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Book Reviews / Critique

Book Reviews

Mechanisms of Continental Drift and Plate Tectonics

Edited by P.A. Davies and S.K. Runcorn
Academic Press,
362 p., 1980
$72.00 U.S. cloth

Reviewed by G.T. Jarvis
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This book is a collection of 26 short papers covering a wide variety of topics of geophysical interest. Nine of these deal directly with the driving mechanism for plate tectonics, while the remainder are concerned with related issues. The book has been assembled from papers presented at the NATO Advanced Study Institute entitled "Mechanisms of continental drift and plate tectonics," which was held at the University of Newcastle upon Tyne, March/April 1979.

Several papers are clearly intended as review articles, while others present current results of ongoing research. Most of the articles are brief summaries, referring the reader to more complete discussions published elsewhere. As a result, the main point of each paper is made quickly, although the authority for it is not always clear.

In the first, introductory article R. Girdler presents an overview of the basic concepts of, and evidence for, plate tectonics. This is followed by a series of unrelated articles on subduction zones, the Rio Grande Rift, evolution of the lithosphere, reconstruction of past plate motions, small-scale convection below continental shields, seismic attenuation below the East Pacific Rise, membrane tectonics, mantle convection and global heat flow.

The next five articles are concerned with laboratory and numerical models of convection in plane layers. The first of these is an excellent introductory article, by Davies, in which the basic dimensionless parameters governing fluid flow are introduced, and the application of laboratory models to the Earth's mantle is discussed. The three subsequent articles each describe carefully controlled laboratory experiments. The final article in this related group presents a numerical simulation of mantle convection.

The book ends with a series of articles on solid state creep, electrical conductivity of the lower mantle, seismic anomalies at the core-mantle boundary, outgassing of the mantle and observations of polar motion.

The last four pages of the text contain a useful subject index which will serve to guide the reader to the appropriate papers of interest. This index, and the introductory articles by Girdler and Davies, are the major links binding the text together.

In general, this book provides a convenient collection of research and review papers which sample present areas of active research in geotectonics. However, because of the wide range of topics included, the book lacks a central theme or structure. Consequently, the format is similar to that of a special issue of a scientific journal. Indeed, a special issue would have been a more appropriate publication route, since at $72.00 the book is highly overpriced.

Uranium in Volcanic and Volcaniclastic Rocks

Edited by Philip C. Goodell and Aaron C. Waters
AAPG (Energy Minerals Division)
Studies in Geology, No. 13
331 p., 1981
$28.00 U.S.; $22.00 (AAPG-SEPM discount); paper

Reviewed by Marcos Zentilli
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This volume is the outcome of a symposium held in 1980 in El Paso, Texas, during the Annual Meeting of the Southwest Section of the American Association of Petroleum Geologists. The symposium probably marks the beginning of a decline in the cycle of interest in uranium, following the remarkable outburst of activity in geoscience studies and exploration for the metal in the preceding decade. The 23 papers which make up this volume, written by representatives of industry, universities and the U.S. Geological Survey, may thus serve as a document of current thinking on the topic. Traditionally, volcanic environments have not been a very popular target for uranium exploration in Canada and the United States, where other host environments (e.g., unconformity, sandstone types) have dominated interest and production. The surge in uranium exploration in the early 1970s led to the seeking of alternative, frontier, targets. Of these, volcanic rocks and their clastic products have been among the most attractive and successful. Regardless of the apparent subordinate importance as a *host* for uranium deposits, volcanic rocks have been looked at as a potential *source* of the metal for some time. D.C. Waters (appropriately coeditor of this volume) and H.C. Granger suggested in 1953 that devitrified glass shards and pumice lapilli in overlying strata could be the source of the uranium found

in underlying organic-rich sandstones, host of the major deposits of the Colorado Plateau. This suggestion, however, was met with skepticism. Incomplete understanding of the processes involved, and the scarcity of quantitative data on the ability of uranium to escape from volcanic materials during devitrification, have led to some hesitation, even in recent reviews, in accepting that volcanic rocks could represent a significant source of the metal.

The first paper of the volume, by R.A. Zielinski (U.S. Geological Survey), should dispel any doubts about the ability of alkaline, oxygenated waters at 60° to 120° C to efficiently remove bulk amounts of uranium (and silica) from a variety of felsic glasses. New data confirm results obtained in over five years of carefully controlled experimental work. This adds credibility to the rest of the volume, which focusses on uranium distribution in regions of known Cenozoic caldera activity and ignimbritic volcanism in the Basin and Range Province of western North America, from Oregon to Mexico.

Areal studies are organized geographically from northwest to southest. Well-illustrated papers describe aspects of, among others, the gigantic McDermitt caldera in the Oregon-Nevada border, U-Be-F mineralization at Spor Mountain and elsewhere in Utah, and deposits in Arizona, New Mexico and Texas. The last eight papers offer a rare summary of the geology, stratigraphy and geophysics of the Chihuahua City area, Mexico, including the important uranium deposits in Tertiary ignimbrites of the Pena Blanca range, lucidly discussed by P.C. Goodell (U. of Texas at El Paso) and others.

A welcome addition is L. Curtis' (Toronto) overview of similar deposits and prospects being evaluated in Canada, Australia and Italy. The author calls attention to the Baker Lake basin, Northwest Territories; the Makkovik fold belt, Labrador; the (U-Th-F) Rexpar deposit in British Columbia (interpreted as synvolcanic-exhalative by F.R. Joubin and D.G. James in 1957); uranium concentrations associated with the (Mo-W-Bi-Sn-F) Mount Pleasant complex in New Brunswick.

The message conveyed is that silicic (preferably alkalic and ignimbritic) volcanic rocks and their clastic derivatives can become, under certain circumstances, effective sources of uranium. Transport and concentration at suitable traps depend on other factors (permeability, temperature, pH-Eh, total dissolved carbonate, etc.), so that volcanic and volcaniclastic rocks need not be the actual hosts of the mineralization. Some traps, however, seem to be directly related to the "normal" development of caldera complexes, including fractures, sedimentary limnic facies, or hydrothermal systems active during some phase(s) of their evolution. Supergene processes may be involved in the genesis of deposits or in their later modification. As expected, there seems to be no substitute for trying to understand the geological evolution of the whole basin.

This volume is attractively presented; the majority of illustrations include metric scales, and typographical errors are minimal. Should the currently dormant interest in uranium exploration and research reawaken, this book will be an indispensable reference. There is, however, much in the volume that is of interest now to geologists studying calderas, the behaviour of (in addition to uranium and thorium) lithium, fluorine, berillium, tin and other elements in volcanic environments, and the geology of a large segment of the Basin and Range Province of North America, a distinguished representative of Circum-Pacific Cenozoic magmatism and metallogenesis.

Facies Interpretation and the Stratigraphic Record

By A. Hallam
W.H. Freeman and Company,
291 p., 1981
$27.95 U.S., cloth

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The stated aim of this book is to be "a contribution towards restoring stratigraphy to its rightful place as the core discipline of geology" (Preface, p. vi). The author deplores the increased fragmentation of this subject and the siphoning away of many of its more interesting and dynamic components into specialized subdisciplines, such as sedimentology, paleoecology, or paleoceanography. He makes the important point that many of the most exciting developments in our understanding of earth history have come about by interdisciplinary research. The science of stratigraphy should therefore be viewed as a very broad umbrella, and it is unfortunate that the word stratigraphy still carries overtones of the old-fashioned, dry as dust approach of laboriously ascending the geological column of selected localities, focussing on definitions, correlations and names.

The book does indeed take us through a wide-ranging survey of the kinds of studies being carried out on sedimentary rocks on continents and beneath the oceans. A basic knowledge of elementary petrology, paleontology and structural geology is assumed. Literature and examples are global in scope.

Chapter 1 discusses the principles and techniques of facies analysis, starting with a discussion of that much-used term *facies*. Hallam surveys the principal methods of studying sedimentary rocks, and does not have very kind words for some of the modern statistical methods of data analysis, grain size studies in particular. Statistical studies are commonly thought to be more "scientific" than the descriptive and semi-quantitative approaches of most stratigraphers, but in truth their pursuit often becomes an end in itself and adds little to a regional analysis.

Chapters 2 and 3 survey the full range of depositional environments and their sedimentary products. These two chapters are necessarily brief, and cover ground made familiar by Reading, Walker, Blatt and coworkers, Selley, Leeder, Friedman and Sanders, Reineck and Singh. Stratigraphers probably should stop writing about facies models for awhile, as their readers are thoroughly sated with the subject.

Chapter 4 is a general discussion of sedimentation and tectonics, in which sedimentary basins are described and interpreted in terms of their plate tectonic setting. This chapter has a slightly dated air. There is little discussion of oblique slip zones or the effects on sedimentary basin development of oceanic transform faults. The exciting new concept of accretionary terranes is covered in four lines, and the Wilson Cycle is discussed by reference to Bird and Dewey's (1970) paper, which is now somewhat out of date. A section entitled "Sedimentation and tectonics in relation to petroleum occurrence" deals solely with the North Sea.

Chapter 5 discusses "ancient epicontinental seas," a subject that has not been effectively covered in other books on sedimentology. The topic is one of Hallam's long-standing interests and, perhaps as a result, this is one of the most interesting parts of the book. The shallowness of the seas has important effects on water circulation and chemistry, resulting in distinctive sedimentary assemblages. Klein's work on tidal patterns over wide shelves and cratons is not mentioned, but Hallam arrives at a conclusion opposite to that of Klein, that tide range would have been negligible within the vast epicontinental seas of the past. Elsewhere in this chapter there are useful discussions of the development of anoxic environments, saline giants, ironstones and phosphorite.

Due largely to the efforts of Vail and his coworkers, the concept of repeated eustatic changes in sea level throughout the Phanerozoic recently has become much in vogue. However, Hallam has been writing about this subject for many years, and

is credited with first suggesting, in a 1963 paper, that volume changes of spreading ridges are the major cause of long term sea level change. A summary of current thinking is given in Chapter 6, in which the new ideas of the seismic stratigraphers are explained but, strangely, the important work of Sloss on which the seismic developments were based is not mentioned.

Climate is one of the major controlling parameters of sedimentary processes. Criteria for reconstructing paleoclimates from sedimentary evidence are described in the first four pages of Chapter 7, followed by a review of climate change through the Phanerozoic. This is a useful summary of a subject dealt with at much greater length in a book by Frakes.

In Chapter 8 Hallam turns to the results of deep sea drilling and the knowledge we have gained about the world's oceans back as far as the Late Jurassic. The chapter opens with a description of Berger and Winterer's brilliant synthesis of the age-depth curve of spreading sea floor and the carbonate compensation depth into a method for backtracking plate movement and deducing paleobathymetric and depositional history of the ocean bottom. Important discoveries of non-uniformitarian character, such as the Mediterranean salinity crisis of the Miocene and the Cretaceous anoxic episodes, are integrated into a general model of oceanic sedimentation.

The Precambrian receives special mention in Chapter 9. The particular problems of this era, such as the first appearance of redbeds and the abundance of banded iron formations in the Lower Proterozoic, are discussed in connection with the evolution of the earth's atmosphere. The evolution of continental plates and of the biosphere are also touched upon.

Finally, in Chapter 10, Hallam discusses "Facies and the Phanerozoic fossil record." Radiations and extinctions are related to plate movements and to such environmental effects as sea level change, anoxic events and climate change. The recent work on meteorite impacts as a possible cause of major extinctions (particularly that which terminated the Cretaceous) is also mentioned.

In summary, this is a very readable book which covers a good deal of ground within what is a relatively short text. The writing style is pleasant, the type and the illustrations are easy on the eye, and the necessary referencing is adequate without being obtrusive. It is always possible to quibble about the choice of subject matter or its organization, but here it is not particularly relevant, as the author certainly achieves his aim of demonstrating the broad, interdisciplinary nature of stratigraphy. University curriculum committees should look at this book because of the implications it conveys about the teaching of sedimentary geology. At the University of Toronto, the subject matter of Hallam's book is dispersed through at least six one-semester courses taught as more or less water-tight compartments, at different times during the 4-year B.Sc. program. It has bothered some of us that this and other subjects are fragmented in this way, and I am sure that many other teachers across the country have similar concerns.

Many in government and industry would find this book useful background reading, and it could serve as a reference text for many undergraduate courses in sedimentology, stratigraphy, regional tectonics, paleoceanography or paleoecology.

Analysis of Fluvial Depositional Systems

By Andrew D. Miall
American Association of Petroleum Geologists Education Short Course Notes Series, #20 75 p., 1982, $5.00 U.S., paper

Reviewed by F.J. Hein
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For the novice interested in fluvial sediments, this set of course notes is a good buy. The text is quite readable, with many illustrations (although captions could be expanded for clarity) and a comprehensive reference list (107 references). This book is not, as the title suggests, an account of methods used in the analysis of fluvial deposits. Rather, it is a general review of facies characteristics and vertical sequences developed in fluvial settings. Topics presented include sediment types and transport modes, channel morphology, methods of facies analysis, bar classifications, facies models, large-scale rivers and large-scale cycles, basin architecture and tectonic setting, fuels, and minerals in fluvial deposits.

Problems with the text arise because of the emphasis on *facies description* with little explanation of *fluvial processes* involved in the generation of facies and their associations. The first half of the book consists of general descriptions of sediment types, channel forms and facies models. Apparent discrepancies arise in the text as a result of this purely descriptive approach. For example, Miall states that the distribution of the planar cross-bedded sands (Sp) in braided river deposits "could represent mid-channel linguoid or transverse bars or sand waves migrating across a sand flat." No mention is made of the differences in grain size or scale between the large Sp sets due to mid-channel bar migrations and the much smaller Sp sets resulting from migrations of sandwaves, an equilibrium bedform. It would be difficult for a novice geologist to sort out the "complexity of fluvial deposits." One is left only with comparisons to general facies schemes and "typical" cycles presented by Miall. The problem with this comparative, descriptive approach is that the reader is left with the impression that fluvial sediments should fit one of the existing models. As pointed out correctly by Miall, though, most of our models are developed from "hot-arid, temperate-humid or fluvio-glacial regimes. Little is known about tropical-humid climates."

The section dealing with methods used in facies analysis presents an approach using "non-embedded Markovian analysis," one of several statistical techniques used in the analysis of stratigraphic sections. Worked examples are given, with complete tables of calculations. What is lacking is a discussion on problems in the applicability of this technique to truncated sequences, such as faulted sections or, in the subsurface, broken or missing cores. There are also difficulties in using Chi-squared tests for testing for the significance of Markov properties in stratigraphic sections, another topic which should have been elaborated.

The second half of the book is the best part of the notes, with discussions of large-scale cycles, basin architecture and tectonic setting. This section is well-written, and contains good tables and diagrams. Here, a discussion of economic deposits associated with fluvial sediments is given.

In closing, I would recommend this book for the non-specialist or as supplemental reading in an introductory sedimentology course.

Proterozoic Basins of Canada

Edited by F.H.A. Campbell
Geological Survey of Canada
(G.S.C. Paper 81-10)
443 p., 1981
$27.95 Canada; $33.55 other countries, cloth

Reviewed by E.H. Chown
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This volume, which is the follow-up to the "Basins and Geosynclines" symposium volume (G.S.C. Paper 70-40), is limited to Proterozoic basins. As Campbell notes in his introduction, the striking difference in the two symposia is the manner in which the later studies demonstrate basinal evolution in the light of plate tectonics. The older studies gave the impression that much of the Proterozoic was composed of vast sheets of pure sands, carbonates and iron formations. Updating shows a much more complete picture of many small rifts and sub-basins composed of fluviatile sands lying on regolith-covered unconformities. The regular appearance of volcanic components in these sequences is not surprising in view of the tectonic setting. A few of the papers published here relate this to some of the Canadian Shield's abundant dyke swarms.

The volume is composed of twenty regional studies and one review of Precambrian fossils. Encouragingly for this day and age, over half of the papers are single-authored, and very few appear to be rehashed previous publications. The papers are presented in a west-to-east order, which leads to some geological *non sequitors*, but which is only a minor annoyance to the reader.

Fifteen papers concentrate on the northwest part of the Shield with a focus on the Wopmay Orogen, equivalent and subsequent formations in adjacent parts of the Shield, the Arctic Islands and the Cordillera. These achieve a fair degree of coherence and an excellent global picture emerges.

The five papers concerned with the Circum Ungava geosyncline, while individually interesting, do not generate the same regional coherence, perhaps reflecting the distance between the studies. Two synthesis papers on the Southern Province and Keweenawan Rift are welcome additions to the bibliography of these regions.

All the extensive stratigraphic descriptions necessary for the sedimentary models are not to be read and digested in one sitting. However, all authors have been conscientious in achieving a balance between supplying enough detail and keeping the text to a minimum. The paleomagnetic studies offer some hope of a magnetostratigraphy, but in general are rather drab and inconclusive in comparison to the sedimentary studies.

Illustrations in the volume are of uniformly high quality, in particular various types of paleogeographic reconstructions. Relatively few printing errors mar the presentation, although the omission of two figures in the paper on early Proterozoic sequences in Labrador warrants an erratum sheet by the publisher. All Rb/Sr age dates are recalculated using a common constant; however, the authors are divided on whether to use Ga or Ma.

In conclusion, this is a well-presented, useful compendium of Proterozoic Basin studies, many of which are likely to stand for a long time, and it is offered at an affordable price.