that covers the entire field of sedimentary phosphates, from sources and origin through prospecting and mining to an overview of the world phosphate industry. Systematic organization of the book into numerous headings and subheadings helps the reader find the data and ideas quickly. The author's practical BRGM background is apparent: the book is oriented to *understanding* how and where phosphorites form with the goal of being able to *find* economic deposits of this useful and irreplaceable earth resource.

Thermal Phenomena in Sedimentary Basins

Edited by B. Durand
Published by Éditions Technip, Paris
326 p., 1984; \$121.50, paper

Reviewed by Ian Hutcheon
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This soft cover volume is a collection of papers from a symposium held in Bordeaux in 1983, and as such is somewhat out-of-date. The papers are all in English and are presented in camera-ready form. The quality of presentation and content is highly variable. Some are merely point-form comments with copies of illustrations, presumably from the original oral presentation. Others are much more complete. The objective of the meeting that spawned this volume was to gather an interdisciplinary group of researchers to discuss the many aspects of thermal processes in Sedimentary Basins. This is a worthwhile goal and as a meeting it may have been successful, but the book is not.

The papers cover a range of topics including the Earth's thermal history, heat flow measurements, subsurface paleotemperature-temperature measurements, fluid inclusions, fission tracks, isotopic compositions, clay mineral reactions, thermal maturation, kinetics applied to thermal maturation, reconstruction of geothermal gradients, models of fluid flow and the influence of fluid flow on distribution of thermal gradients, models of petroleum formation, models of basin evolution (Rhine Graben, North Sea and Gulf of Lion), and relationships of formation waters and ore deposits.

There are too many separate papers, some of them two pages in length, to present a summary of each paper. Choosing the "best" papers is difficult because a broad range of topics is covered and such a choice is inevitably rooted in background and personal preference. Some topics have more meat than others and these include papers on thermal modelling of maturation data, some of the papers on modelling of heat and fluid flow and the paper on applications of the fission track "chronothermometer", a method to measure time and temperature. Storzer and Selo provide a detailed summary, particularly of the use of annealing as a method to determine the thermal history of fission tracks in apatite. Two examples of the use of tracks are given that highlight the potential of this powerful tool.

There is a series of papers on thermal modelling using organic geochemical data coupled to various geological models. MacKenzie presents a kinetic model for organic

maturation and links this to a "geophysical" model. The model is then applied to some basins to generate thermal history scenarios. Unfortunately this chapter is too short to guide the novice, and, I suspect, too general for the specialist. For those interested in Canadian examples there is a chapter on the Nova Scotia continental margin, co-authored with Beaumont. Espitalié uses the fit of vitrinite reflectance data to reconstruct paleogeothermal gradients. The paper does not give many of the details of the models used, but does present a solid starting point for anyone interested in pursuing similar methods.

Two other papers related to mineral reactions in sedimentary basins are presented. Velde gives a review focussing on illite-smectite diagenesis. Fritz *et al.* give an interesting account of the use of Sr isotopic data in examination of carbonate cements. The paper is brief, but does give a reasonable picture of the relationship of fluid flow to mineral diagenesis.

The other topics covered in the book are covered much more completely in other sources. For example the papers on isotopes, while interesting, are largely superseded by short course notes produced by the Mineralogical Societies of Canada and America. The same is true for the paper on fluid inclusion applications. The volume *Geochemistry of Hydrothermal Ore Deposits* or short course notes published by SEPM are better starting places than this volume for anyone interested in basin waters.

In summary, this book has a noble purpose, to integrate many studies that relate to the understanding of the burial history and thermal evolution of sedimentary basins. It was born from a conference and was probably very successful if one had the opportunity to discuss problems with the participants. At best the book is useful as a reminder of the topics that are important in this area. For the few papers that might be of an interest to any individual, I would recommend writing to the author for a reprint, or visiting your local photocopier. I cannot recommend the book at any price, and warn potential purchasers that the listed price is exorbitant. The dismal quality of this volume give me second thoughts about spending the time to consider any publications from Éditions Technip.

Evolution of the Lewisian and Comparable Precambrian High Grade Terrains

Edited by R.G. Park and J. Tarney
Blackwell Scientific Publications, Palo Alto
315 p., 1987, \$80.00US, cloth

Reviewed by David R.M. Pattison
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The Lewisian rocks of northwest Scotland comprise the most extensively studied early Precambrian rocks in the world. This volume contains the most up-to-date research on the Lewisian terrain, and therefore supersedes Park and Tarney's 1973 volume *The Early Precambrian of Scotland and Related Rocks of Greenland* as the standard reference on the subject.

Precambrian terrains are typically so large, and often difficult of access, that a comprehensive examination of all of the various geochemical, petrological, structural, isotopic and geophysical aspects of their evolution is logistically prohibitive. The Lewisian is therefore a valuable touchstone for comparison with other Precambrian high-grade terrains, partly because of the broad range of geological features characteristic of Precambrian terrains worldwide that are found there, and partly because of its accessibility, good exposure and relatively small size, which has facilitated the detailed, multidisciplinary work that makes it the best understood piece of early Precambrian crust in the world.

This volume comprises papers presented at the third Lewisian conference, held at the University of Leicester in March 1985. It is fitting that the volume has been dedicated to Professor Janet Watson of Imperial College, London, who was in the forefront of Lewisian research for four decades, and who, with her colleagues and students, established many of the most fundamental relationships in this classic terrain.

There are 24 papers in the volume. Leading off is a paper that identifies some of the major unanswered questions about the Lewisian terrain, and by extension of early Precambrian terrains in general. This is followed by an introductory paper which summarizes the present state of knowledge of the Lewisian, providing an invaluable framework for those who are not familiar with the extensive Lewisian literature.

The 22 articles that follow reflect the broad range of disciplines that have been brought to bear on different aspects of the Lewisian complex. These include: a synthesis of the most recent work by the British Geological Survey on the Lewisian in the Outer

Hebrides; six articles on the geochemistry, petrology, and petrogenesis of the tonalitic and trondhjemitic gneisses, supracrustal rocks and Scourie dykes, focussing on the origin and subsequent metamorphism of these rocks; an article on the causes of the granulite grade metamorphism; five articles on structural aspects of the Lewisian, focussing in particular on the role of the major shear zones and faults that separate the various coherent blocks found in the terrain; three articles on geophysical studies, including a summary of the physical properties of Lewisian rocks, deep seismic profiling and paleomagnetism; and six complementary articles on comparable Precambrian terrains in Greenland, Labrador, Antarctica and China.

From these articles, it is apparent that the basic petrogenetic, structural and age relationships of the Lewisian terrain have been fairly well established. Some of the most difficult, and most interesting, questions that were addressed in the volume are concerned with the processes that were at work in the formation and metamorphism of the terrain. One of the most outstanding questions is how the major accretion of the Lewisian crust at about 2.9 Ga took place, for this is part of a worldwide phenomenon of massive growth of continental crust during a relatively short period (3.2-2.6 Ga) of Earth history. Another major question concerns the interrelationships between the movement of magmas and fluids in the crust, and the bearing this has on early Precambrian granulite metamorphism.

Blackwell Scientific Publications have produced a handsome volume, with clear diagrams, good photographic reproduction, and an index. My only criticism is the US\$80.00 price, which puts it out of reach of individual buyers.

From Mineralogy to Geology. The foundations of a Science.

By Rachel Laudan
University of Chicago Press, Chicago
278 p., 1987, \$27.50US, cloth

Reviewed by William A.S. Sarjeant
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Though indeed, as its title proclaims, a study of geology's origins, this work does not adopt standard approaches. It is instead an attempt to determine the principles underlying the reasoning processes that guided the work of early geologists. As such, its interest to philosophers of science is likely to be quite as great as to historians of our discipline.

The author notes that, heretofore, philosophers have backed off from considering geology, since it is too intricate a science for ready analysis. She believes that geologists have been striving for answers to two sorts of questions:

"One is historical; geology should describe the development of the earth from its earliest beginnings to its present form. The other is causal; geology should lay out the causes operating to shape the earth and to produce its distinctive objects. This distinction corresponds closely to the distinction between "historical geology" and "physical geology" (p. 2).

Her own interests lie in the development of causal geology and she notes (p. 7) that it is geologists with that concern who have proved most receptive to ideas from other disciplines.

In an era when too many editors insist on a depersonalization of texts, it is all too easy for authors to conceal their personal judgements under the guise of received dogma. I find it refreshing that Rachel Laudan has the courage to identify her ideas clearly, writing "I believe ...", "I consider ...", "I conclude ..." and does not commit the too-widespread sin of cloaking opinion as fact.

The story she presents is a fascinating one, for anyone interested in the growth of scientific concepts. When reading her proper criticisms of the eighteenth-century cosmogenists, who would build an elaborate theory on the slender foundation of just a few incompletely verified facts, it is depressing to reflect how often this is still done today. Nor is it just done by such pseudo-scientists as Velikovsky and von Deniken, but also by quite reputable chemists, physicists and — yes — even geologists in seeking, for example, to explain by an extraterrestrially induced catastrophe the extinctions at the end of the Cretaceous. Yet those extinctions have been shown clearly by recent evidences to have occurred, not as mass deaths on a single time plane, but over millions of years. (Can anyone

provide a single instance of that much-touted iridium layer lying directly upon dinosaur bones or ammonite shells?)

However, we are shown that the opposite approach — the method of eliminative deduction — may also have unfortunate consequences. Had Darwin allowed the information on fossils available in the mid-nineteenth century to influence his thinking, he might well have let his evolutionary theory lie unpublished. Laudan notes his neglect of palaeontology (p. 7) but does not discuss it; however, she does demonstrate (p. 11) how Darwin's use of this method to explain the parallel "roads" of Glen Roy only led him into error. The proper conclusion is that, while there is no single satisfactory approach, accurate observation and the critical consideration of suitable analogies (p. 8, 13) together provide the most satisfactory path toward the truth.

To readers confused by usages of such words in early texts, Laudan's exposition of the former, very different comprehension of the words "mineral" and "mineralogy" (p. 21) and of "earths" and "stones", "salts" and "sulphurs" (p. 26) is valuable — the last category, for example, included coals and bitumens! Her clarification of the concepts implicit in Aristotle's "exhalations" (p. 29) and her emphasis (p. 77) on the lateness of the recognition by chemists and geologists that crystallinity is not rare, but general in minerals — not until the 1830s was this perceived — are also helpful to the better comprehension of such texts.

Her striving to set right the impression given by earlier histories of geology — that most major advances were made in Britain and most "foreigners", though gifted with occasional insights, usually stumbled into error — is salutary, as is her stressing of the influences upon geological thinking of the concepts of other scientists — not merely chemists, but even botanists. Thus she treats Cuvier and Werner, in particular, much more kindly than have most geological historians heretofore. Her revelation of the influence, for better or worse, of the Becher-Stahl school of chemical cosmogonists will surprise most readers.

The problem is that, in her eagerness to dethrone the old idols, Laudan tries too hard to bury them into the dust afterwards. Whilst it is proper that James Hutton's writings be given critical scrutiny, her eventual assessment that he made only a "limited but significant" contribution to the development of geology (p. 137) seems to me unjust — especially when one of his great contributions, the recognition of unconformity and the perception of its implications, is not even mentioned.

William Smith and George Greenough also receive unkind treatment. That Greenough was indebted to Smith is made explicit (p. 169); consequently, how can Laudan justly argue that

"For Greenough (1819), the very suggestion that fossils could reveal anything about formations was anathema ..." (p. 156)?

The point surely is that Greenough accepted that fossils served to identify formations, but questioned the rectitude of using extinct organisms as indices of past environmental conditions — a scepticism that is understandable, even if it is one that can be answered by modern approaches.

As for Smith, his independent discovery of many approaches that have proved lastingly valuable in stratigraphy is noted but, rather than being given full credit for this, he is criticized for the lack of "theoretical underpinnings" to his work (p. 164). One might equally justly criticize Darwin's work for its lack of direct, practical utility! The impression that Smith's observations were not available for use by geologists at large until after 1815 (p. 168) is false: his listing of strata had been circulated by Richardson and Townsend at the very beginning of the 19th century and had given a great stimulus to stratigraphical investigation. Surely few historians of geology will acquiesce in Laudan's final judgement (p. 168) that "it is hard to imagine that the development of geology would have been much different if [Smith] had never published". Certainly I do not, for unlike Laudan I recognize the immense impetus given to stratigraphy by Smith's work. But then, of course, stratigraphy is perhaps not "causal geology" ...

Sir Charles Lyell is another target for Laudan's iconoclasm. He is given credit for recognizing the link between changing geography and changing climate; but that is about all the credit he receives! Laudan's conclusion that "what we ... know tends to favour the position that Élie de Beaumont was more influential than Lyell" (p. 221) can surely be countered by the demonstrable fact of the influence of the *Principles* upon Charles Darwin, even without consideration of Lyell's influence on the generations of other geologists whose careers were so much enhanced by their reading of the various editions of that great work.

Though Laudan trains her iconoclastic cannons most often upon British targets, certain continental European geologists also fare ill. Giovanni Arduino's considerable influence in the development of chronostratigraphic concepts is virtually ignored, while the wide-ranging practical and conceptual contributions of Jean-Étienne Guettard to the development of geological mapping, and to the understanding of erosional processes, are respectively given passing mention (p. 52) and ignored entirely.

Some of Laudan's statements are of dubious validity. When writing (p. 38) that

"By the late eighteenth century, most saw the Flood as simply one of a series of a series of upheavals or "revolutions" ... that had taken place in the history of the earth."

she is surely incorrect. Yes, as she demonstrates, a few scientists *did* already have that idea; however, only much later did it gain a wider currency, with Cuvier's *Discours sur les Révolutions de la Surface du Globe* (1821, 1826). As for her comment that "Simple literalism [in the reading of Genesis], at least so far as those interested in the history of the earth was concerned, was already defunct in the seventeenth century."

— well, that is simply not correct, as a whole shelf-full of 19th century works — not merely by cranky amateurs, but also by serious geologists makes clear. Indeed, with creationists still abounding, and some of them being practising geologists, can we even claim it to be true today?

In a work so large, it is creditable that misspellings and misprints are so few; but there are a few mis-statements. Yes indeed, "non-mineralogical names replaced mineralogical ones" for stratigraphic units (p. 161); but there are quite a few survivors, e.g., Lias, Cornbrash, Chalk, Carboniferous, Cretaceous, which pass unmentioned. "Erz Mountains" (p. 48) is an unfortunate infelicity and "Eiffel" (p. 196) a confusion of the name of a tower with that of a German district. My preference for "cropping out" rather than "outcropping" (p. 153) and dislike of the word "individuate" (p. 30) may be dismissed as pedantry. However, Laudan is in error when she credits d'Omalius d'Halloy with coining the word "Cretaceous" (p. 155); that was Conybeare and Phillips' (1822) later modification of Halloy's "terrains crétacés", in which the adjective meant, not "chalk fossils" as she states, but simply "chalky".

Yet my review of this work, with its refreshing approach and explicitly personal judgements, should not end on so low a note. If one is stimulated into disagreement with some of Laudan's opinions, it is to her credit that she has succeeded in being stimulating; and, if her work is perhaps out of balance in some directions, in others it serves healthily to restore the balance of our perceptions concerning the history of geology. All serious geological historians, and all philosophers of science whose thinking is not too much clouded by the nebulosities of Kuhn, should buy this book and use it as a whetstone for their thinking.

Gold '86. An International Symposium on the Geology of Gold Deposits, Proceedings Volume

Edited by A.J. Macdonald
[available from] Konsult International Inc.
44 Gemini Road, Willowdale, Ontario
Canada M2K 2G6
517 p., 1986; \$50.00, cloth

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This book includes 38 papers presented at Gold '86 — an international symposium on the geology of gold deposits, held in Toronto in September 1986. The volume is organized into five sections which deal respectively with "Canadian Precambrian gold deposits re-interpreted", "New Canadian gold deposits", "Gold in the Precambrian Shields", "The Hemlo gold camp", "Epithermal deposits", and "Epithermal and other deposits". The stated objectives of the organizing committee were to take stock of new discoveries and conceptual advances that had developed since the 1982 symposium on gold in Zimbabwe, and which have resulted from the surge of interest in gold during the '80s. Emphasis is placed on descriptive studies of new deposits, or new observations on established deposits, continuing the tradition of the 1948 Jubilee and 1957 Congress volumes on the geology of Canadian ore deposits, which stand as landmarks of observational science.

Andrews *et al.* report data for the geochronology of volcanic and plutonic rocks in the Red Lake area: they demonstrate that the main deformation and Au mineralizing events were contemporaneous, and formed in response to the diapiric emplacement of batholiths. Three papers consider the Hollinger-McIntyre-Coniaraum system of the Timmins district. Burrows and Spooner document two types of mineralization: (1) intrusion hosted Cu-Au±Ag, Mo vein and disseminated ore and (2) a gold-pyrite quartz vein system, largely confined to the volcanic sequence. These authors, together with Wood *et al.*, rigorously document the separation of porphyry intrusion from gold mineralization by an intervening shear deformation, and accordingly rule out a genetic relationship between the two. In contrast, Mason and Melnik suggest that the Cu and Au orebodies at McIntyre are both related to the "porphyry" intrusions, in a manner directly analogous to near-surface "porphyry style" deposits, and further infer that cleavage and metamorphism post-date the ore-forming event. A magmatic origin for the Au is advanced by Wood *et al.*, based on

carbon and oxygen isotope data, despite the fact that the data reported are not uniquely diagnostic of a "magmatic" source. Wyman *et al.* show that Abitibi gold deposits define a continuum of C-isotope ratios, which extend beyond the "magmatic" range at both ends.

Marmont describes the shear-zone hosted Detour Lake deposit, which formed post peak amphibolite facies metamorphism, and is interpreted to be closely related to felsic plutonism. The Doyon Au deposits, in Bousquet Township, are discordant pyrite-quartz veins which formed contemporaneously with tectonism, and are linked to the Mooshla stock magmatism (Savoie *et al.*). Wyman *et al.* demonstrate that in detail Ag-Au mineralization at Agnico Eagle cross-cuts stratigraphic boundaries, and has characteristics of typical epigenetic Archean mesothermal gold deposits. The Detour Lake, Bousquet area, and Agnico Eagle deposits have all formerly been interpreted as syngenetic.

Six deposits are described in the section on new Canadian gold deposits, of which five are Archean, located within the Superior Province. Musselwhite is an ironstone hosted deposit in the Sachigo Subprovince formed during peak metamorphism at 530 to 550°C and 3kb (Hall and Rigg). At the Cameron Lake, McDermott, Lac Shortt and Duport deposits (Melling *et al.*; Workman; Morasse *et al.*; and Smith, respectively) mineralization is described as shear zone hosted. A common theme is that Au introduction is late in the greenstone belt evolution, and syn to post peak metamorphism. The majority of authors argue that although remobilization of Au from a "protore" cannot be ruled out, there is no direct geological evidence for such a process. On the other hand, Pattison *et al.* promote a multi-stage model for the Casa Berardi deposits, in which preconcentration of Au in a graben environment is inferred to be the first stage. The Chetwynd deposit, Newfoundland, is described as being analogous to Tertiary epithermal Au, Ag deposits (McKenzie).

Radically opposed views are given for the origin of the Ropes gold deposit, Michigan. Bornhorst *et al.* advocate a typical mesothermal Archean style shear zone hosted model, whereas Brozdowski *et al.* interpret the system as synvolcanic. Clark *et al.* present an interesting paper on the geology of the Victory Au mine, Kambalda, with meticulous documentation of metasomatic reactions accompanying mineralization. The remaining papers in this section describe the Gwanda deposits, Zimbabwe (Fuchter and Hodgson), the Kolar gold field (Hamilton and Hodgson) and Crixas, Brazil (Thompson).

Seven papers are devoted to the Hemlo camp, which has generated intense interest following the discovery of gold in 1981, because of the magnitude, high grades, and unusual geological features. Harris characterizes the geochemistry (Au, Mo, Sb, As, Hg, Tl, V and Ba) and mineralogy (barite, Ba-

microcline, rutile, V-muscovite gangue) of the ores, highlighting the presence of a low temperature mineral assemblage of cinabar, realgar and orpiment. Burk *et al.*, Kuhns *et al.*, and Kuhns provide descriptive studies of the lithologies and metamorphic grade. There is a general consensus among these authors that gold mineralization is concentrated in the domain of highest strain within the Hemlo Shear Zone, postdating high pressure metamorphism, but prior to the final low pressure amphibolite facies metamorphism. Walford *et al.* report detailed microprobe data for the host rocks and ores of the Page-Williams deposit. In a comprehensive structural study, Hugon concludes that the Hemlo Shear Zone is an oblique thrust of regional scale which juxtaposes two different terranes. All primary layering is transposed: ductile shear, folding and metamorphism are coeval, and related to the intrusion of the Cedar Lake pluton. Most of the authors consider that the Hemlo deposits share some affinities with Phanerozoic "porphyry-style" molybdenum deposits. A diametrically opposed precept is advanced by Valliant and Bradbrook, who present a synvolcanic model of the deposits, although it is not clear as to how primary basin morphology and feeder faults can be reconstructed in rocks where all primary fabrics are transposed, at a terrain boundary.

In the sections on "epithermal and other deposits", Bakken and Einaudi provide an up-to-date overview of the Carlin deposit; Mustard describes the Kidston Au deposit, NE Australia; Ott *et al.*, the sandstone hosted Cannon Mine in Washington; and Saunders and May, the Bessie G deposit, which is part of the "bonanza type" deposits of the Tertiary Colorado mineral belt. There are notable contributions on the El Indio Tambo epithermal deposit, Chile (Siddeley and Arana); the Carolin mesothermal deposit, British Columbia (Ray *et al.*); and the Jarritt Canyon epithermal deposits in Nevada (Birak). The longstanding controversy as to whether oxidized ore in epithermal deposits is hypogene, supergene, or of mixed origin, remains unresolved.

This volume represents a valuable compilation of significant new observations on gold deposits. It is unfortunate that there are no contributions from new deposits in the Slave Province, dictated perhaps by considerations of space. The editor has conducted an outstanding job in ensuring a high quality of text, figures and photomicrographs, as well as a uniformly high standard of presentation. This volume is required reading for all geologists interested in gold at the exploration or research levels.

Ore Deposit Geology and its influence on mineral exploration

By Richard P. Edwards and Keith Atkinson
Chapman and Hall, Ltd., Toronto
 466 p., 1986; \$64.95 hardcover, \$49.95 paper

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The authors' stated reason for writing the book is that economic geology should not only be a (theoretical) study of ore genesis through chemical, physical, and structural problems, but should also include (practical) economic and technical factors that determine viability of an ore deposit. The book is aimed at the undergraduate level and would present students with a thorough understanding of mining camps, their geologic associations, what makes them economic, and how to go about studying one, or finding another. It would continue to be used as a reference book. I think it's an excellent book overall, and I liked it better the more I read it.

Each chapter is devoted to one of the following deposit types: magmatic, magmatic-hydrothermal, hydrothermal veins, placers and paleo-placers, sediment-hosted Cu-Pb-Zn, ores formed by weathering, sediment-affiliated iron ores, sediment-affiliated uranium ores, and ores formed by metamorphism. Except for the last category (in reality, skarns), I like this classification scheme because it groups deposits into families with genetic connotation when there is little controversy over genesis (e.g., magmatic, weathering) and into generic categories without undue attention to origin when there is controversy (e.g., sediment-hosted Cu-Pb-Zn). Each chapter begins with a useful world map of the distribution of the family, followed by a summary of lithologic and tectonic associations, grade and tonnage, mineralogy, alteration, and genesis. One or two representative mining camps are then described in detail. For example, the Bushveld Complex section in the magmatic chapter covers geologic setting, chromite layers, distribution of PGEs, genetic hypotheses for the Merensky Reef, and mining geology. The Porcupine district section in the hydrothermal vein chapter includes stratigraphy, tectonic setting and structure, mineralogy, classification of veins, alteration, and timing of mineralization. The book concentrates on deposits in North America, Europe, southern Africa, and Australia, possibly reflecting the diminishing world of exploration. The heavy emphasis on Australia and Africa for detailed studies provides welcome insight into deposits unfamiliar to most North Americans.

The final chapter contains a concise summary of the many facets (finance, politics, logistics, etc.) involved in designing and implementing exploration programs.

The written text is necessarily concise but the reader is frequently referred to the up-to-date bibliographies at the end of each chapter for details. No petrography is used to illustrate textural relationships of the ore minerals, but ore-host relationships are used to determine associations and controls of mineralization and to evaluate genetic concepts. Exploration guides and methods used for each deposit type, with some case histories, are presented. The methods used to outline and evaluate an ore deposit once found then generally follows. Discussion remains professional throughout, with no undercurrents of personal bias apparent.

The exception in this rosy picture is the chapter on "metamorphic" ores, a misnomer which should be called "skarns". In the introduction to the section, metamorphism is defined as high-T, high-P phenomena, low-T, low-P alteration and replacement, and seemingly even early diagenetic alteration of sediments. Not many deposits would fall through that net. Metasomatism is then defined and the rest of the chapter devoted to a good discussion of skarns, their classification, distribution, size and grade, lithology and alteration, tectonic setting, etc. The lost discussion on metamorphism and ore deposits is, however, really out of character with the rest of the book. Any student would certainly be confused as to what a metamorphic deposit is.

A major omission, with no explanation given, is that there is no mention (at all) of epithermal Au-Ag deposits. The names Comstock, Creede, Alligator Ridge, Jerrit Canyon, Carlin, and Pueblo Viejo are not to be seen. I couldn't believe it. On the one hand it's refreshing to see such braggadocio that can ignore the source of US gold, but on the other I can't help feeling that they left a chapter off by mistake. A section on epithermal deposits should have been included.

Throughout the book, the authors stress the importance of genetic models in exploration. As a former exploration geologist, I agree that knowing how ores form enables a geologist to be more effective both at regional and mine exploration levels. Otherwise, exploration becomes prospecting. However, while genetic models are valuable guides when they are correct, what happens when they are wrong? The billion-tonne Lubin Cu-Ag deposits in Poland would have been found earlier than 1957 if the sanctioned genetic model of the time had pointed to underlying basement highs, rather than basin edges, as the topographic control. Of course, in other cases, it doesn't seem to matter. Much Ontario gold has been found using both syngenetic and epigenetic models for the same thing. Geologic associations and controls rather than genetic models may

be the key, especially in controversial areas and when selling it to management.

The type print is easily read except for the italics in some tables, and the grammar is good and sentence structure clean, making it easily followed by a North American audience, despite liberal usage of the conjunction "whilst". Diagrams are well made, clear, and standardized, although some photographs are out of focus. Photographs of mine faces should, in most cases, have had sketches of the noteworthy features as was done with one photo of Zimbabwean tellurides. The index may need major revision. In my search for Carlin-type deposits, of the four page references to "Arizona" in the index, two were wrong. A misleading index seriously detracts from a book's usefulness. Some host rock ages I'm familiar with are in error (e.g., Early Proterozoic rather than Upper for Udokan, Permian rather than Permo-Triassic for Lubin). These are easily checked and should have been corrected.

This book succeeds as a textbook because it teaches the undergraduate about the broad topic of economic geology in the right amount of detail and it is easy to read. It also acts as a first pass, general information and reference source for senior undergraduates and graduates when researching a project — the important questions are discussed and the specifics are referenced. In this sense it would be generally useful for industry geologists. None of my friends would learn much about Archean gold, but where do you look first when you're asked to find a marine tin placer or evaluate a bauxite discovery?

Sedimentology of Gravels and Conglomerates

Edited by Emlyn Koster and Ron Steel
*Canadian Society of Petroleum Geologists
 Memoir Number 10*
 441 p., 1984; \$34.00, members,
 \$39.00 non-members, cloth

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If the usefulness and significance of a publication can be gauged by the number of times it is pulled from the shelf, then this has to be one of the most valuable books to have appeared in a long time. This is subjective, but here is one of those books that from day one has to have "NOT TO BE REMOVED FROM LAB" fastened to it or else it will disappear, not to be available at that critical moment day or night when it only can solve the problem or find the citation. The contributors and the editors who were behind the "Rudites Formed By Unidirectional Flow" at the International Association of Sedimentologists Congress (1982) at Hamilton, Ontario, from which this volume grew, are to be congratulated.

The volume, published by the Canadian Society of Petroleum Geologists, starts with a preface by Roger Walker, himself an erudite pioneer of rudite studies. He is in a better position than anyone else to look at the development of the field over the last twenty years. Not much, says Walker who states that his first impression is that "ways of studying conglomerates in the field have changed little over the last ten years". But he goes on to say (and this is why the book is worth its cost) what is new is the amount of information being extracted from tried and true techniques such as measurements of clast fabric, maximum clast size and bed thickness.

The contents are divided unequally into *background considerations*, consisting of excellent review chapters by Nemeč and Steel, and Hein on alluvial and coastal conglomerates and deep-sea and braided river deposits respectively, *fluvial processes* (6 papers), *modern and ancient alluvial systems* (8 papers), *ancient fan-delta systems* (6 papers), *wave/tide-dominated systems* (2 papers) and *ancient submarine slope-fan systems* (5 papers). The fluvial process section contains an interesting account of the flood origin of larger boulder clusters in coarse-grained rivers by Brayshaw, and newly-identified "chute and lobe" features on braidplains. This paper, together with Reid and Frostick's paper on the initiation of particle motion in coarse alluvial channels, contain useful descriptions of laboratory and field experiments involving coarse sediments.

What is still surprising with regard to conglomerate facies is how little is known of the characteristics of shallow marine conglomerates and their separation from braided river deposits. Several good chapters help in this regard, that of the aforementioned paper by Nemeč and Steel on alluvial and coastal conglomerates, and that by Bourgeois and Leithold on wave-worked conglomerates. Ethridge and Wescott in their paper on fan-delta deposits provide a useful summary in the form of a table of criteria for distinguishing beach and fluvial gravels based on an extensive literature review. In general, a major strength of the book is the ease of access to the literature it provides readers. The good quality photographs in these contributions are particularly useful for field workers.

Those interested in downslope re-sedimentation and the generation and placement of sediment gravity flows are well served. As with the other sections in this book, the excellent contributions are too numerous to mention and there are no bad ones either. Burgisser describes an exceptionally large debris flow served from a large Miocene rockfall of Upper Triassic carbonates from the Alpine front. Varley relates the sedimentology of the Cadomin conglomerates of the foothills of the Canadian Rockies which is a major gas reservoir. More research, the paper concludes, is needed on the diagenesis of poorly sorted facies; a theme re-emphasized by Ethridge and Wescott with regard to reservoirs in fan-deltas in Oklahoma and the Texas Panhandle where the relationships between permeability and porosity differ radically from conventional reservoirs.

The contributions by Postma (Mass flow conglomerates in submarine canyon), Nemeč, Steel, Porebski and Spinnanger (lateral variability in mass flows on a lacustrine fan delta) and Kleinspöhn, Steel, Johannessen and Netland (debris flows on fan delta fronts) are good examples of detailed field observations and facies descriptions supported by excellent photographs. In many respects the field is suffering from information overload and there is now a need for synthetic treatments identifying general facies types, support mechanisms and field criteria. Walker, in his preface, is reminded of turbidite research in the 1950s before Bouma and before the "turbidite mess" was mopped up, to paraphrase a famous paper. One particular problem is a lack of experimental and field geotechnical data with regard to the evaluation of flow support mechanisms during flow and the difficulty of reconstructing such parameters from consolidated deposits. Simplification and distillation into models also carries its own dangers, an aspect addressed by Surlyk in his paper on fan-delta to submarine fan conglomerates of the Wollaston Forland in Greenland. He shows, convincingly, that there is no well-

defined downslope evolution of conglomerate facies from subaerial fault scarps to the basin axis, which runs counter to the well-established models of Walker and Lowe which relate systematic facies changes to proximity to source and downslope evolution in grain-support mechanisms. Surlyk cautions that these published models are based on limited fieldwork in areas of considerable tectonic complexity; the Wollaston Forland group in contrast is 3 km thick and is exposed, undisturbed, for up to 20 km across strike and tens of kilometres down dip. Surlyk argues that whilst the evolutionary facies schemes may work within individual beds, they are of limited use in basin reconstructions because flows do not originate from the same geographic area. In addition, many grading characteristics are established during deposition and are not in any way related to travel distance. Clearly more data is required on well-exposed fan sections where downslope and across slope outcrop is available; the "sharp-eyed geologist still has a lot to contribute to the understanding of gravels and conglomerates" says Walker.

The book is large format, easy to handle and very pleasantly printed; given the quality of the contributions and the book's obvious "benchmark" status, no one will quibble about the price. The sedimentologist's library is incomplete without a copy.

Palaeoecology and Biostratigraphy of Graptolites

Edited by C.P. Hughes and R.B. Rickards
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Blackwell Scientific Publications
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 277 p., 1986; \$75.00US, cloth

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The subtitle of this volume, "Proceedings of the 2nd International Conference of the Graptolite Working Group of the International Palaeontological Association held at Cambridge University, 1-15 September 1981", which does not appear on the cover, reveals much more about its contents than does the title. Of the 26 papers in this book only one is primarily paleoecological in content (Paškevičius) while 12 deal with taxonomic, morphologic, evolutionary and other aspects of graptolite studies.

My other main complaint with this volume is the length of time it took to get published (this is also a complaint of many of the authors). Five years in press is a long time for a conference volume. In that time, some of the authors have published more substantial papers or new ideas on the same topics. The third graptolite conference has since been held (Copenhagen, 1985), the proceedings for which have already been published (*Bulletin of the Geological Society of Denmark*, v. 35, nos. 1-2, 1987).

Among the 13 biostratigraphic papers, the most substantial contributions are those of Lenz and Jackson (Arenig-Llanvirn, Canadian Cordillera), Finney and Bergström (*Nemagraptus gracilis* Zone worldwide), Legrand (the unique, endemic Ordovician-Silurian boundary faunas of NW Africa) and Bergström (correlation between Ordovician conodont and graptolite zones). Fortunately, Bergström has added a note in proof to bring that paper somewhat more up-to-date.

The papers of Bjerreskov (Silurian, North Greenland) and Williams (Ordovician-Silurian boundary, Dob's Linn, Scotland) are biostratigraphic summaries of more substantial systematic works which have since been published. The contribution of Williams, however, is significant since it provides a synopsis of what has since been selected as the Ordovician-Silurian boundary stratotype. Berry describes an O-S boundary fauna from Nevada and Obut and Sennikov discuss the regional significance of O-S zones of the Gornyy Altai (south-central Siberia) and also the zonal thicknesses and their implications for zonal time spans.

The papers of Yu and Fang (Ordovician, Jiangxi, China) and Fu (Ordovician-Silurian, Shaanxi, China) present little more than sequences of zones and faunal lists. Huo and Shu provide regional comparisons of Silurian formations and zones throughout China although critical, zone-by-zone comparison of the sequences of the various regions, which would have been useful, is lacking.

The studies of Deng and Huo, Fu and Shu represent, in my view, highly oversimplified approaches to the study of the evolution of the cyrtograptids which do not take into account the range of thecal of rhabdosomal complexities. Furthermore, it is recommended by these authors that the base of the Wenlock coincide with the first appearance of *Cyrtograptus*, a level one full zone below the base of the Wenlock in its type area and elsewhere in the world.

Rigby presents a very useful review of the development of graptolite classification schemes and suggests some very sensible revisions, although no new approaches to graptolite taxonomy are attempted. Obut and Zaslavskaya provide a detailed discussion of retiolitid classification. Although I disagree with many of their taxonomic decisions, there are some useful observations and discussions several new taxa are described. Erdtmann's reconsideration of the affinities of some *Dictyonema* species sheds some new light on the classification of this common genus and the early evolution of the planktonic graptolites.

Numerical morphometric methods are applied to some graptolite groups by Schleiger and by Mitchell with some promising new approaches to old problems. Mitchell, and also Spjeldnaes, analyse astogenetic (colony development) patterns to achieve some new insights into graptolite phylogeny. Finney uses detailed morphologic studies to reveal some evolutionary patterns, specifically punctuation and heterochrony, within specific graptolite lineages.

Ultrastructural observations by TEM (Urbanek and Mierzejewski) and SEM (Bates and Kirk) add to the growing body of knowledge of graptolite skeletal structure. The latter authors, in particular, continue to challenge the widely accepted notion of graptolite skeletal secretion — the pterobranch model. The exciting observations of Dilly on modern pterobranchs, in the final paper of the volume, however, shed new light on the versatility of the pterobranch mode of secretion and the potential affinities of these two groups.

Of some interest to sedimentologist is the paper by Palmer who, in addition to doing morphologic analysis, measures and plots the orientation of rhabdosomes on a single bedding plane. He finds a bimodal orientation pattern which he attributes to a single current — the longer rhabdosomes mostly being oriented along the flow direction and most of the shorter ones normal to it.

This volume is well bound on good quality paper and well edited. The photographic illustrations are, for the most part, adequate, although a few are too dark and lacking in contrast. The line drawings are very good with the exception of Legrand's figures 2 and 3 which are overreduced.

Anyone working with graptolites would need a copy of this book. The non-specialist working on some areas specifically addressed by one of the biostratigraphic papers or interested in some of the paleontological approaches would certainly want access to a copy or a reprint of the specific paper of interest. It is not, however, designed to be of general interest and at \$75US is unlikely to grace many personal bookshelves.

Karst Geomorphology

by J.N. Jennings
Oxford University Press, Toronto
 293 p., 1985; \$23.75, paper

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When *Karst* by Joe Jennings was published in 1971, it was welcomed as a comprehensive introduction to karst geomorphology. Jennings died in 1984, after revising and updating the text for a new edition, called *Karst Geomorphology*. The final editing and compilation were carried out by Peter Bull and Andrew Goudie. The book has been almost completely rewritten, and the text has grown in length by 40%, but the volume is still reasonably priced.

Karst produced a balanced synthesis of the field in 1971. In the ensuing years there has been a growing emphasis on processes in karst studies, particularly in the fields of hydrology and solution chemistry. Each of these fields has now seen books published on them. Jennings, however, gives only a general overview. The new edition maintains the same approach as the old one, concentrating on the geomorphology of surface and subsurface features of karst terrains.

A strength of the book is the broad geographical scope it encompasses. Jennings lived in Australia for the last 30 years of his life, and many of the examples he cites are drawn from his own studies in Australia, New Zealand, Papua New Guinea and eastern Asia. These are balanced by inclusion of more familiar sites from the Northern Hemisphere, drawn both from English language and European literature.

The first three chapters set the stage for karst geomorphology: the nature of karst,

karst rocks, and processes. These are succinct and concise, perhaps overly so. The mere six pages devoted to the solution of limestone belie both the fundamental importance of this process and the understanding that has been gained in recent years.

Chapter 4 discusses karst drainage systems both on the surface (where rivers may be present or absent) and underground (where there are varying proportions of flow in pores, fissures and conduits). Examples illustrate the diversity of karstic aquifers.

Surface landforms are described in three chapters. These give a comprehensive survey of surface features. The first is entitled "Surface Weathering", but is more a description of small-scale forms. A long chapter on large-scale forms follows, explaining the many distinctive features special to karstic areas. A new chapter, on karst and coasts, reflects the growing interest in coastal processes, especially in tropical reef environments where depositional and erosional processes are intimately linked.

Two chapters give a clear exposition on caves and their sediments. Caves are classified in evolutionary terms, from forms caused by sluggish percolation flow through to those caused by underground streams and waterfalls. This helps explain cave morphology, though some would quibble about the terminology; in particular, the nothepheatic stage, proposed by Jennings in 1977, has not found general acceptance. A brief survey of the various deposits found in caves is followed with an overview of dating methods, stressing the valuable paleo-environmental information that may be obtained from cave deposits.

In the first eight chapters of the book most forms and processes have been discussed within the context of massive limestones and a temperate climate; now two more variables are introduced. A chapter on geological structure and lithology and a chapter on climate show how these variables modify the surface and underground forms described earlier. This is a neat way to provide a clear understanding of these complex interactions.

The concluding chapter on the historical geomorphology of karst is the most interesting. Jennings reviews some of the past and current controversies: karst cycles, effects of climatic change on various karst landforms, cave formation by H₂S, and correlation of cave levels with surface terraces. The final section is a masterly description of the contrasts of the four major karst areas of the British Isles.

This book yet provides an excellent account of the distinctive nature of karst, and provides a useful overview for anyone interested in the more technical aspects of solution or hydrology of karst terrains.

GEOLOGICAL ASSOCIATION OF CANADA NEWFOUNDLAND SECTION

PRICE LIST

The following is a list of field trip guidebooks prepared for St. John's '88 GAC-MAC-CSPG Joint Annual Meeting. These volumes are available from the Secretary-Treasurer, GAC Newfoundland Section, c/o 4 Clarke Place, Memorial University of Newfoundland, St. John's, Newfoundland, Canada A1B 3A6.

All prices quoted are in Canadian Funds and include shipping and handling. We will invoice orders or, alternatively, a cheque or money order (Canadian Funds Only) may be sent in advance. Cheques or money orders should be made out to "Geological Association of Canada, Newfoundland Section". PLEASE NOTE: QUANTITIES ARE LIMITED.

Trip	Title & Author(s)	Price
Trip A1.	Geologic Cross-Section of the Appalachian Orogen (P.A. Cawood, H. Williams, S.J. O'Brien and P.P. O'Neill).....	\$25.00
Trip A3.	Cambrian Depositional History and Stratigraphy, Avalon-Bonavista Region, Southeastern Newfoundland. (Ed Landing and Alison P. Benus).....	\$12.00
Trip A4.	Late Precambrian Sedimentation and Related Orogenesis of the Avalon Peninsula, Eastern Avalon Zone. (A.F. King, M.M. Anderson and A.P. Benus).....	\$15.00
Trip A5.	Volcanic-Hosted, High-Alumina, Epithermal Environments and the St. Lawrence Fluorite Deposit in the Avalon Zone, Eastern Newfoundland. (C.F. O'Driscoll, C.J. Collins and J. Tuach).....	\$15.00
Trip A6.	Quaternary Geology of Western Newfoundland. (D.N. Proudfoot, D.R. Grant and M.J. Batterson).....	\$12.00
Trip A7.	Lower Ordovician Deltaic, Shallow Marine, and Ironstone Deposits and Associated Trace Fossils, Bell Island. (R.K. Pickerill, D. Fillion and M.J. Ranger).....	\$15.00
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Trip A10.	Middle Paleozoic Calderas and Plutons of West-Central Newfoundland. (Marylou Coyle and D.F. Strong).....	\$12.00
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Trip B2.	Structural Geology and Melanges of Eastern Notre Dame Bay, Newfoundland. (P.F. Williams, C.F. Elliott and B. Lafrance).....	\$12.00
Trip B4.	Eastern Margin of the Newfoundland Appalachians - A Cross-Section of the Avalon and Gander Zones. (S.J. O'Brien, P.P. O'Neill, A.F. King and R.F. Blackwood).....	\$20.00
Trip B6.	Storm-Shelf and Tidal Deposits of the Chapel Island and Random Formations, Burin Peninsula: Facies and Trace Fossils. (P.M. Myrow, C.M. Narbonne and R.N. Hiscott).....	\$18.00
Trip B7.	The Grenvillian Long Range Inlier of the Great Northern Peninsula, Newfoundland. (J.V. Owen and P. Erdmer).....	\$10.00
Trip B8.	The Bay of Islands Ophiolite (T.J. Calon, S.D. Dunsworth and G. Suhr).....	\$25.00
Trip B9.	Gold: The Hope Brook Mine and Prospects in the White Bay and Mings Bight Areas (John Tuach, Colin B. McKenzie, David Gower, Garth Graves and Victor A. French)	\$16.00