Book Reviews / Critique

Book Reviews

The Evolution of the Igneous Rocks

Edited by H.S. Yoder, Jr
Princeton University Press, Princeton, N.J., 588 p., 1979
$35.00 cloth, $15 00 paper

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There is a continuing need among teachers and professional geologists in general for discerning reviews of relatively broad fields of research. As the volume and breadth of geological literature inexorably grows, the acuteness of the need increases. This fiftieth anniversary volume reviewing progress in the subject areas originally covered by Norman L. Bowen in his 1928 classic of the same title, is dedicated to his memory and will be warmly welcomed. The remarkable insights gleaned from careful laboratory experimentation coupled with a wide acquaintance with field occurrences of igneous rocks provided Bowen the powerful tools he used so effectively in formulating and presenting his viewpoints in clear and concise terms. The form and presentation of the anniversary volume constitutes a profound tribute to a pioneering giant in the application of the principles of physical chemistry to the interpretation of magmatic processes.

In the preface to his own book, Bowen made clear his strong prejudice for regarding igneous rocks series as primarily due to fractional crystallization of magmas, a position that was less than wholeheartedly endorsed by his contemporaries. After 50 years of subsequent progress, most igneous petrologists view crystal-liquid fractionation as proven to be the single most important factor influencing the diversity exhibited by igneous rocks. However, the modern viewpoint is tempered by greater, though incomplete, understanding of other factors such as bulk composition and mineral assemblage of source materials, degrees of partial fusion, compositions and pressures of volatiles, and mixing of magmas that may be significant in some circumstances

The contents of the book, chapter by chapter, follow closely but not exactly the form of Bowen's 1928 volume. Eighteen chapters, each prepared by an acknowledged authority in the field, review and discuss progress made in understanding principles and processes that bear on the interpretation of igneous rock suites. Various chapters consider the diversity of igneous rocks, silicate liquid immiscibility, fractional crystallization and partial fusion, silicate systems, the reaction principle, fractional crystallization in basaltic magmas, illustration and interpretation of rock variation, glassy rocks, crystal cumulates, assimilation, siliceous potassic rocks, feldspathoidal rocks, melilite-bearing rocks and lamprophyres, fractional resorption, volatiles in magmas, petrogenesis related to physical processes of the Earth, and classification of volcanic rocks.

The chapters vary in length from short to moderate Although it is not strictly valid to compare the space devoted to similar topics in the old and new volumes, it is interesting to note that Bowen's two longest chapters discussed assimilation and variation diagrams whereas these subjects receive a good deal less relative space in this volume. Silicate liquid immiscibility, fractional crystallization and partial fusion, the reaction principle, and volatile constituents get lengthier treatments in the new book. These differences merely reflect the changing emphasis and degree of interest and progress in the respective fields.

For various reasons several chapters particularly stand out. Chapter 2 is a thorough, balanced treatment of silicate liquid immiscibility by E Roedder. Chapter 3 by D C Presnall is a succinct discussion of the roles of fractional crystallization and of partial fusion in the generation and evolution of primary and derivative magmas. Chapter 9 is an elegant combination of theory and natural examples of crystal-liquid fractionation in basic magmas by T.N. Irvine. In Chapter 16 C.W. Burnham reviews the considerable advances made in understanding the role played by volatiles in silicate melts, one which Bowen in 1928 regarded as relatively unimportant in magmatic differentiation; Bowen's subsequent work with O.F. Tuttle on granitic systems caused him to reconsider that view Chapter 17, by P.J. Wyllie, points out some of the most exciting and far-reaching advances made in relating petrogenesis to the physics of the solid Earth, viewed in context, the insights shown by Bowen on the basis of very scanty data were remarkable

Any modern textbook bearing the title 'The Evolution of the Igneous Rocks' would be considered incomplete without extensive treatments of element partitioning between minerals and melts, trace element distribution and fractionation, kinetics of crystallization and reaction, isotopic geochemistry, diffusion in silicate melts, structure of silicate melts, etc. The fact that this volume contains little of such subject matter is a deliberate omission and an indication of the healthy expansion of research vistas since 1928.

The high standard and freedom from errors of this 'son of Bowen' anniversary volume is a credit to the authors, the editor and publishers The eminently reasonable price puts it within easy reach of all students of igneous petrology.

MS received August 25, 1980

The Interpretation of Igneous Rocks

By K G Cox, J.D. Bell and R.J. Pankhurst
Allen and Unwin, Inc., Winchester, Mass., 450 p., 1979
$41 00 cloth, $21.00 paper

Reviewed by David Strong
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This is primarily a "how-to" book, aimed at illustrating methods, especially via geochemical and phase equilibrium calculations, of understanding the genesis of igneous rocks. Its underlying philosophy is that igneous rocks are *related* in some *evolutionary* fashion, mainly by crystal-liquid fractionation processes enshrined by N.L. Bowen over fifty years ago. As with Bowen, such processes as diffusion, liquid immiscibility, and volatile transfer appear to be underplayed, especially in the light of numerous recent papers on these processes. Furthermore, the book is concerned mainly with mafic volcanic rocks, with little concern for granites and other igneous rocks.

" 'Will you walk into my system?' said the spider to the fly." The first two chapters, on "Fractionation in igneous processes" and "Compositional variation in magmas" state the authors' assumptions and describe their approach. If the reader accepts them, he is thereafter led on a most enjoyable and enlightening journey through a web of cotectics, phase boundaries, and many other curious things. These chapters clearly state the main problems of igneous petrology, with many new terms printed in boldface and explained as part of the text. This is a very effective procedure which will be welcomed by both students and teachers. However, there does seem to be an excessive concern with Harker-type X-Y plots of chemical variation, especially when no example is given of the many other "standard" plots (e.g., AFM or CNK) or other more sophisticated diagrams.

Chapters 3 to 5 clearly explain the principles and uses of phase diagrams, from one-component to three-component systems. The mechanical treatment of phase diagrams, including the use of reaction equations, is especially elegant and I predict that it will allow many students to understand the subject for the first time. It's unfortunate however, that there's a complete lack of any thermodynamic references which would clarify some principles. For example, the Clausius-Clapyron equation would have been helpful in explaining P-T effect on phase boundaries.

Chapters 6 and 7 provide a break from phase diagrams and return to the real world with "The interpretation of two-element variation diagrams" and "Petrographic aspects of volcanic rocks". Again, the concentration is entirely on X-Y plots, but Chapter 6 certainly does fully illustrate their usefulness, at least for crystal-liquid equilibria. Chapter 7 complements this treatment, showing how phenocrysts, xenocrysts, quench textures and other features can be recognized, and how they provide petrogenetic clues for use in conjunction with the whole rock chemistry. Some discussion of mineral chemistry would have been appropriate in either of these chapters, considering the present ubiquity of electron microprobes.

Chapter 8 returns to phase equilibria with "Quaternary systems", and is mainly concerned with the mathematics of plotting in, and projections within, such systems. Chapter 9, "Experimental work on natural basaltic and allied rocks", and Chapter 10 on "Water-bearing basic rocks systems" crystallize the research of this past decade, especially the generation of magmas at high pressures.

Chapter 11, on "Compositionally zoned magma bodies and their bearing on crystal settling", provides an interesting discussion of these phenomena in the light of crystal fractionation. However, students should be aware of alternative explanations of similar data, e.g. those by Smith and by Hildreth in the GSA Special Paper 180 published since this book was written.

Chapters 12 and 13 provide definitions of the petrographic terms and explanations of some physical processes associated with basic igneous intrusions, with only minor reference to chemical aspects.

Chapter 14 illustrates the use of trace elements, including the rare earths, in modelling various processes of crystal fractionation and partial melting. The explanations and examples are clear, but again restricted to crystal-liquid equilibria, although there is increasing evidence for the influence of volatiles on these elements.

The book concludes with a chapter on "The use of isotopes in petrology", both radiogenic and stable isotopes. It deals with strontium, neodynium and lead radiogenic isotopes, but surprizingly omits $^{40}Ar/^{39}Ar$ – a useful technique both for estimating cooling rates of intrusions and the detection of sub-solidus metasomatic effects.

An important teaching asset of the book will be the problems ("exercises") provided at the end of each chapter. Also useful are the appendices on Nomenclature of igneous rocks, whole-rock chemical data, norm calculations, CMAS calculations, reprersentative mineral analyses, and answers to exercises.

Despite the biases described above, I do agree with the authors that their "methodological approach has an inherent interest" and I recommend it to "petrologists of all ages". It will be especially useful as a senior undergraduate text in igneous petrogenesis and is a bargain at the price (even for the cloth-bound edition).

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Evolution of the Earth's Crust

Edited by D.H. Tarling
Academic Press, London, 443 p., 1979
$35.25

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This is an unusual book, designed by the editor to provide '. . .'snap-shots' of the major tectonic – processes at specific times . . .". Factual presentations followed by speculations on tectonic processes were sought from the contributors. The result is 10 reviews involving 14 different authors. The contributions are well referenced (15% of the book) and there are two good indices (together 7.5% of the book). These percentages are a good measure of one of the book's principal assets – its value for reference. Among its disadvantages are the many typographical errors and the lack of a substantial article on the oceanic crust. The contents certainly encompass a good range of 'snap-shots' of the continental crust. Tarling begins and ends the book with "The first 600 million years and Plate tectonics: present and past" (which includes a brief discussion of the oceanic crust). Bridgwater, Collerson and Myers review the Archean of the North Atlantic craton; Anhaeusser deals with the Barberton Mountain Land and Hunter and Hamilton with the Bushveld Complex. Goodwin continues the Archean part with a study of the Archean of Canada, but there is then a dramatic shift to Eriksson and Truswell on Geologic processes and atmospheric evolution in the Precambrian, we are then half way through the text. The Proterozoic of the North Atlantic is dealt with in 13 concise and informative pages by Sutton, but the Caledonian-Appalachian region is given 70 pages (plus 15 of references to 1975) by Roberts and Gale. G.A.L. Johnson reviews European plate movement during the Carboniferous, from which point Tarling concludes with plate tectonics.

Some 'snap-shots' are thus enlargements and others are miniatures. Two portraits are

entirely missing, the Mesozoic-Tertiary of the Pacific Rim and the Alpine. There is also nothing about the vast Proterozoic sedimentary basins or the poorly understood basement complexes of the Proterozoic, outside the North Atlantic. I have already mentioned the oceanic crust problem and there is no reference to seismic studies of the continental crust.

Tarling's own contributions are excellent 1976 summaries of subjects which are difficult to simplify. An ingenious argument, which I do not remember seeing elsewhere, is that plate tectonics began when the strengths of the oceanic and continental lithospheres approached (or re-approached?) comparability (p. 397). However, "core segregation – was catastrophically fast" is decidedly too definite (p. 10). The articles on the Archean of the North Atlantic Craton, Barberton and the Bushveld are excellent. They are factual, quantitative and treat almost every aspect of these complexes, equally, their reference lists are valuable. The Canadian Archean is more selectively treated. The review is essentially confined to the Superior Province. It needs to be read in conjunction with Goodwin's other review in *Variations in Tectonic Style in Canada* by Price and Douglas (GAC Special Paper 11). The other articles are more variable in content and authority. I found them generally less valuable, for a variety of reasons.

Thus one is faced here with a curate's egg, not one for one's own library in 1980, but useful for references and reviews on tectonics and some aspects of crustal evolution, especially for reading by senior students.

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Geochemistry of Water in Relation to Cardiovascular Disease

By Panel on the Geochemistry of Water in Relation to Cardiovascular Disease (POWC)
U.S. National Committee for Geochemistry, National Academy of Sciences, Washington, D.C. 1979
$10.75

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This volume represents an attempt to review and document relations between water quality parameters and cardiovascular diseases. Several aspects of the problem, related both to the pathway that drinking water takes to man and its transit through man, are reviewed. The topics covered range from the effects of the distribution system on water chemistry to the role of the constituents of drinking water in cardiovascular diseases.

Beside the introductory section (Chapter 1), the volume contains 8 chapters by different authors. Chapter 2 gives an adequate review of the geochemistry of drinking water as affected by distribution and treatment. Chapter 3 gives a rather terse account of the influence of geology on water characteristics. In the absence of any really hard data, the discussion of interactions among elements and binding ligands that may relate to cardiovascular disease (Chapter 4) remains speculative. Chapters 5 to 8 respectively cover: Pathogenesis and classification of cardiovascular diseases in relation to minerals in drinking water; Epidemiological review and critique of the association of water hardness and cardiovascular diseases; The role of chemical constituents of drinking water in cardiovascular diseases; The association of trace elements and cardiovascular diseases. In spite of the overlaps between chapters, the reader will likely find these comprehensive reviews of the associations of the various water quality parameters and cardiovascular diseases to be very stimulating.

The chapters are fairly uneven in breadth and depth of coverage. It is rather surprising that the organic compounds, natural or pollutant, in drinking water were ignored as an aetiological factor. A discussion of the potential impacts of elevated levels of pollutants on the incidence of cardiovascular diseases would have added to the overall impact of the report. The use of regression and correlation coefficients in demonstrating causal relations represents a flaw in certain sections of the volume. These are minor criticisms however.

The volume is readable and remarkably free of typographic errors. It certainly represents an authoritative review of the state of current knowledge on the controversial question of the relation between the hardness and composition of drinking water and cardiovascular mortality rates. It should be fundamental reading for anyone interested in the human habitat as it affects our health and welfare. The following sombre conclusion from the report should be food for thought for any geologist:

> "Extensive review of the epidemiological literature indicates that there may be a water factor associated with cardiovascular disease. Its existence, however, is far from certain. The factor can hardly be softness (or hardness) as such because of its biological implausibility and the numerous exceptions to the negative association of hardness with cardiovascular disease. Available evidence suggests that the water factor is not mediated solely by blood pressure or serum lipids."

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Geochemical Processes: Water and Sediment Environments

By A. Lerman
J. Wiley and Sons Inc., 481 p., 1979
$29.95

Reviewed by P.G.C. Campbell
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The author suggests in his preface that the approach of this book to geochemistry can be summarized in the question, "What happens, and how, and how fast does it happen, when waters, solids and gases interact in the earth's surface environment?" The term *water and sediment environment*, as used in the title, refers to much of the earth's surface environment including the zone of up to a few kilometres above and below the land and ocean surfaces, the term *geochemical processes* is taken to include the complex variety of processes – geological, physical, chemical, biological – involved in the evolution of this environment. The emphasis is on major element geochemistry, with occasional reference to nutrients (nitrogen, phosphorus, sulphur), trace element and organic geochemistry are practically absent.

Chapter 1, dealing with certain introductory aspects of global geochemical cycles,

proved somewhat disjointed; the author's aim was not immediately obvious to the reviewer, particularly in the later sections dealing with the phosphorus, carbon and oxygen cycles. The subsequent chapters, however, are arranged in a logical sequence and the author's direction becomes much more evident. In effect, at the beginning of each of these chapters the author has summarized the approach he intends to follow and the principal subjects to be covered. These subjects include the transport processes responsible for the major fluxes of materials on land, in waters and in the atmosphere (Chapters 2 and 3); the growth and evaporation of rain droplets, the uptake of solids and gaseous components by rain, and controls on the chemical composition of rain (Chapter 4); the physical and chemicl weathering of the earth's crust (Chapter 5); the production and removal of particulate materials in the water column of lakes and oceans, and the regeneration of biologically formed materials (Chapter 6); the reactions characterizing the sediment-water interface, and the rates of transport of dissolved and solid materials across this interface (Chapter 7); and the early stages of chemical diagenesis in sediments (Chapter 8). The book concludes with four appendices (the error function; solution of differential equations for a one-dimensional system where diffusion, advection and chemical reactions occur, settling velocities of particles of different shapes; physical constants and units), an extensive bibliography, a glossary, an author index and an adequate subject index.

In developing the subjects mentioned above, the author often emphasizes phenomena at the microscopic level (e.g., the section on the physics of settling and coagulation, plus Appendix C, while paying considerably less attention to macrophenomena (e.g. fluvial transport). This should not be construed as a criticism of the approach; the author himself notes that the subjects presented in this book reflect his personal interests, and this particular example is cited simply to illustrate his inclinations. He has adopted a highly mathematical approach emphasizing the derivation of equations representing various physical and chemical processes operating in the water and sediment environments. Unfortunately, the frequent occurrence of mathematical formulations and derivations renders the text somewhat difficult to read. In this connection, the author notes (p. 120) that R.E. Liesegang published a 170 page book in 1913 dealing with the role of diffusion in geology, and managed to avoid including any equations for diffusion whatsoever! The author professes astonishment at the fact that someone would attempt to write a book on diffusion without including the simplist Fick's equation. While concurring on this point, this reviewer would respectfully warn the potential buyer that Dr. Lerman has swung far in the opposite direction, rendering his book difficult for the non-mathematically oriented reader.

Despite the minor reservations noted above, this volume has much to recommend it. Writing clearly and concisely, and with a commendable sense of history, the author has carefully documented his text; the 475 cited references cover a span from 1687 to 1978. Typographical errors are few and the quality of editing is excellent. Primarily intended as a textbook for a course at the graduate level, this book should also be of interest to mathematically oriented research scientists in such fields as geochemistry, limnology and oceanography, as well as to practising environmental engineers.

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Environmental Geochemistry

by John A.C. Fortescue
Springer-Verlag, 347p., 1980
$34.80 (U.S.)

Reviewed by Walter A. Glooschenko
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I have become quite skeptical when I see the word "environment" preceding a disciplinary name in a book title. In the case of "Environmental Geochemistry" by J A C Fortescue, the use of such a prefix is somewhat justified as his text includes many aspects of the environment in relation to geochemistry, i.e., he attempts to be "holistic". But I believe the book is mis-named as I will discuss later.

Fortescue has written his book for three groups of readers including: 1) professional geochemists, 2) environmental scientists such as geographers, ecologists, soil scientists, foresters, etc., and 3) scientists and non-scientists interested in geochemistry as it relates to pollution, land use management, or environmental health. The author redefines geochemistry as "the study of the role chemical elements play in the synthesis and decomposition of natural materials of all kinds". He constantly uses the word "Landscape geochemistry" as "the study of the environment that occurs at or near the daylight surface of the earth". I am puzzled why the book was not entitled "landscape geochemistry". The word "landscape" is used more by European scientists, and this indicates the author's emphasis upon Russian literature, especially that of geochemists such as Perel'man, Vernadski, Polynov, Glazovskay, and Kozlovskiy.

Fortescue believes a central concept in geochemistry is the geochemical cycle which summarizes the circulation patterns of elements in nature during geological, (>10,000 years), pedological (>5,000 years) and ecological time (>500 years). I feel one cannot separate pedological and ecological time when discussing ecosystems as Hans Jenny and other pedologists have demostrated. This brings up a criticism of the book – perhaps many geochemists have neglected "holistic" approaches, but soil scientists certainly have not. His environment "occurs at or near the daylight surface of the earth". This describes soil science; why should geochemistry be singled out as the only discipline to do such work?

Fortescue's philosophy of environmental geochemistry includes four "graded organizations" or "hierarchies". These include: 1) space, 2) time, 3) chemical complexity, and 4) scientific effort. I think he has played down the role of chemical complexity. I feel that one of the major problems in ecology and agriculture is the question of the availability of elements, both essential and toxic, to biota. The literature contains numerous examples of chemical fractionation techniques, yet what is the environmental value of lists of concentrations of various elements without an idea of potential bio-availability?

A major part of Fortescue's book is devoted to his seven major concepts of environmental geochemistry. These are: 1) element abundance, 2) element migration, 3) geochemical flows, 4) geochemical gradients, 5) geochemical barriers, 6) the historical geochemistry of landscapes, and 7) geochemical landscapes. Much of the basic information presented can be found in other geochemical texts, and much is a repeat of previously published Russian geochemical research. Some of this Russian literature appears outdated, and I am sure more recent information would be better used.

The book does contain minor errors and in places the author has misrepresented data by using secondary sources. For example, on pages 36 and 37, Fortescue discusses a paper on land classification in California, then presents data on forest nutrients which he claims is from "the same area of country". I did not like beech trees growing in California and checked the original source. It was a secondary reference based upon two papers, one from Germany and one from the U.S.S.R. – not exactly California! The book also contains many large data tables which may be of little interest to the reader; examples rather than repeated tables would help.

For a "holistic" approach, certain areas are neglected. Very little is available on the geochemistry of oceans, lakes, rivers, ground-water, and the atmosphere. Nutrient cycling is limited in discussion, and the role of microbial processes is virtually absent. The book is very terrestrial in emphasis, another reason that it should have been called "Landscape Geochemistry"

Who should read this book? In my opinion much of the audience this book is intended to reach will not understand or appreciate many of the examples without some prior background in geochemistry or soil science. For the non-specialist, a book such as Levinson's *Introduction to Exploration Geochemistry* would be more valuable as an introduction to the area of environmental geochemistry For the geochemist, I doubt much will be new except some of the author's philosophical discussions.

Fortescue's book is not that easily read especially due to a lot of unfamiliar terminology and I am afraid he is trying too hard to sell a potentially valuable area of research in too confusing a manner. His philosophical discussions often become too repetitive and require reference to past chapters and confusing terminology. I cannot recommend this book to base a course around.

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Estuarine Hydrography and Sedimentation: A Handbook

Edited by K.R. Dyer
Cambridge University Press, 230 p., 1979
$39.50 U.S. (hardcover), $13.95 U.S. (paperback)

Reviewed by Bruno d'Anglejan
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Since the first multidisciplinary volume on estuaries published by G.H. Lauff 13 years ago, many monographs have presented increasingly numerous and detailed studies of these complex transitional environments. The overall impression left is that only broad generalizations are possible and useful, and comparison of results stresses the uniqueness of each system. However the problems encountered, the objectives pursued and the techniques required are often the same, so that estuarine research has now emerged as a field of its own. Comprehensive handbooks introducing the methodology available in the various subdisciplines are therefore timely It seems appropriate that the first of a series sponsored by the Estuarine and Brackish Water Association, followed by others on estuarine chemistry and biology, be devoted to physical and sedimentological aspects since these are essential to further considerations of biological or chemical exchanges.

This handbook covers the spectrum of techniques now offered for oceanographic and geological surveys of estuaries. A vast collection of references at the end of each chapter makes up for lack of details in some of the outlined methods. Unfortunately, cross-referencing between the various review articles is virtually nonexistant. As an introduction Dyer provides a good summary of the characteristics of bedload and suspended load dynamics as controlled by the various types of estuarine circulation and stratification. The two following chapters briefly deal with two topics which are preliminary to any estuarine work. N.C. Glen discusses tidal measurements mainly from the practical point of view of water level and reference datum determination, with only a brief outline of the more complex domaine of tidal analysis and prediction The methods concerned with the determination of position and depth are examined and compared by D.J. Hooper. The acoustic tools available to study the estuarine physiography and subsurface stratigraphy are described next by d'Olier. Side-scan sonar and the various options available for continuous seismic profiling are covered with clear explanations as to the capabilities, interferences and interpretation problem particular to each. A very complete review by A T Bullers and J. McManus covers all aspects of sediment sampling and analysis, from field considerations of sampling techniques and survey design, to the elaborate routines of sample preparation and grain-size analysis in the laboratory, as well as the various formats of data presentation and the final interpretation. Off the channel floor, a paper by I McCave offers a panoramic survey of all available approaches to determine the properties of suspended sediments. It examines the relative merits of the various methods of collection – filtration or centrifuge, the direct estimation of concentration by optical beams, particle size measurements, and chemical analysis Balancing the often high cost of the equipment against the quality of the results, matching data obtained by different physical techniques are two of the problems. "The thorny problem of net flux" determination remains the crucial one. Numerical modelling now makes some prediction possible Spatial and temporal variations in suspended matter concentration raise the difficult question of sampling frequency. Guidance in planning strategies is to be found in a good understanding of the physical oceanography of the studied estuary. This area is examined by K. Kjerfve, who describes in detail the process of time-averaging of velocity, salinity and temperature, and the essential calculations of the net discharge as well as the net flux of dissolved and particulate constituents. The program PROFILE which serves this purpose is offered in the appendix. Presentation of simple numerical examples helps illustrate the procedure

This most useful volume offers to students and researchers in all fields of estuarine studies, but mainly to geologists and sedimentologists, a vast array of methods to select from, as well as enough discussion of their limitations to heed excessive optimism or inappropriate use.

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Paleoceanography

By Thomas J.M. Schopf
Harvard University Press, 1980, 341 p
$25.00

Reviewed by M.J. Risk
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The time is ripe for an integrated text on Paleoceanography, and Tom Schopf's new book is very welcome indeed. It is based on Schopf's course of the same name at Chicago, a course which must have been conscientiously and laboriously revised every year: most of the literature cited in this book is mid-70s or later.

The organization of the book is logical and lucid. Each of the seven chapters deals with a particular oceanographic characteristic (for example, Ocean Volume), and each chapter begins with a statement of the present-day situation, followed by a discussion of determining or estimating ancient conditions, and concludes with a summary. Chapter 1, Ocean Volume, dives immediately into the knotty problem of rates of ocean accumulation, then discusses relationships between continent morphology and sea level. The next chapter, Bathymetry, I found most interesting, because of the tremendous breadth of material and the wealth of concepts. There is a general treatment, from a sedimentological point of view, of means of determining energy and hence environment. Bedforms, grain size distribution and cement chemistry are all covered. Later in the chapter there is a good review of carbonate compensation depth and biological bathymetric models. Chapter 3, Water Studies, includes coverage of tides, currents, and ocean circulation. There is excellent coverage of the origin of tides, variations in tidal height, and intertidal sediments (I was happy to read on p. 80 that intertidal facies are "distinctive", as this matter has recently been puzzling me and some of my colleagues). Chapter 4, Temperature, discusses the major methods now used for determining paleotemperatures (isotopic, chemical, organism morphology and gradients in organism distribution). Chapter 5, Chemistry, is again an attempt to synthesize a wide variety of sources and concepts into a coherent whole: in this case, Schopf logically hangs the discussion around the question of salinity changes. The next Chapter, Climatology, consists largely of a discussion of the use of sediment types to determine climate, but also contains a timely discussion of the effect of storms. Those of us who work in modern environments are all too aware of the effect of the catastrophic event. The final chapter, Biology, attempts to cover such diverse topics as productivity, diversity and biogeography and largely succeeds.

Although in general the synthetic parts of the book are well done, I had some minor objections. Some of the sedimentological models were accepted uncritically, and coverage of the use of biogenic sedimentary structures to determine climatic conditions, water depths and energy levels was brief to non-existent. Schopf's dismissal of some concepts occasionally borders on the dogmatic: for example, in discussing the possible effect of "rapid" environmental changes on extinction, he sets up a couple of straw men, demolishes them, then concludes that no density-independent mechanisms of extinction are plausible as major contributions to extinction patterns, and that no rapid rate of environmental change can really be rapid, compared with the potential adaptation rates of organisms. Now, he may be right – and, of course, many of the proposed density-independent factors, such as temperature changes, are very efficient accellerators of density-dependent factors. Schopf's own papers are frequently cited in this chapter, and I was left unsure whether I had been led in the right direction, especially in view of recent evidence for truly catastrophically rapid rates of change.

On the whole, however, this is an excellent book, and certainly of good value. Collecting and synthesizing all this material must have been an exhuasting job. The emphasis on principles which can be utilized throughout the span of the record will be welcomed by Paleozoic people, jealous of the better data enjoyed by their more "modern" colleagues. This book will be excellent supplemental reading for graduate and senior undergraduate courses in paleontology and paleoecology – which is exactly how I plan to use it.

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Climates Throughout Geologic Time

By L.A. Frakes
Elsevier Scientific Publishing Co., 310 p., 1979
U.S. $58.50

Reviewed by James T. Teller
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This book is the best available overview on the earth's paleoclimatic record, and is packed with interesting and up-to-date information. For example, did you know that late Precambrian tillites in Australia reach the astonishing thickness of over 5500 m? Paleomagnetic evidence indicates that almost all glacial deposits of this age accumulated at low paleolatitudes (less than 30°) with no definite polar glaciations yet recognized! Ponder the fact that many late Precambrian tillites are interbedded with dolomites. And, consider that there is evidence for glaciation in every period of the Paleozoic and every epoch of the Cenozoic but the Mesozoic – apparently the warmest and driest era in the earth's history – was spared this type of refrigeration. These are but a few of the interesting facts in Frakes' book on paleoclimate. The author has undertaken an enormous task in trying to summarize the huge and rapidly expanding literature on climate of the globe through geologic time. Indeed, Frakes is well qualified for such a task, having been in the forefront of paleoclimatic research for the past decade.

The emphasis in this book is on using key sedimentary parameters in combination with paleogeographic (including paleo-latitudinal) reconstructions to deduce the climate. However, as Frakes notes, while the paleoclimatic record has a "bountiful and sometimes bewildering array of pertinent geologic facts", it must be remembered that the intensities, interrelationships, and even specific components of climate-determining processes involving the solid earth, atmosphere, ocean, biosphere, and galaxy have varied through time. Considering this, it is a wonder that anything about our ancient climate can be deduced with certainty. But it has been, and Frakes puts it all together in a somewhat brief state-of-the-art summary. For the most part, the book reads easily except where the overwhelming number of facts occasionally get in the way. Frakes has successfully found a balance between readability and detailed documentation of pertinent facts.

The first chapter in the book is an excellent brief statement of climatic elements on the modern earth, and sets the stage for conclusions reached later in the book. The next six chapters deal with the progression of climate through the ages, from early Precambrian to Quarternary. These discussions are somewhat uneven in terms of emphasis. While this may partly reflect my own knowledge or expectations, it does seem, for example, that the role of the Quaternary pollen record or the use of coiling ratios of Cenozoic foraminifera in helping decipher the paleoclimatic record should merit more than the few sentences alloted by Frakes. The last chapter attempts to deal with selected climate-determining factors that were not mentioned previously. Here, Frakes should have synthesized all discussion in the book relating to causes of climatic change. As it is, the reader gets no overall feeling for possible causes, feedback mechanisms, and their interrelationship. In fact, the entire topic is not thoroughly pursued and there are a number of notable omissions. More importantly, however, is the fact that major points and key paleoclimatic interpretations in the book are all too often left unreferenced. Although Frakes points out in the preface that he has been very selective in citing published material in order to preserve a readable style, it should be incumbent on the author to give at least one key reference when citing specific data or making fundamental interpretive points.

One further criticism of this book is the absence of a chapter that presents and discusses the major tools used in interpreting climate from the stratigraphic record. I consider this a major shortcoming even though Frakes has scattered some basic discussion through the central six chapters (e.g., "Recognition criteria for glaciation" in Chapter 3; "Evaporites", "Coal", "Reef limestone", "Bauxite", "Phosphorite" in Chapter 4; "Oxygen isotopes" in Chapters 6, 7, and 8; Carbonate Compensation Depth in Chapters 6 and 7). A chapter near the beginning which brings together all this (and more) fundamental information would have greatly improved the book and would have widened its appeal.

There are other minor shortcomings in this book but overall it is a welcome addtion. While some omissions seem to stand out, especially with regard to non-glacial climatic indicators on the continents, there is a great deal in this book to recommend it. Unfortunately like so many of Elsevier's publications, the price is beyond the reach of most students and all but the most devoted professionals.

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Origin of Thermoremanent Magnetization

Edited by David J. Dunlop
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This book was inspired by a highly successful one-day session devoted to "The Origin of TRM" (thermoremanent magnatization) held during the 1976 fall meeting of the American Geophysical Union. Of the 22 papers presented at that session, 13 appear in this volume in their final form. Although inclusion of papers in the original oral session was interpreted quite liberally in terms of the title of the session, this book possesses a fair degree of close integration of ideas and concepts. This statement is particularly true of the first half of the book.

In the first half, the physical origin of TRM is considered through the single domain, pseudo-single domain and multidomain size ranges of magnetite and titanomagnetite. For students of rock magnetism, it will provide a valuable supplement to Stacey and Banerjee (1974).

The second half of the book is more diverse in character, the papers are a blend of rock magnetism and paleomagnetism. One involves the reduction of hematite to magnetite, a phenomenon which occasionally plagues thermal demagnetization experiments and paleointensity determinations.

The healthy interaction of the paleomagnetists and geochronologists at the University of Toronto led to the production of one paper on multi-component NRM and the correlation of these remanences with cooling ages as deduced by the $^{40}Ar/^{39}Ar$ stepwise heating technique. Two papers in the second half concern extra-terrestrial materials, one with shock-induced remanence in iron particles and the other with the NRM of iron meteorites and its comparison with laboratory TRM.

Two additional papers concern the nature of the magnetization in the oceanic crust, one based on DSDP material and the other from rocks of ophiolite complexes. Both of these papers emphasize the role of CRM (chemical remanent magnetization) processes during the aging and alteration of oceanic crust.

Origin of Thermoremanent Magnetization is the first in the new Advances in Earth and Planetary Sciences series. The technical quality (type setting of equations, reproductions of figures and photomicrographs) is excellent and augurs well for future volumes.

References

Stacey, F.D. and S.K. Banerjee, 1974, The Physical Principles of Rock Magnetism, Elsevier Scientific Publishing Company, 195 p.

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