Geoscience Canada

# Book Reviews / Critiques

Volume 10, Number 4, December 1983

URI: https://id.erudit.org/iderudit/geocan10_4br01

See table of contents

Publisher(s)

The Geological Association of Canada

ISSN

0315-0941 (print)
1911-4850 (digital)

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Cite this article

(1983). Book Reviews / Critiques. *Geoscience Canada*, *10*(4), 217–224.

## Book Reviews / Critique

# Book Reviews

## A Geologic Time Scale

By W. B. Harland, A. V. Cox,
P. G. Llewellyn, C. A. G. Pickton,
A. G. Smith and R. Walters
*Cambridge Earth Science Series*
*Cambridge University Press*
*1983, 131 p., $24.95 US; cloth*

Reviewed by Andrew D. Miall
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Most of us probably have a rather utilitarian attitude to the concepts of geologic time, slapping names such as Albian or Upper Silurian on rocks as if they were so many soup can labels. Somewhere we may have heard echoes of fierce debates about the relative philosophical superiority of time-rock scales versus rock-time scales, or tried to sort out the differences between geochronology, geochronometry, chronostratigraphy, and so on, but may not have paid much attention.

However, behind the scenes there has been an immense interdisciplinary effort to refine and quantify the time scale. The biostratigraphic basis for our system of eras, periods, epochs and ages had its origins in nineteenth century stratigraphy, and the first systematic attempt to quantify this scale of relative ages, by using radiometric dating techniques, was that of Arthur Holmes in 1937. In 1964 the Geological Society of London published a milestone compilation of recent work in the area, later revised in a 1971 supplement, and these became standard references. Many earth scientists accepted the London time scale as practically the last word on the subject, but this was not to be. Refinements in radiometric dating techniques, the acquisition of vast amounts of Jurassic to Recent stratigraphic data from the Deep Sea Drilling Project, and the appearance of an entirely new dating technique, magnetostratigraphy, have opened up whole new vistas of research. The International Union of Geological Sciences got in on the act soon after its formation in 1960, and its various commissions, subcommissions and working groups have been beavering away ever since. At the Sydney International Geological Congress in 1976 a number of useful steps were taken, including agreement on standardized radiometric decay constants. The proceedings of a symposium on geologic time held at that congress (published as *American Association of Petroleum Geologists Studies in Geology No. 6)* summarized much important research in the area. Which brings us up to the present book.

Two of the authors, Harland and Smith, were co-editors of the London effort, and have, so to speak, done a lot of time on time. The group of six authors, all of whom except the well known paleomagician A. V. Cox, are British, do not represent any "official" working group. But they do comprise a group with global stratigraphic experience and interests. Their recognition of the need for this book, and its completion within three or four years, is an interesting contrast to the slow deliberations of IUGS. Their lack of "official" status has enabled them to come to quick conclusions and make many useful suggestions without the cumbersome procedures of an international commission. The result is this excellent book, which is certain to be regarded as another milestone on (in) time, and a benchmark for future work.

The book was written with two main objectives:to provide an up to date time scale with all the necessary supporting documentation, and to explain clearly what the scale means and how it was derived. There are five main chapters.

The first chapter discusses the various ways in which time has been and is being measured, and the different scales that have resulted. It is made clear that only two scales are necessary, a scale of standard time units—years—which the authors term the geochronometric scale, and a chronostratic (or chronostratigraphic) scale, which comprises the familiar eras, periods, etc. (e.g., Paleozoic, Triassic, Campanian). The first is a time continuum to which rocks are fixed by radiometric methods. The second is defined by a set of carefully selected stratigraphic sequences. Chronostratigraphic units will all be defined eventually on the basis of their boundaries (the so-called "golden spike" concept), each boundary stratotype defining the base of a unit, but not the top of the one below (in the event that the stratotype turns out to have been placed at a disconformity).

Chapter two, the longest in the book, documents the chronostratigraphic scale, from the pre-Archean to the Holocene. This is largely a historical and geographical review, explaining where, why, how and by whom the various age, period, and other names were derived. A series of tables illustrates the main biostratigraphic zonal schemes and some typical stratigraphic sequences from different parts of the world. Appendix 2 of the book lists over 200 age names, including many now obsolete, with their authors, type locations, references and synonyms. Virtually all the names now in use originated in the nineteenth century, and the majority are European in origin. However, many ages are still poorly defined, and only one major boundary, that between the Silurian and Devonian, has been blessed with an official IUGS golden spike. Recent work on each age is summarized in Chapter 2, and it is astonishing to note how little North American geology has contributed to the standard global scale. The Phanerozoic is still almost entirely European, with contributions on Cenozoic biostratigraphy from offshore sediments. The Proterozoic scale consists mainly of Russian and Chinese definitions. Only the Triassic scale, though using European names, is based in part on North American type sections, many of them Canadian sections proposed by E. T. Tozer of the Geological Survey of Canada.

The Precambrian scale is essentially a geochronometric one. For example, the base of the Proterozoic is defined not by a type section but by the internationally agreed radiometric age 2500 Ma B. P. Various other geochronometric boundaries have been proposed by different working groups, and a new set is offered here. The authors also discuss possible chronostratigraphic subdivisions. Some Russian and Chinese sections seem to offer good possibilities but, for rocks older than about 1600 Ma, the record in most areas is too localized and incomplete. Harland and his coworkers make some suggestions that seem to consist of a rather random selection of names culled from South Africa and elsewhere. The name Huronian appears here, which may startle some readers of this journal. Although the selection of this name for an early Proterozoic era is not explained, it probably was derived from a reading of some proposals by R. J. W. Douglas. It is unlikely that it will meet with universal acceptance in Canada (e.g., see M. J. Frarey in G. S. C. Paper 81-C), and Canadian geologists probably will prefer to stay with Stockwell's geochronometric scale (Aphebian, Helikian, Hadrynian).

Chapter three discusses the geochronometric calibration of Phanerozoic chronostratigraphic boundaries. Although thousands of radiometric age determinations have been made, very few are suitable for accurate chronometric calibration. This is partly because of laboratory error, and partly because of ambiguities surrounding the chronostratigraphic significance of the rocks being dated. The authors discuss the statistical and geological basis for selecting the key "tie points" on the scale, and only forty-three determinations from around the world pass these tests. For two periods (Devonian, Jurassic) no tie points are deemed acceptable. For these, and other sparsely populated parts of the Phanerozoic, estimation procedures have been used, including magnetostratigrahy and an hypothesis of average equal duration of ages. This chapter conveys the important message that most determinations of chronostratigraphic boundary ages are still estimates and some could be in error by as much as 30 Ma.

Chapter four discusses the magnetostratigraphic time scale. A brief discussion of what is known about the nature of the geomagnetic field is presented, and the appropriate terminology of the reversal hierarchy is introduced. The basis of the time scale is the sequence of numbered "anomalies" that were first recognized from ship-borne magnetic surveys across oceanic spreading centres. Recognising these anomalies in DSDP cores or in outcropping sedimentary or volcanic rocks that could be dated by biostratigraphic or radiometric methods has consumed much of the research effort to date, and the process is still continuing. Many of the anomalies were initially dated on the basis of estimated rates of sea-floor spreading, and these have required considerable revision with the acquisition of better data. A revised reversal scale, extending back to 165 Ma B. P., is offered.

A final (fifth) chapter discusses a wall chart that has been prepared to accompany the book. The Exxon work on eustatic sea level changes is incorporated in the chart. This is a little surprising, because the published documentation on the Exxon sea-level curve is minimal, and this contrasts dramatically with the rigorous treatment of radiometric and other data in the rest of the book. The elevation of the sea-level curve to another standard of geologic time is certainly not justified at the present.

There are four appendices to the book, tabulating radiometric age constants, conversion procedures, and scale comparisons; biostratigraphic age source data (referred to above); preferred chronostratigraphic names and their abbreviations; and a discussion of the ideal standard unit of time. A case is made here for the use of the second as the basic time unit (this is probably a Harland touch), but it would lead to the cumbersome necessity to refer to $3.156 \times 10^4$ petaseconds instead of 1 Ma. It does not seem likely to catch on.

The scope and thoroughness of the book, and the authority of its authors, will probably bring about its rapid acceptance as an "unofficial" (i.e., non-IUGS) standard reference on geologic time. Every statigrapher who is concerned with precise correlation should have access to a copy.

## The Buchans Orebodies: Fifty Years of Geology and Mining

Edited by E.A. Swanson, D.F. Strong and J.G. Thurlow
*The Geological Association of Canada, Special Paper Number 22, 1981*
*$29.00 (members); $36.00 (nonmembers)*
*Part 1: Text, 350 pages, cloth*
*Part 2: Maps (in color)*
*(1) Geological Map of Buchans Area, Newfoundland (Scale 1:50,000)*
*(2) Geological Compilation of the Newfoundland Central Volcanic Belt (Scale 1:250,000)*

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This Special Paper was prepared to mark the 50th anniversary of the first production from the high-grade polymetallic ores at Buchans, Newfoundland. It is the first comprehensive account of the geology and history of the Buchans ore deposits. The text contains a 64-page summary of the mining history of Buchans by George Neary, the latest Assistant General Manager and a long-time employee at Buchans. It also contains fourteen technical papers on various aspects of the geology, ore deposits and exploration by the top experts on the area.

The Neary article details the history from before the initial discovery by Matty Mitchell in 1905 through the start of production in 1928 until 1979. The amount of ore milled to 1979 totalled 17,511,000 short tons, with an average grade of 14.62% Zn, 7.60% Pb, 1.34% Cu, 3.69 oz/ton Ag and 0.043 oz/ton Au. In terms of tons of metal mined, the Buchans deposits have produced more than the combined tonnage of all the Noranda area deposits.

The regional setting of the Buchans deposits is reviewed in an article by Kean, Dean and Strong entitled "Regional Geology of the Central Volcanic Belt of Newfoundland". This article is accompanied by the 1:250,000 scale geological compilation map. Buchans deposits are compared to those in other parts of northern Newfoundland.

Details of the geology and ore deposits of Buchans are reviewed in papers by several authors, including Thurlow, Swanson, Strong, Barbour and Walker. The 1:50,000 scale geology map provides the setting of these papers.

Bell and Blenkinsop review the geochronological data available on the Buchans area and provide some new data on the major rock types. One conclusion is that the volcanic rocks of the Buchans Group were erupted at about 450 Ma ago.

Two other very interesting papers are the "History of Geophysical Exploration..." by Moss and Perkins and the "Development of Genetic Concepts and Exploration Practice..." by Swanson. Other papers cover glacial geology, stable isotope studies, metamorphism, and the genesis of ore metals. The text concludes with a 25-page paper by Hutchinson on "A Synthesis and Overview of Buchans Geology".

In conclusion, this Special Paper is an excellent case history of a major mining area. It is worth its cost for just the Neary article and the two geological maps. This is an essential reference work for every economic or exploration geologist anywhere who has an interest in base metal deposits. I highly recommend it.

## Diagenesis in Sediments and Sedimentary Rocks, 2

*Developments in Sedimentology 25B*
Edited by G. Larsen and G. V. Chilingar
*Elsevier Scientific Publishing Company*
*1983, 572 p.,*
*$117.00 U.S., cloth*

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This volume is the second of two companion volumes concerning the diagenesis of sedimentary rocks. Together both volumes succeed an earlier volume on diagenesis, also edited by Larsen and Chilingar. This fact in itself is indicative of the vast expansion of studies concerning diagenesis in the time period following publication of Larsen and Chilingar's first volume.

In order to characterize this latest volume of Larsen and Chilingar, it is perhaps best first to describe what it is not. It is definitely not a well organized review of diagenetic studies dealing with an orderly progression of topics that are linked by a common theme or themes. Instead, the reader is confronted by a series of independent and largely unrelated papers which the editors, rather illogically, have designated as chapters. There is not even a logical division of topics between the two companion volumes. For example, papers describing the diagenesis of carbonate and terrigenous sediments may be found in both volumes. In fact, the subdivision of topics between these two volumes appears to be based on expedience rather than logic in that the subject material covered in the first of these companion volumes is largely a repetition of Chilingar and Larsen's earlier compilation. The subject material of the second volume, however, is almost entirely new and is not simply an outgrowth of previous work. This revelation may be small comfort to someone who, for instance, is interested specifically in the diagenesis of carbonates and is faced with the prospect of purchasing both of these volumes in order to obtain complete coverage of this subject.

The five review papers that constitute the subject material of this latest volume are contained in chapters 2 to 5 and, oddly, in Appendix A. Chapter 1, by the editors, is designated as an introduction; but in reality it is a collection of extended abstracts summarizing the contents of the following papers. Chapter 2, by Rhodes Fairbridge, provides a general description of realms of diagenesis in terms of the setting of diagenesis (e.g., near the sediment water interface-syndiagenesis). He also describes the major chemical (e.g., pH, Eh, ion adsorption) and physical (e.g., pressure, temperature) controls on diagenesis and their effects in each of the three diagenetic realms. Fairbridge includes an interesting discussion on the fate of silica in sediments and on halmrolysis, diagenesis primarily of clay minerals at or above the seafloor. A few erroneous statements, such as that the Fe/Mg ratio of dolomites is constant and that dolomitization results in a 12% increase in porosity, have crept in, but on the whole Fairbridge's article serves as a good introduction to the papers that follow. Chapter 1 is really not necessary at all and amounts to padding.

Chapter 3, a paper by A. Singer and G. Muller, concerns diagenesis in argillaceous sediments during deposition and burial. Processes governing shallow burial (e.g., bacterial reduction of sulphate) are contrasted with conditions of deep burial (e.g., high temperature). The evolution of pore water chemistry and of the mineral products of diagenesis such as illite are described in shallow versus deep burial settings. Probably most readers are cognizant of the progressive conversion of smectite to illite attendant on burial, but fewer will be aware of the development of authigenic illite within sediments at or near the seafloor in some places. Discussion of illite diagenesis constitutes the bulk of this paper but other aspects, such as silica diagenesis, feldspar diagenesis, diagenesis of organic material, the formation of sulphides and the formation of carbonate concretions, also are described. One anomaly worth mentioning is that although the pore water chemistry in the sediment pore waters from holes of the Deep Sea Drilling Program (DSDP) are described in detail to exemplify the composition of pore waters in argillaceous sediments of deep burial, the documentation of the mineralogical changes attendant on deep burial comes not from the DSDP but rather from the large deltaic basin-filling sequence such as the Gulf Coast sequence of the United States. There are some recent studies (e.g., Milliken *et al.*, 1981) which do integrate data on pore water chemistry and mineralogic changes from the same argillaceous sequence. In spite of the drawback, Singer and Muller have provided a well organized, comprehensive and readable review.

The situation for the reader improves still further with Chapter 4, a paper concerning the diagenesis of deep sea carbonates by H. E. Cook and R. M. Egbert. This paper is a little gem and is the high point of the entire volume in terms of readability. To some extent this is due to the more circumscribed nature of the topic, with a data base restricted almost entirely to the results of the Deep Sea Drilling Program. The constituents of the present-day deep sea carbonate oozes (e.g., coccoliths, foraminifers) and the changes due to physical compaction and progressive cementation with burial are well described and illustrated in an orderly manner. The variation in elemental (Mg, Sr) and isotopic composition ($\delta^{18}O$, $\delta^{13}C$) with burial depth are described concisely but the author's explanation for these variations is too simplistic; that the interpretation of these variables is a matter of controversy is not mentioned. Another ommission is the absence of any discussion of the diagenesis of hemipelagic carbonates. The paper concludes with an interesting discussion regarding the acoustic properties of deep sea carbonates and their relevance for stratigraphic studies.

Chapter 5 is a long paper by H. Kisch concerning the mineralogical changes attendant on burial diagenesis and incipient metamorphism in terrigenous sediments. The first part of this paper is devoted to a review of definitions and methods of defining the demarcation between burial diagenesis and incipient or burial metamorphism. No firm conclusion is reached, but the author seems to imply that the term *burial diagenesis* may be applied where the original attributes of a sedimentary rock are still discernible. Perhaps the most useful part of this paper is a discussion of the use of the degree of illite crystallinity as a reliable criterion for the determination of the degree of diagenesis in the deep burial environment. However, a major portion of this paper is devoted to a discussion of the development of metamorphic mineral assemblages, a subject of only peripheral interest to those interested in the diagenesis of sedimentary rocks.

The final paper in this book is a short one by L. Bubenicek concerning the effects of diagenesis on oolitic iron ore deposits. The author shows that the path of diagenesis depends primarily on the nature of the original constituents and in particular on the quartz content. The volume ends with a massive bibliography of references compiled by Kisch concerning burial diagenesis and incipient metamorphism published since 1976.

This book is reasonably well illustrated with tables and diagrams. However, the lack of logical cohesion amongst the papers in this volume limits its overall usefulness, although some individual papers are very readable. I would recommend it as a source of reference material for the subjects that are dealt with but not as a specialist's textbook on sedimentary diagenesis in general. European studies are particularly well referenced.

## Geology in the Nineteenth Century. Changing Views of a Changing World

By Mott T. Greene
*Cornell University Press*
*1982, 324 p., $39.90*

Reviewed by William A. S. Sarjeant
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The least satisfactory feature of this book is its title. This is *not* a general history of geology in the nineteenth century; instead, it is an account of the development of concepts in dynamic geology between the late eighteenth century and 1912. Anyone turning to it, in the hope of finding a modern equivalent to Zittel's classic history of geology and palaeontology, will find his or her hopes unfulfilled.

Had the subtitle appeared as principal title, all would have been well; for these are what are presented. As Dr. Greene stresses, the growth of geological concepts during this period was by no means a step-by-step construction of a growing pyramid of knowledge, as has been implied in some standard histories. Instead, in his words (p. 14-15),

> "change in geological theory is not slow, cautious and uniform, but rapid, radical and sometimes catastrophic.... No credence can be given to the idea that geology has advanced and changed in a series of clear-cut victories of one theory over another, followed by a period of unanimity and orthodox interpretation. In no period from the eighteenth century to the present has such a state of affairs existed across all national boundaries."

He is right also to note that the work of continental European geologists (oddly enough, though an American, Dr. Greene uses the word, e.g., on p. 76, "European" as a British geologist might, as exclusive of the British Isles and even of Scandinavia) has been given far too little stress in past histories and, where referred to, often has been seriously misinterpreted. The French geologists Haug, Bertrand and de Margerie are accorded a fairer treatment than in other histories and the work of Eduard Suess is given extensive treatment (*over*-extensive, some might argue).

In particular, and no doubt as a consequence of vigorous advocacy in many papers by Alexander Ospovat, a fairer evaluation of Abraham Werner's work is presented than has been usual hitherto. The account of Werner's mineral system (p. 34-35) is a masterpiece of lucidity; the difficulties in separating his ideas from those of his students are properly pointed out (p. 37-39); and the final assessment of Werner's contribution to geology (p. 44-45) is very fair.

In contrast and no doubt in an attempt to restore what is seen as a past imbalance the major British geologists are given rather a rough handling. While it is proper that attention be paid to the weaknesses in James Hutton's work—and, in particular, his "ubiquitous deistic teleology" (p. 24)—it is regrettable that he is accorded no such balanced final assessment as was Werner.

Moreover, it seems to me that, despite his extended treatment of Lyell's work, Dr. Greene has not fully appreciated its particular stress, that the world should be interpreted on the basis of processes still occurring, and not in terms of cataclysmic events without present-day parallels. (This does not involve an assumption that terrestrial conditions have been absolutely constant; Lyell's writings show a clear appreciation of differences between present and past circumstances on earth). Certainly Lyell did not understand the processes of mountain-building, but these are processes *still in operation* and thus within his conceptual compass. Dr. Greene's comment that "some periods in the history of the earth showed a greater tendency toward the creation of mountain chains than others", so that Lyell's "strict interpretation of uniformitarianism became untenable" (p. 98) is surely countered by our present awareness that mountain building has been occurring continuously throughout the earth's history, rather than being concentrated into brief episodes, and is certainly in progress today. The comment that Lyell's views "never gained a foothold in [continental] Europe during his lifetime" (p. 77) is negated by Dr. Greene's own statement that the influential French geologist Constant Prévost was "one of his strongest supporter—implicitly, not the only one!—"in France" (p. 96), while his assertion that Élie de Beaumont's theories had "a profound and lasting influence on the develoment of geotectonics—an influence far greater than that of Lyell" (p. 121) can be justified only if Lyell's influence on the methodology of geology is excluded, an exclusion I cannot accept.

However, Dr. Greene's lance is aimed only at the giants of British geology; its lesser figures fare much better. The "neptunist" responses of John Murray to Hutton's theories are well expounded (though, oddly, the equally hostile responses of grandson John Murray III to Lyell are not mentioned). A balanced account is given of the geodetic problems faced by Pratt and answered, in part, by Airy (p. 239-242), while Thomas Mellard Reade's hypothesis is rescued from an unmerited obscurity (p. 246-247).

In my view, there are two major weaknesses in this work. The first is its inadequate treatment of Cuvier's concepts of global revolutions, widely influential even up to the present century when the supposed mountain-building periods were still being called "revolutions"; the second weakness is a general lack of perception of the significance of stratigraphy to tectonic theory. I regret also that the recognition of the effects of glaciation by Louis Agassiz and his associates, with its immediate interpretational consequences and its longer-term relation to concepts of isostasy, gains so little attention.

However, no historian of so wide a field can be expected to be omniscient and omnicompetent, and the strengths of this work greatly exceed its weaknesses. Among the former are a particularly clear, brief exposition of the nappe theory (p. 205-206) and an equally lucid setting-forth of the reasons for its decline; a very fair account of the contraction theory and of the observations that forced its abandonment; and the sense of proportion with which U. S. contributions to tectonic theory are assessed. Dr. Greene's demonstration (p. 245) that Dutton's formulation of his concept of isostasy occurred almost a decade earlier than generally supposed deserves special mention.

Errors of detail are commendably rare. The only ones I noted were the misspelling of Torbern Bergman's surname (pp. 30, 40, 50) and those of André Jean Marie Brochant de Villiers (p. 98), plus a failure to cite Thomas Sterry Hunt's paper, discussed on p. 128.

In these days when plate tectonic theory conditions so much of our thinking, it is salutary to be reminded that, before the beginning of this century, Thomas C. Chamberlin already was pointing out the dangers of such an attitude (p. 260):

> "A theory, once formulated, became itself the centre of attention, and investigators would use it to select "important" data (which supported the theory) and to dismiss the rest as insignificant."

Chamberlin's method, that of multiple working hypotheses, surely remains the best. Instead, as Dr. Greene notes (p. 121):

> "Today one finds the same phenomenon [a desire to partake of the general theory of the earth] with regard to plate tectonics—no matter how conventional the subject, the author generally appends a short final paragraph tugging his forelock in the general direction of the plate margins."

All in all, this is a book destined to become a classic work on the history of dynamic geology. Though one might not be prepared altogether to accept von Buch's quoted judgement (p. 178) that mountain structure is the key to the whole of the science of geology (personally, I would assign that role to stratigraphy), it remains a matter close to the heart of our discipline. May I hope Dr. Greene will go on to produce companion volumes surveying, along the lines he sketches on p. 293-294, the history of this subdiscipline since 1912?

In the meantime, here is a volume deserving to be read by any geologist willing to raise his eyes above the narrow furrow of his own specialisation in order to survey broader acres.

## Geology Under Cities. Reviews in Engineering Geology, Volume V

Edited by Robert F. Legget
*The Geology Society of America*
*131 p., 1982, $26.00 U. S.*

Reviewed by E. A. Christiansen
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*Geology Under Cities* is a compilation of nine papers on the geology under Washington D. C., Boston, Chicago, Edmonton, Kansas City, New Orleans, New York City, Toronto and Minneapolis—St. Paul. This book arose as a result of Dr. Legget's unending commitment to the role of geology in engineering practice.

The papers deal with most geological environments in North America but unfortunately, as pointed out by Legget in his introduction, they do not include several cities the geology under which would have completed his sample for this book.

The book describes in considerable detail the geology of Piedmont Plateau, Fall Line, and Atlantic Coastal Plain on which Washington D. C. is situated, the bedrock and Quaternary geology of the Boston Basin, the Recent sediments of the Mississippi Delta plain in New Orleans, and the bedrock and Quaternary deposits in the New York City area. The remainder of the book describes the geology in terms of geotechnical considerations primarily. In Chicago, Edmonton and Toronto the emphasis is on the geology of tunnels; in Kansas City it is on shale heave in space beneath the city and in Minneapolis—St. Paul on geotechnical mapping and data handling.

The role of geology in the occurrence of construction material and groundwater, in marsh reclamation and flooding, in slope instability and foundations, and in shore erosion is exemplified near these cities. The availability of construction material ranges from an unidentified problem in Kansas City to a haulage distance of up to 1,300 km for New Orleans. Groundwater problems range from encountering water in sandy lenses in till during tunnelling in Edmonton to literally drowning New Orleans.

Marsh reclamation in Massachusetts Bay, Boston; in the Mississippi Delta plain, New Orleans; and in Jamaica Bay for the John F. Kennedy International Airport, New York City required geological knowledge of Recent fluvial, lacustrine, and marine environments. Flooding occurs where humans insist on building upon present-day fluvial, deltaic, lacustrine, marine environments, such as New Orleans.

Slope stability is a problem in most of the cities. The problem ranges from probably the greatest hazard in Edmonton to not being mentioned in Kansas City. Foundation problems include severe settlement in New Orleans, shale heave in Kansas City and swelling clays in Edmonton. New York City has about 40 km of salt water beaches which require maintenance for recreational purposes. To provide effective solutions for beach erosion requires an understanding of the geological processes which build and erode these features.

Although the papers are limited in length and scope by their number, the book serves to wet the appetite for urban geology and geotechnics. This book and *Cities and Geology* (Legget, 1973) are cries in the wilderness by an engineer who sees much more clearly than do geologists the potential role of geology in engineering practice.

This book should be in the library of every geologist and geotechnical engineer who devotes a part of his or her time to urban geology and geotechnics. The book is well organized and written. The (8 1/2"x11") format is large enough for maps and small enough to fit most shelves. The use of bold print and italics makes for a pleasing appearance and easy reading.

## Major Structural Zones and Faults of the Northern Appalachians

Edited by P. St. Julien and J. Béland
*The Geological Association of Canada Special Paper Number 24*
*280p., 1982, Members $24.00, Non-members $29.00; cloth.*

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When I took an introductory course in geology over thirty years ago we used one of the "Yale texts". Appalachian geology was presented in a straightforward manner and, except for a mythical continent that once lay somewhere in the Atlantic Ocean, the geology appeared to fit into a rather simple picture. This is not the state of affairs today. Appalachian geology is, in fact, incredibly complex; tremendous advances have been made in the past decade with the recognition of tectonostratigraphic zones and their relationship to plate-tectonics models.

This volume consists of some of the invited papers presented at a symposium held during a Geological Association of Canada meeting at Quebec City in May 1979. It is comprised of an introduction by the editors, seven papers under the heading *Structural Zones* and five papers under the heading *Zone Boundaries and Faults.* The papers range in scope from comprehensive summaries of rather large regions to detailed accounts of single tectonic elements or rock units.

In the introduction the editors summarize the geology of the Northern Appalachians and review the papers. The inclusion of a map showing the tectonostratigraphic zones and simple vertical sections illustrating the tectonic evolution of the region would have been helpful.

Hall and Robinson describe stratigraphic-tectonic subdivisions in southern New England, relate them to zones in Canada and account for their tectonic significance. The Avalon and Gander zones of central eastern New England are discussed by Lyons, Boudette and Aleinikoff, who suggest that four microplates were present in New England at the closure of Iapetus. Hatch describes the Taconian Line in western New England and illustrates the significance of the line, in terms of plate tectonic models, by means of a series of cross sections for various time periods. Doolan, Gale, Gale and Hoar point out the role of the Québec re-entrant in pre- and post-collision events. They suggest that the Vermont serpentinites represent remnants of obducted oceanic crust rather than ultramafic intrusions through sialic basement. Structural elements formed by the Taconian and Acadian orogenies in central and northern New Brunswick and those formed by the Acadian and Hercynian orogenies in southern New Brunswick are described and related to plate tectonics models by Fyffe and by Ruitenberg and McCutcheon, respectively. Ophiolitic rocks, exposed on the western shore of Notre Dame Bay, Newfoundland, are traced beneath the bay by means of magnetic and gravity measurements (Haworth and Miller).

The Baie Verte—Brompton Line, characterized by ophiolite complexes, extends from northern Newfoundland to the Québec-Vermont border. Williams and St. Julien suggest that the line represents the junction between deformed rocks of a continental margin and a bordering ocean, juxtaposed in Ordovician time. According to Boudette, ophiolite rocks in central western Maine originated by the obduction of oceanic crust during the early Paleozoic and prior to the Taconian Orogeny. The Dover-Hermitage Bay Fault, the boundary between the Gander and Avalon Zones in Newfoundland, is described by Kennedy, Blackwood, Colman-Sadd, O'Driscoll and Dickson. According to Rast and Dickson, the separation of the North American plate and the Avalon Plate began in the Late Precambrian and at the site of a major shear zone—the Pocologan mylonite zone of New Brunswick. The tectonostratigraphic zones in the Northern Appalachians display a Z-shaped bend between the Québec re-entrant and Newfoundland. Keppie, by means of palinspastic maps, argues that the Avalon and Meguma Zones were originally straight. They arrived at their present configuration by a dextral offset along the Minas Geofracture of several hundred km.

There are a few errors in the text and diagrams, but they are of a minor nature. The lettering and decoration on some of the maps are very small and difficult to read, while some maps have unnecessarily large letters. Terms and phrases such as "structuration" and "imbricated continental margin ocean crust east dipping obduction surface" could only warm the heart of Robert Bates. The bibliography occupies approximately 36 pages and many of the entries are repeated several times; a singe bibliography for all the papers would have been more elegant.

In conclusion, the general reader, who wants to obtain an overview of the geology of the region and who is unfamiliar with the Northern Appalachians, will find the papers heavy going. The number of local names of places, rock units and tectonic elements is rather baffling. On the other hand, anyone working or contemplating work in the Northern Appalachians will want to have a copy of this volume; it provides at a reasonable price an excellent summary of zones, zone boundaries and faults and a comprehensive bibliography.

## Marine Geology

By James P. Kennett
*Prentice-Hall*
*813 p., 1982*
*$35.95; cloth*

Reviewed by Gustavs Vilks
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We finally have a textbook in marine geology that reads well, is useful to students as well as to practicing geoscientists and is as complete and up-to-date as it possibly could be (over 1000 references, up to 1981, most between 1970-80). The reader should be familiar with basics in geology at least at a sophomore level to fully benefit from the text.

After a very short history of marine geology, the book follows the logical sequence of chapters from the earth's core to the crust: the physiography of ocean basins, continental drift and plate tectonics. The plate movement through time is the basic forcing function in paleoceanography, and this topic is favoured by the author and discussed in great detail throughout the book. The reader is led systematically through time and space: how major basins opened and closed, how major current systems and water masses originated and how these created major climatic fluxes leading to the Quaternary glacial finale.

The book draws heavily on the data provided by the Deep Sea Drilling Project (DSDP), which during the last decade has drilled at over 500 sites. Since comparable material is not available from the Arctic Ocean, the latter plays a very small role in the paleoceanographic models developed in the book. It is an unfortunate gap; however, it is also interesting that the author did not express the need for information from the Arctic Basin. Evidently the stratigraphic record of the sediments in the oceans as established by the DSDP cores is sufficient to explain major geological events of the sea floor on a global scale.

Having read the book, one is left with the impression that the frontiers of global marine geology are found principally in the deep ocean, in its tectonics, sediments and biology. This is not entirely true, but the bias of the author is understandable. The book is closing a decade of scientific revolution in offshore marine geology. Under the unifying concept of plate tectonics, crustal and sedimentary processes can now be explained in unprecedented completeness. The DSDP cores provide overwhelming evidence confirming plate tectonic models, in addition to the worldwide isotope and biostratigraphy that can only be found in deep sea sediments.

The book is well illustrated and has author and subject indexes. It is a good investment for $35.95.

## Metallogenic Map of the Province of Nova Scotia

By A. K. Chatterjee
*Nova Scotia Department of Mines and Energy*
*1982; $5.00*

Reviewed by D. F. Strong
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Imagine yourself to be an exploration geologist (unless you really are one!), arriving in a new area which you know little about, except that there is potential for finding just those minerals which your boss (probably a lawyer or an accountant) ranks as having the highest priority, at least for this month. You know the government files are crammed with useful information, but the task of wading through it is formidable, never mind formulating a coherent understanding. If only they could invent a way of relaying all this information to you at a glance! Of course this has been done, and the invention is called a metallogenic map. The problem has been that many "metallogenic maps", especially in North America, have provided little more than geographic locations, and so have had less than total success.

Imagine that you are a harassed professor, and you try to emphasize to your Economic Geology students how valuable metallogenic maps are and, in these days when "relevance" is king, you can find decent examples only for far-away places, such as New South Wales or Europe.

Two recent events indicate that things are beginning to change. One is the publication of Phillip Guild's metallogenic map of North America, now available as an open-file release from the U. S. Geological Survey and certainly a monumental compilation and production of great value. The second, and the subject of this review, is Dr. Chatterjee's metallogenic map of Nova Scotia, which will certainly set the standard from now on, and hopefully inspire the other provinces (indeed, the United States, too) to follow his lead, and even his legend.

The map is produced at a scale of 1:500,000 (7.89 miles/inch) on a geological background of pastel colours and comprehensive symbols which provide more detail of stratigraphy and lithology than does the average geological map. Twenty different symbols show the main structural elements, i.e., five types of faults, anticlines and synclines of four different ages, four metamorphic isograds, axes of gravity anomalies and dykes.

The different mineral deposits or occurrences are shown by symbols of different shapes (circles, squares, hexagons, etc.) according to the age of their host rocks, with sizes proportional to their value (in 1980 Canadian dollars). They are coloured according to commodities (pale blue for Cu, bright blue for Pb, green for Sn), with subdivisions of the symbols to show their relative importance. The peripheries of symbols are marked at different positions by sub-symbols designating ore characteristics at 3 o'clock (open triangle = disseminated, solid triangle = massive), chemical class at 12 o'clock (Cu = native, <u>Cu</u> = sulphide), host rock at 9 o'clock (triangle for silicic volcanics, rectangle for sandstone), class or genetic type at 6 o'clock (various upward- or downward-pointing arrows for hydrothermal, intramagmatic, surficial alteration). Morphology of the deposits is shown by arrows, lines, etc. inside the main symbols, with their orientation showing the deposit orientation. These symbols are readily understandable and can be assimilated by only a few minutes of study, and a very detailed picture of a particular deposit can be obtained at a glance.

Along with the detail, the map also presents a clear overall view of the regional patterns, and reveals things which might not otherwise be seen. For example, it has long been known that Nova Scotian gold deposits are found in the Meguma zone, but the map also suggests that the largest ones are distributed in northwest-trending linear groups parallel to major faults. Furthermore, the main mineral groupings, or "metallogenic domains", of the map are enclosed by lines coloured according to the main metals present, and these show clearly how some gold veins are associated with base metals, some with Sb, some with W, etc. Does this suggest anything to you, gentle reader? It might imply some source control, and it might indicate that a given assemblage or pathfinder can be trusted only within its own metallogenic domain.

There are numerous other interesting, and sometimes surprising, patterns which stand out, including those of Ag which have been highlighted on a smaller scale inset map, but you won't see them if you don't stop and look. I recommend the map to everyone. At five dollars, it is the geological bargain of the year, which even an accountant or lawyer would appreciate.

## Sandstone Depositional Environments

Edited by Peter A. Scholle and Darwin Spearing
*American Association of Petroleum Geologists*
*Memoir 31, 410 p., 1982*
*AAPG-SEPM members—$32.00 US*
*Others—$38.00 US*

Reviewed by Richard Hiscott and Richard Hyde
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This book is written for non-sedimentologists, particularly those in the petroleum industry. This audience is similar to the audience for the Geoscience Canada reprint series volume, *Facies Models*. The AAPG product is longer than *Facies Models* and makes extensive use of coloured drawings and field photographs, but it is also more expensive and excludes carbonate and other chemical-biochemical sediments.

The book is divided into twelve chapters. The editors "tried to match chapter length to the significance of individual environments to general exploration for oil, gas and minerals". The chapters and their authors are as follows:

Glacial: D. J. Easterbrook; Eolian: T. S. Ahlbrandt and S. G. Fryberger; Alluvial fans: T. H. Nilsen; Lacustrine: T. D. Fouch and W. E. Dean; Fluvial: D. J. Cant; Deltas: J. M. Coleman and D. B. Prior; Estuarine: H. E. Clifton; Tidal flats: R. J. Weimer, J. D. Howard and D. R. Lindsay; Barrier-island and strand plain: D. G. McCubbin; Continental shelf: A. H. Bouma, H. L. Berryhill, H. J. Knebel and R. L. Brenner; Continental slopes: H. E. Cook, M. E. Field and J. V. Gardner; Submarine fans: D. G. Howell and W. R. Normark.

In some cases there has been a failure to match chapter length to importance in exploration for hydrocarbons or minerals. For example, based on the number of words, this volume would suggest that alluvial fan or eolian sediments are more frequent exploration targets than are sediments deposited in river, barrier island, submarine fan, or continental shelf environments.

The degree to which individual authors took advantage of the colour format varies and results in significant differences in the quality of visual presentation. For example, the chapters on lacustrine, fluvial and barrier-island environments all contain more than 85% coloured line drawings, whereas 6 chapters had no coloured line drawings. The quality of coloured field and core photographs is also quite variable. Many were probably reproduced from colour slides, resulting in occasional fuzziness or false colours. A strong feature of this volume is the number of illustrations and photographs, but commonly these are many pages away from the corresponding reference in the text (maximum difference noted was 6 pages in the slopes paper). The submarine fan chapter has all its photos following the text, with no connection between the two!

Four of the chapters, those on alluvial fans, fluvial facies, tidal flats and barrier-islands, are of outstanding quality in that they are accurate, complete, current, generally concise and well illustrated. Minor flaws are as follows: alluvial fans—inconsistent quality of photos and line-drawings, two missing tables; fluvial facies—overemphasis of braided rivers, insufficient explanation of symbols and abbreviations used in line drawings; tidal flats—decrease in the quality of illustrations for ancient examples; barrier islands—one paragraph duplicated.

Some chapters are, in our view, too parochial or rely too heavily on the authors' own work (i.e., eolian environments, deltas and the continental shelf); the deltas chapter deals almost entirely with the Mississippi, and the continental shelf chapter does not stray from American waters. Important eolian characteristics are either poorly illustrated or poorly explained. Some delta core photographs display false colours or lack way-up criteria and scales.

Multiple authorship results in unnecessary duplication. For example, the content of the chapter on estuaries is almost entirely contained in the tidal flats chapter; hummocky stratification and storm deposits are treated much more thoroughly in the barrier island chapter than in the shelf chapter.

We feel compelled to single out several poor chapters, for reasons given below: glacial—most listed references are not cited in text, no references post-1975, figure captions are too brief; lacustrine—20 pages of captioned photographs are presented instead of text to cover several topics; important references, measured sections, core photographs and discussions of saline lakes, tropical lakes and carbonate deposition are either omitted or only briefly mentioned; continental shelf—poorly prepared or oversized line drawings and poor field photographs; continental slopes—inconsistent use of the terms *slide* and *slump*, poorly prepared line drawings, inadequate lithological descriptions; two figures on contourites but no discussion in the text; submarine fans—text is too brief, odd selection of references for ideas best attributed to others, use of process terminology that is largely avoided by workers in this field.

General strengths of the volume are: (1) abundant and coloured illustrations and field photographs; (2) good integration of sedimentology and economic geology; (3) generally accurate typesetting.

General drawbacks are: (1) lack of coordination between authors of related chapters; (2) uncritical incorporation of material from the literature; (3) failure to point out classic references; (4) lack of well analysed ancient examples for nonmarine environments; (5) descriptive rather than process-oriented discussion.

We recommend this book to petroleum geologists because it does a good job of integrating their field with sedimentology. Upper level undergraduates and graduate students will find the book (particularly the photographs) to be a handy reference. Field mapping geologists will probably find Geoscience Canada's *Facies Models* book a better buy at $8.00. The better chapters in this book should be studied by all sedimentary geologists.