

Book Reviews

The Cretaceous System in the Western Interior of North America

Edited by W. G. E. Caldwell
*Geological Association of Canada
Special Paper
Number 13, 666 pages, 1975
Members \$14.00, nonmembers \$18.00*

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This descriptive title of this collection of regionally oriented papers is a deceptive umbrella sheltering a number of contributions that far transcend provincial and stratigraphic constraints. In his preface, the editor expresses the hope that publication of the 28 papers presented at the Geological Association of Canada sponsored symposium will lead to a "wider appreciation of the many and varied aspects of Western Interior Cretaceous geology." The topical range of the contributions certainly serves this end and, if fault is to be found, it may lie in the larger proportion of papers dealing with northern interior rather than southern investigations and more with the western side of the seaway than the basin center or eastern margin. Synthesis of Western Interior Cretaceous Geology is not, however, the stated objective of the volume. Among the papers of general interest one should especially note that the superlative ammonite zonation of the Western Interior has been integrated with detailed K-Ar dates derived from bentonites by Obradovich and Cobban. They provide much new data on Cretaceous stage boundaries which will serve as a comparative standard for years to come. Like most good things,

however, their accomplishments are to a minor degree blemished by the contribution of Williams and Baadsgaard in which samples from presumably coeval zones in Saskatchewan are dated as several million years older than samples from the United States dated by Obradovich and Cobban.

In another interesting contribution, Couillard and Irving present data from which they deduce a mean pole position for the Cretaceous of Lat. 68°N, Long. 185° and construct a paleolatitude map of North America for the period. The map should provide a useful base for plotting Cretaceous climatic zonations and zoogeographic information. Williams and Stelck provide a new set of paleogeographic maps of the continent for various intervals of Cretaceous time. New interpretations are presented for the northern parts of Canada and the eastern margin of the seaway. Those geologists acquainted with the Gulf Coastal Plain will be surprised to discover that, among other questionable interpretations, the shoreline during "Early *Hoploscaphites hippocrepis* time" (text-fig. 6) is some 100 or more miles south of outcrops containing the designated species.

Biostratigraphers and paleontologists in general should be especially interested in Erle Kauffman's detailed summary of the dispersal ability of benthic *Bivalvia*. He makes a strong case for their increased utilization in the erection of zonal frameworks. Among other paleontological papers, two on palynology are mutually supportive. Norris *et al.* and Singh both summarize the evolution of Interior Cretaceous pollen and conclude that Early Cretaceous floras were of cosmopolitan aspect, but that those of the Late Cretaceous were disjunct. They demonstrate that during Late Cretaceous times *Aquillopollenites*

types, with their Siberian affinities, dominated Interior assemblages and contrasted strongly with the Normapollis dominated, European related, floras of the Gulf and Atlantic Coastal Plains.

General stratigraphers and sedimentologists will find reward in the series of papers on both the nature and extent of unconformities (Hattin, "Stratigraphic study of the cyclic Niobrara unconformity . . .") and on the cyclic and deltaic sediments so exquisitely exposed along the western margin of the Interior seaway. Among others, the Wiemer and Land study of Maestrichtian deltaic and interdeltic sedimentation provides a worthy classroom example in interpreting depositional environment.

In summary, the volume is a pleasure to read. It is well edited with clear and pertinent figures throughout. References accompany individual contributions, and the only improvement would be the inclusion of an index.

MS received June 1, 1976.

Canada's Continental Margins and Offshore Petroleum Exploration

Edited by C. J. Yorath, E. R. Parker, and D. J. Glass
Canadian Society of Petroleum Geologists
 Calgary, Alberta. 898 p., 1975.
 CSPG and GAC members \$15.00;
 non-members \$19.00

Reviewed by Nicholas Rast
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This capital volume is the outcome of two symposia held in 1974 in St. John's, Newfoundland and Calgary, Alberta respectively. The range of topics is wide and divided into some 50 papers and 17 additional abstracts. There are 22 papers on Atlantic margins, five on Baffin Bay, 11 on Arctic Ocean margins and two on the Pacific. In addition four general papers, five environmental contributions and a keynote address by Sir Edward Bullard complement the main thrust of the volume.

The Atlantic Ocean margin has received most of the attention, so much so that not only the Canadian margin is examined, but so is the British, the Scandinavian and the East Greenland among others. Thus, although the official topic is somewhat transgressed the volume has extra data which are otherwise not available. To a geotectonician the North Atlantic exposition is therefore particularly useful, and this is despite the fact that in one or two cases the substance of the papers in this volume, and even the figures have been published elsewhere. The section on the Atlantic in itself can make a useful volume with its mix of sedimentological, geophysical and tectonic information.

The section on Baffin Island and adjacent areas, although more limited in scope, again provides most useful data and ideas, which in some cases verge upon the speculative as is for instance the suggestion by R. L. Beh that Greenland is traversed by a series of large transform faults.

Equally interesting and important is the part of the book dealing with the Arctic Ocean margins. Here such potentially important regions as Beaufort Sea and Mackenzie delta are described in detail and individual gas and oil fields are examined. The Pacific margin unfortunately is somewhat sketchily dealt with, although the paper by R. L. Chase *et al.* provides a sound general geophysical statement and R. A. Stacey deals well with the Queen Charlotte basin.

The so-called General Topics section is a heterogeneous group of papers of which at least two could have easily been included in the Atlantic margins part. Perhaps despite its shortness the paper by W. S. Fyfe dealing with solid earth-hydrosphere interactions is the most original and a paper by G. Dailly on the development of deltas is the most pertinent.

The last section of the book is concerned with the engineering problems of environmental control and although outside the hub of the symposium is both interesting and informative. In these days of concern with environmental factors it can stand reprinting as a pamphlet.

The book as a whole is well printed, amply illustrated and is generally free from typographic errors. It can be recommended to the professionals and advanced students alike and is an indispensable tool in tectonic research. How much it impinges on petroleum geology as such I am not qualified to judge, but it provides a background of data and ideas that I am certain no petroleum geologist can disregard.

MS received May 31, 1976.

Petroleum and the Continental Shelf of North West Europe

Edited by Austin W. Woodlang
Halsted Press, John Wiley and Sons
 501 p., 1975.
 \$47.50

Reviewed by D. G. Penner
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This book is a major contribution to the interpretation of the geology of the continental shelf of northwest Europe. The volume is a result of a conference held in London and organized by the Geological Society of London, the Institute of Petroleum and the Petroleum Exploration Society of Great Britain. Closely associated with the conference were societies from United Kingdom, United States of America, Germany, France and Norway.

The volume contains 38 papers contributed by oil companies active in the region, scientific and government institutions of UK, Norway and Germany, consulting firms and universities of UK. Most of the material is new, largely due to the release of much heretofore confidential data obtained by oil companies through drilling during the past seven or so years.

For the purpose of this review the papers are grouped into six categories:- 1) three papers describing the tectonic and sedimentary history of northwest Europe, 2) eight dealing with the stratigraphy and lithology of individual horizons or formations, 3) eight papers treating local areas or basins, 4) fourteen describing as many gas and oil fields in the North Sea, 5) four papers giving results of special studies, and 6) one describing a new seismic technique that has application in the North Sea.

The dimensions of the book, eight by eleven inches, permits good sized and usable scale maps and cross-sections, all noted for completeness of information including geographical placement.

All the papers have an extensive list of references at the end followed by a record of a discussion between the speaker and delegates. An index is at the back.

The first of the regional structural papers by P. E. Kent is an excellent account of the sequence of tectonic events, a history of the positive areas and the numerous offshore basins around the British Isles. The two other regional papers are by P. Ziegler and W. Ziegler. Both recognize five stages in the tectonic history of the North Sea and both present numerous paleogeographic maps to illustrate the sedimentary history from Cambrian-Devonian to Tertiary time.

In the group of stratigraphic and lithologic papers the horizons discussed are Rotliegendes, Zechstein, Triassic, volcanics in the Jurassic, chalk of the North Sea, base of Cretaceous, Lower Tertiary (Paleocene) sand and Lower Tertiary tuffs and volcanics.

The Rotliegendes paper by J. Marie covers the UK portion of the southern North Sea basin. The nine accompanying maps are of small scale but still offer much subsurface interpreted data. The information on the Zechstein of the English sector of the North Sea is updated by J. C. M. Taylor and V. S. Colter. The authors recognize remarkable parallels with the Permian of certain North American basins. T. P. Brennan applies the new threefold subdivision to the Triassic of the North Sea. The variable lithologies encountered in the large area covered by the paper are ideally depicted with time - facies diagrams. R. J. Johnson reports on the mineralogy and micropaleontology of sediments below and above the Jurassic/Cretaceous unconformity. It sheds light on the sedimentation in the northern North Sea before and after the subject sedimentary break. F. Howitt, E. Aston and M. Jacque describe the occurrence of volcanics in the Jurassic of the North Sea. These materials are most prominent in the Forties and Piper field areas and are considered related to a fault and rift system in that region. The Cretaceous Chalk section is described by J. M. Hancock and P. A. Scholle. Scholle concludes with a discussion of the relationship between depth of burial, porosity and permeability, hardness and finally time of oil migration into a chalk reservoir.

Of great economic significance is the paper by J. R. Parker describing the Paleocene Sand interval and its three depositional sequences - coastal

deltaic at the top, slope in the middle and deep water fan with turbidite sand at the base. The excellent illustrations include one interpreted seismic section.

M. Jacque and J. Thouvenin describe the lithology, mineralogy and chemical analysis of the volcanic material at the top of the Paleocene. The authors suggest a connection between the volcanism and tectonic events at the time of the Atlantic opening.

The areas and basins which to date have seen limited or no exploration by drilling are discussed in eight papers. D. R. Whitbread describes thirteen basins west of the United Kingdom from standpoint of stratigraphy, results of drilling and productive horizons to date, and suggests horizons in Jurassic, Permo-Triassic and Tertiary remain to be explored. A paper by V. S. Colter and K. W. Barr discusses the Cheshire Basin and adjacent Irish Sea. The geology of the Sea of Hebrides and the Minches is treated by P. E. Binns and colleagues. The authors conclude that due to the history of events the area has attracted little commercial activity. The Dutch part of the Central North Sea Graben is described by P. Heybroek on basis of geophysical and limited subsurface data.

The large offshore area stretching from west coast of France, west of Ireland and Scotland to Barents Sea, off Norway, is described in four papers based on geophysical, sea bed core sampling and shallow-penetration seismic profiling. The Western Approaches and South American shelf is treated by F. Avedik. To the north, the development and petroleum potential of three basins, Porcupine Seabight, Hatton-Rockall and Rockall Trough is discussed by D. G. Roberts. The Scottish shelf, the Faeroe Block and intervening region is described by M. H. P. Bott. Finally, the Norwegian shelf is described in terms of three geological areas, the North Sea, the Møre-Lofoten system and the Barents Sea by H. Ronnevik and his associates.

Fourteen excellent field papers by company geologists and geophysicists are included in the volume. They are: West Sole, Leman, Indefatigable, Viking and Hewett gas fields of UK sector of

southern North Sea, Auk, Argyll, Brent, Piper, Dan, Ekofisk, Montrose and Forties oil fields of northern North Sea and Lower Cretaceous gas fields of Holland. All are illustrated with high quality maps and cross-sections of wells and most with a seismic section.

Included in the group of special papers are four describing the results of particular studies. A proposed standard lithostratigraphic nomenclature for the southern North Sea is given by G. H. Rhys on behalf of a committee. New groupings, new names and type section wells are described and illustrated. D. G. Blair gives an overall review of structures in the North Sea and states that "almost all significant hydrocarbon accumulations to date are in closed structures of four styles". Each style is discussed and illustrated with an example. T. D. Eames presents evidence of the source of gas in the southern gas fields as being the underlying Carboniferous Coal Measures. Moreover, a subcrop map shows all the major gas fields in the Rotliegendes to overlie the main coal productive formations. B. S. Cooper and his colleagues apply their knowledge of the relationship of paleotemperatures to oil and gas generation and accumulation to the North Sea. Their results of a study of fifteen North Sea wells suggest there are prospects for future finds of hydrocarbons from source rocks older than Jurassic.

Finally, one geophysical paper by T. Krey and R. Marschall describes a technique called "salt dome undershooting". Its purpose is to map seismically the base of the Zechstein and so top of Rotliegendes reservoir.

This book will be mainly of interest to specialists in the field of geology, geophysics and reservoir engineering and others who are concerned with or interested in data of the North Sea. The reviewer regards this book as the textbook on northwest Europe, particularly the North Sea, for many years in the future, and as such is a must in the libraries of oil companies, universities and concerned government agencies.

MS received May 21, 1976.

Introduction to Petroleum Geology

G.D.Hobson and E. N. Tiratsoo
*Scientific Press Ltd., Beaconsfield,
 England, 360 p., 1975.*
 \$28.50 (£10.50 in U.K. only)

Reviewed by Gordon E. Tebbutt
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Indisputably, crude oil and natural gas play a major role in modern society. More than 20,000 million barrels of oil are produced every year from 62 countries, supplying 60 per cent of our total primary energy requirements and the vast array of petrochemical products upon which we have come to rely.

Hobson and Tiratsoo have written this book to synthesize the principles of petroleum geology, in light of its application to world wide exploration for hydrocarbons. The volume consists of ten chapters, each of approximately 30 pages.

Chapter 1, *Petroleum Accumulations*, deals with the nature of hydrocarbon accumulations, chemical and physical characteristics of crude oils, natural gases, and oilfield waters, and the global history of oil production from its inception.

Chapter 2, *The Origin of Petroleum*, examines hydrocarbon source materials and alteration of organic material.

In Chapter 3, *The Migration of Petroleum*, the effects of compaction, solubility, temperature, and pressure upon migration of fluids are discussed.

Chapter 4, *The Accumulation of Petroleum*, outlines rather thoroughly the types of trapping mechanisms found to be effective, and reasons for their successful entrapment of hydrocarbons.

Chapter 5, *Surface Exploration for Petroleum*, gives a very good account of basic techniques used for reconnaissance exploration; this is particularly useful for preliminary appraisals in "underdeveloped" areas.

Chapter 6, *Subsurface Exploration for Petroleum*, provides a good general account of gravity, magnetic, seismic, electrical, geothermal, geochemical and radioactivity techniques.

Chapter 7, *Formation Evaluation*, involving use of cuttings, core analyses, drillstem tests, electrical logs, etc., is an excellent treatment of the subject, but needs more and better illustrations.

Chapter 8, *Delineation of the Reservoir*, discusses the principles of correlation, using paleontology and micropaleo, the significance of reservoir pressures, and the use of subsurface maps.

Chapter 9, *Petroleum in Space and Time*, describes the geological framework of the earth - its shields, platforms, and geosynclines, and includes a cursory view of plate tectonics.

Chapter 10, *Petroleum Production and Reserves*, deals with mechanisms of primary and secondary recovery and means of accurately estimating reserves, and ends with an interesting compilation of reserve figures, including "national" and "ultimate" reserves.

The authors have tackled a vast, rather unwieldy subject which must include virtually every phase of sedimentary geological studies and also associated geophysical and geochemical considerations. They have succeeded in assembling a systematically arranged mass of useful facts which generally is highly informative.

Outstanding among several shortcomings of the book, however, are the poor illustrations found throughout. With few exceptions, the figures are sketchy and overly reduced - in some cases, to the point of illegibility, and commonly are not clearly illustrative. Illustrations are not indexed, and frequently appear far from their citation in the text. Furthermore, the quality of paper used is of rather low grade in spite of the high cost of the book.

Lamentably, the writer's style is not scholarly, either in vocabulary or in sentence structure. Improper grammar, imprecision in explanations, awkward constructions, and poor and incomplete sentences all too commonly contribute to a disturbing lack of fluency.

However, in spite of its substantial disappointments, this book does contain most of the facts essential for an introductory treatment of the subject, and the inclusion of extensive up-to-date bibliographies provides access to more detailed studies.

MS received June 4, 1976.

Trek of Oil Finders: A History of Exploration for Petroleum

E. W. Owen
*Memoir 6, American Association of
 Petroleum Geologists, 1975, 1647 p.*
 \$38.00

Reviewed by J. S. Bell
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 335 8th Ave. S.W.
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This is the third volume commissioned to commemorate the first fifty years of the American Association of Petroleum Geologists. In it, Edgar Owen has traced the role of geologists in the development of the oil industry up to the early 1970s. It is a monumental study concentrating on people rather than "phases" or "trends" and I am sure most readers, and especially those with many oil industry years behind them, will find it a fascinating narrative.

The book is most engagingly written which will compensate those who find some of the technical jargon unfamiliar. It is easy to read in small doses; I have spent many bus journeys immersed in it. All the same, this book does not provide a quick survey of the issues in our present energy crisis. As one reads through it, however, one can see how the oil industry has responded to markets, as well as sponsoring their growth, and chapter after chapter emphasises that uncertain and changeable political controls have been an everpresent backcloth to exploration and production. Owen also makes clear how difficult it has been to locate economically producible oil and gas accumulations, and what incredible chances wildcatters have had to take.

The early chapters discuss the ancient production and use of petroleum. The section on China is particularly interesting; by 347 AD, the Chinese could drill to 800 feet. Six chapters discuss the development of both the industry and the practice of petroleum geology in the United States before 1920. One chapter is devoted to the international scene between 1911 and 1920. The succeeding discussion of technological advances is neither exhaustive nor up-to-date, but it does

explain when and how many familiar techniques were developed. Again the treatment is for geologists; laymen will have some difficulty understanding theory and practice or even why a particular tool had such wide-ranging effects on operations. The remainder of the book treats the post-1920 oil industry geographically, with each chapter concentrating on a particular part of the world. The United States receives the most detailed treatment, but there is a succinct twenty page summary of Canadian activities following the discovery of the Turney Valley field in Alberta.

Canadian readers will be interested to learn that the anticlinal theory of oil accumulation was probably first enunciated effectively in a lecture in 1861 given by T. Sterry Hunt, then an officer of the Geological Survey of Canada. A year later he published good supporting arguments while describing the commercial oil field at Enniskillen in Ontario.

"Trek of the Oil Finders" contains maps but no photographs which is mildly disappointing, but it is most adequately indexed and readers can quickly locate references to their colleagues and the fields they worked on. This book is most timely and, had it not been written now, I doubt if it would ever have been compiled so well. We owe Edgar Owen, and all those who assisted him, a very great debt for all the time and care that was devoted to its compilation.

MS received March 25, 1976.

On the History of Geophysics

"Zur Geschichte der Geophysik"
(in German)

Edited by H. Birett, K. Helbig, W. Kertz and U. Schmucker
Springer-Verlag, Berlin-Heidelberg-New York, 288 p., 1974.
DM 78.00, US \$32.00.

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Surprisingly, this appears to be the first entire book on the history of geophysics ever published. It commemorates the fiftieth birthday of the German Geophysical Society with contributions by 24 German geophysicists ranging from "Geophysically interesting ideas of Copernicus and Kepler" to "Beginnings of reflection seismology in Germany". Still, a reader expecting a systematic treatment going back to Galilei if not ancient Chinese geophysics would be disappointed, nor does the book claim to be a complete history even of German geophysics. Professor Kertz stresses this in his introduction, but argues that even a loose collection of papers may serve as a historical contribution or at least offer enrichment to scientists.

This seems valid enough. There is, for example, a fascinating account of pioneers of rock magnetism such as Macedonio Melloni, who discovered thermoremanence eighty years before Koenigsberger's classic study of the 1930s. Taking apart a wall in Pompeii made from blocks of Vesuvian lava, Melloni found the blocks to be permanent magnets with their axes randomly directed, and demonstrated experimentally that this stable magnetism must have been acquired as the original lava cooled in the Earth's magnetic field. In these heady days for the Earth sciences it is sobering to reflect that the key to the crucial evidence for plate tectonics was this single early discovery!

The first chapter is on the German Geophysical Society itself. Among its prominent members were Professors Wiechert (first chairman), Angenheister, Bartels, Jung, Mintrop and Schmidt. The

Society's somewhat uneven progress recalls the recent history of German geophysics itself, with its far-reaching international contribution between the world wars, then isolation and decline resulting from the Hitler regime, and renewed vigour since. That the Society is affiliated with the German Physical Society, but not also (as in Canada) with the geologists, seems to reflect a historical emphasis in Europe on the "physical" roots of geophysics.

There follow three interesting chapters on: pre-history of Newton's tidal theory (beginning with mythology); Copernicus and Kepler; and models of isostasy. The latter deals largely with Pratt and Airy, but it is shown also that Leonardo da Vinci already had formulated a mechanism resulting in an inverse relationship between the density of rocks and their elevation.

Four chapters each are devoted to (a) German geophysical observatories and surveys; (b) Early history of reflection, crustal and applied seismology; (c) Aeronomy topics, including the aurora, atmospheric electricity, cosmic radiation and the discovery of radiowave propagation. Two other chapters are on Tomaschek's gravimetric work and the history of the magnetic variometer.

The book begins with facsimile reproductions from two letters by Alfred Wegener to his father-in-law, the climatologist Wladimir Köppen. The first letter, dated December 6th, 1911, is the earliest preserved document referring to the continental drift theory. Wegener writes "Dear Father . . . I do think you are regarding my primeval continent idea as more fantastical than it is, and don't realize yet that it is only a matter of interpreting observed data . . .". Continuing in this confident vein, he makes the important point that foundered land-bridges are incompatible with isostasy, yet in the second letter (1912) ascribes untenable, rubber-like elastic properties to the sima. Incidentally, Köppen is said to have warned young Wegener against digressing far into neighbouring fields rather than apply all his energy to his "proper" subject - meteorology. One might wonder what particular global tectonic viewpoint would be dominant today, had Wegener accepted this advice.

The book includes a good source index on history of geophysics. Drawbacks are its high price and an overemphasis on central European material, which might restrict its English-speaking readership even if it were translated. This is a pity, since the volume offers a useful historical perspective and is stimulating to read.

MS received March 22, 1976.

Geological Survey of Canada Report of Activities Part A, 1975

Edited by R. G. Blackadar, P. J. Griffin
and Helen Dumych
Geol. Survey Can. Paper 76 - 1A
Information Canada, Ottawa
522 p., 1976.
Soft Cover, \$5.00

Reviewed by R. Y. Watanabe
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The Geological Survey of Canada reports its activities each year in summary volumes comprising two volumes per year during the period 1963 to 1974, and three volumes per year beginning in 1975. Only Report of Activities, Part A (GSC Paper 76-1A) is covered by this reviewer, with special attention directed toward sections on Cordilleran Geology, Precambrian Geology, and their contained mineral deposits. Papers 76-1B and 76-1C will appear later this year, but are less useful to geologists in the mineral industry.

The Report of Activities, Part A, is one of the most eagerly awaited publications each year within the Canadian mineral industry, and its usefulness is a reflection of the degree of respect in which it is held by its users. The Geological Survey of Canada is to be commended in its efforts to produce good quality reports of its individual projects commonly just a few months after completion of summer field programs. Early release of new data is clearly beneficial to exploration geologists, available for office studies and applicable to the field setting just months after release of new data.

Mineral exploration in the *Cordillera* has been hampered by the lack of good *geologic maps and even the non-existence of maps for large areas*. The Report of Activities contains reports of two regional comprehensive programs which are helping to upgrade these shortcomings. "Operation Finlay" is a mapping program in a large unmapped region in north-central British Columbia. The "Takla Project" centred on the McConnell Creek map-area, focuses on

the late Triassic and early Jurassic rocks which are recognized as host to a number of significant mineral deposits in the Cordillera.

Important lead-zinc-silver deposits occur in shales of the Selwyn Basin, Yukon, and the recent discovery of another deposit, the *Grum deposit*, will contribute to increased exploration activity. Blussons's mapping and study of the Selwyn Basin will facilitate exploration efforts. Conceptually, he shows that the large, bedded massive sulphide deposits occur along the flanks of a broad trough, and it is suggested that the deposits owe their origin to conditions similar to the Red Sea sulphide deposits. The report on the Pelly Mountains area by Tempelman-Kluit, Gordey and Read strongly suggests that this miogeoclinal setting is favourable for the occurrence of mineral deposits equivalent to Selwyn Basin deposits since rocks of similar facies and age can be correlated across the Tintina trench. A section on guidelines for mineral exploration is even included. This is a well-illustrated, comprehensive report which embodies considerable deliberation.

Eisbacher's report on the Redstone River area, Mackenzie Mountains, focuses on an area of active exploration, where a claim staking rush transpired from his report of a new copper showing.

Sangster and Lancaster comment upon the statistics of discovery of Canadian lead and zinc deposits, establish the concept of the Mackenzie Valley lead-zinc-district analogous to the Mississippi Valley district, and compare selected U.S. and Canadian lead-zinc deposits in carbonate rocks.

Two petrologic studies in separate Archean segments of the *Precambrian Shield* caught my attention. Jolly's study of the metamorphic history of the Archean Abitibi Belt (Superior Province) indicates that prehnite-pumpellyite metamorphic grade is widespread in the volcanics, and amphibolite rank metamorphism of volcanic rocks bordering gneissic rocks is in general a popular misconception. Lambert's mapping of the Back River felsic volcanic complex (Slave Province) is intriguing for its volcanological insight. Lambert identifies both submarine and subaerial volcanic environments, with postulated ring fractures related to calderas in the subaerial environment

Metagenetic study of the Abitibi Belt by Ridler continues, with special focus on "exhalites" i.e., chemical sediments of volcanic origin, which host mineral deposits and serve as markers for correlation. Tihor and Crockett's study of gold-bearing carbonate zones is a collaborative effort with Ridler, and attempts to determine the origin of the carbonates and establish the mechanism of gold concentration.

In recent years, many researchers have advocated that ore deposits are formed from solutions and metals derived from the surrounding country rocks. Franklin's study of the Mattabi massive sulphide deposit similarly concludes that lahatic breccia footwall rocks provided the metals and solutions, the driving force for thermal water convection being felsic volcanism.

The overall impression of GSC Paper 76-1A, in the eyes of this reviewer, is that a very useful summary volume of the previous field season's results has been produced even under editorial panic conditions. This state of panic is expressed by the disorganized sequence of reports and the confusing lack of explanation how individuals in team projects relate to each other. Readers of Paper 76-1A are strongly advised to carefully study the Introduction by R. G. Blackadar to mentally group related reports and better understand the purpose and basis of the many programs. The Table of Contents contains one significant omission - Report numbers are absent even though Blackadar makes frequent references to them in his Introduction.

As a general statement from a member of the mining industry, I congratulate the GSC for its efforts in providing good quality mapping data and practical research results, quickly placed at the disposal of exploration geologists, for their spirit of cooperation with the mining industry, to a degree and extent probably unmatched in the Western World. To exploration geologists in Canada, I heartily endorse that the GSC summary reports be placed on their list of necessary reading, and for the geologic fraternity in general, the summary volumes provide thorough insight into current research by the Geological Survey of Canada.

MS received June 1, 1976.

Deformed Root of a Composite Diapir in Granulite Facies

K. Schrijver
Geotektonische Forschungen, v. 49,
November, 1975, 118 p.
Price not shown

Reviewed by A. R. Berger
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This monograph is the latest contribution to the geology of that fascinating suite of anorthositic and charnockitic rocks that occur throughout much of the central Grenville Province. It is a study of the Lac-Croche Complex (LCC) which is one of a series of deformed pyroxene-bearing monzonites that occur near the Morin Complex, itself well-known from the work of Schrijver and Jacques Martignole, among others. The present work is the result of an estimated 12,000 hours of field and laboratory study carried out intermittently since 1963, and as such must surely rank the LCC as one of the most thoroughly studied plutonic complexes in the Canadian Shield.

Schrijver shows that the foliation of the main units of the LCC (ranging from leuconorite and quartz-mangeritic gneisses to jotunite and granite) defines a composite basin which overlies concordantly a variable assemblage of regional gneisses. Despite the absence of unequivocal contact metamorphism and of discordant offshoots cutting the envelope, the textural and mineralogical features indicate a magmatic heritage for the Complex, and the author concludes that it is the root of an igneous body "the major part of which was deformed and metamorphosed simultaneously with the country rocks during diapiric ascent."

The author pays very close attention to the "form-orientation" of the minerals in the LCC, describing it in terms of the L-S fabric system. He shows convincingly how changes in this fabric are related to changes in shape, alignment and distribution of aggregates of grains, individual grains and mineral species. The orientation and geometry of the L-S fabric vary widely over the

Complex, but its parallelism with that in the surrounding country rocks indicates that regional deformation has affected the LCC. Schrijver points out that major structures in the Complex "tend to become more elusive with increasing development of the linear fabric", and one is left with the uneasy feeling, not dispelled by some of the other contemporary literature, that either sensible kinematic interpretations of L-S fabrics in many plutonic complexes have not yet been found, or that structural geologists have over-rated their importance as universal indicators of strain.

One of the most fascinating aspects of this work is its many comments on the "plutontektonische Bastardstrukturen" of Hans Cloos - those structures due to synplutonic deformation which have long confused and intrigued many of us who have been seduced by the structure and fabric of plutonic rocks. The fundamental questions always seem to be whether they result from the flow-into-place of a mobile body or from the in-situ deformation of a body more ductile than its country rocks, whether this mobile and ductile mass was relatively solid or relatively liquid, and whether the causative stresses were due to buoyancy, to a genuine regional deformation, or were simply the ambient regional stresses acting on a part of the region suddenly made ductile. While answers to these questions are not always forthcoming, the author presents a wealth of incontrovertible evidence that the crystallization of the LCC was accompanied by a profound deformation which exerted a major influence on its geometry, textures, internal structures and even on its mineralogy.

There is a mine of information on other topics too, such as the mineralogy and the isotope chronology, but despite the author's claim to have made "drastic use" of Ockham's Razor, this reader wishes that he had invested in a new blade and obtained a closer shave. However, the candid and often startling comments on methodology that are scattered throughout this monograph provide adequate compensation for bulk and detail. The reader is, after all, warned at the outset that so as to provide "sufficient information to form his own opinion, data are included that play at most a subordinate role in the formulation of hypotheses." After a brief

and inconclusive discussion of structures in the country rocks, the reader is both jolted and relieved to learn that the "structural analysis of the envelope, even more so than that of the Complex, comes to a dead end." Again the author cautions that the "petrography leans heavily on the rock specimens that happened to be collected" and not on a thorough sampling of all exposed bedrock, that his subdivision of dykes into two distinct generations is "too radical", and that a conclusion here and there had in fact been "carelessly expressed" in an earlier section.

The major conclusion is that the "LCC is part of the missing link in the debate on diapirism", the present level of exposure being a horizontal slice through the downward-tapering and allochthonous root of a diapir now mostly eroded away. This reviewer is however tempted to wonder if the basinal shape of the complex with its inwardly increasing dips could also be interpreted a major Class 1 A synform of Ramsay. Could this shape be the result of an essentially horizontal buckling of two layers (or layered complexes) of which the lower and less ductile one is represented by the country rocks and the upper more ductile one by the rocks of the LCC which were forced to squeeze out of the core of a tightening synform? If so then any bulk upward movement would have been more a consequence of regional folding than of independent diapirism from below. At any rate it is worth pointing out that similarly shaped synforms can also be found in other Precambrian terrains, as in the granulite facies Highland Series of Sri Lanka, where the cores of the synforms are occupied by mobilized and migmatized hornblende-biotite gneisses.

This is a major contribution which should be read and pondered carefully by all interested in the anorthosite suite, the Grenville Province, and the structural behaviour and emplacement of plutonic units.

MS received March 10, 1976.

Compaction of Coarse-Grained Sediments (I)

Edited by G. V. Chilingarian
and K. H. Wolf
*Elsevier Scientific Publishing Company
Amsterdam, 552 pages, 1975.
\$54.25*

Reviewed by N. C. Wardlaw
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Compaction is a process particularly affecting fine-grained sediments and it is a surprise to see a volume of 552 pages devoted to the compaction of coarse-grained sediments and to realize that this is just the first of a comprehensive two volume treatise on the subject. Eleven authors have contributed to eight chapters which form rather independent subject units, not all of which are closely related to the book's title. Reference is made to the works of 700 authors:

The introduction provides a survey of the composition and classification of coarse-grained sediments outlining methods for the measurement of textural properties (size, shape, sorting, packing and surface characteristics) and relating these relationships amongst porosity, permeability, surface area, capillary behaviour and compressibility.

Chapter 2 deals briefly with the mechanics of sand compaction and is followed by a long chapter on the compaction and diagenesis of carbonate sands. The results of compression tests on a variety of natural sands and clays are presented and rock type, load type and compressibility are categorized yet the causes of differences in behaviour are not well defined in terms of sediment composition and texture. Cementation of grains limits mechanical compaction and is particularly important for carbonate sands where cementation may be early and extensive. Geological factors favouring compaction of carbonate sands and the relationships of compaction, cementation and pressure solution are clearly documented along with a review of methods, based on textural observations, for estimating the extent of compaction (compaction index). One

would like to see further illustrations of the application of compaction indices to the solution of geological problems.

The main theme of Chapter 4 is subsidence and, although little is said about compaction of sands, it provides a review of the distribution and development of sedimentary basins in North America. Crustal movements are described and explained with a blend of traditional geosynclinal theory and plate tectonics.

The role of sediment compaction in determining the geometry and distribution of fluvial and deltaic sandstones is the subject of Chapter 5. This case study shows that the distribution of sands in a fluvial-deltaic complex is controlled by the differential compaction of sand and mud and can lead to offsetting of successive channel deposits.

The effects of compaction on porosity, permeability, strength, compressibility and other properties are discussed in Chapter 6 and the succeeding chapter outlines the use of well logs in identifying lithology and depositional environment. Major logging tools are described with emphasis on those providing information on porosity. Porosity then is used for estimating degree of compaction.

The final chapter provides a mathematical analysis of sand compaction. The works of Terzaghi and Biot are reviewed in detail and show that compaction and rebound of sediments form one of the many divisions of the general theory of elasticity. Models presented have many simplifying assumptions but provide a guide to understanding real processes.

The scope of this volume is much broader than suggested by the title and the chapters appear as self-contained reviews. A possible criticism is that effect (compaction) is not as satisfactorily explained as one would like in terms of cause (composition, texture, load type, etc.), either for laboratory experiments or natural occurrences. Nevertheless, this work provides an excellent summary for all interested in sediment compaction. In addition, there is material for the non-specialist with more general interests in regional stratigraphy and sedimentology.

MS received May 17, 1976.

International Stratigraphic Guide

A Guide to Stratigraphic Classification, Terminology, and Procedure by International Subcommission on Stratigraphic Classification of IUGS Commission on Stratigraphy.

Edited by Hollis D. Hedberg
Wiley-Interscience, John Wiley and Sons, New York, London, Sydney, Toronto, 200 p., 1976.
 \$9.50 (discounts: 25-99 copies, 20%; 100-499 copies, 32%).

Reviewed by R. W. McQueen
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Many factors make this Guide timely, particularly the new understanding of the dynamics of the earth and the global interest it has fostered. The Guide is a "principles and concepts" document, which sets out the essentials of stratigraphic terminology and classification in clear and concise language - a reflection of more than 20 years of study by members of the International Subcommission on Stratigraphic Classification. ISSC is but one of a large number of international groups attempting to formulate internationally accepted standards, principles, and concepts, and thereby achieve increased understanding of the geologic record. Other groups are concerned with magnetic polarity, geochronology, Precambrian stratigraphy, and system, series and stage boundaries: the host organization for many of these activities is the IUGS Commission on Stratigraphy.

Eight chapters comprising 96 pages make up the text of the Guide. Chapters one to four, 30 pages, include the introduction, principles of classification, definitions and procedures, and stratotypes (type sections). Chapters five to seven cover in detail the widely accepted three-fold scheme of stratigraphic nomenclature: lithostratigraphic units - group, formation, member, bed; biostratigraphic units, defined on the range of a particular fossil or fauna and including assemblage-,

range-, acme-, and interval-zones; and chronostratigraphic units, bodies of rock formed during a specific interval of time and bounded by isochronous surfaces - stage, series, system, erathem. These chapters contain the meat of the Guide, and provide the most complete and comprehensive discussion of the three-fold scheme of nomenclature yet published. The last chapter on relationships among the three types of stratigraphic units is only useful for students. The text is accompanied by 14 illustrations; eight of them show clearly some of the complexities of the various types of fossil zones which make up biostratigraphic units. Four short appendices deal mainly with Subcommission background material: one lists the 41 national or regional stratigraphic codes in existence to 1975. The remainder of the Guide contains what must be the most complete bibliography of stratigraphic classification assembled anywhere to date (about 1500 items), with choice of selection limited to items on principles, procedures, and rules of stratigraphic nomenclature. A comprehensive index provides easy access to all material discussed in the Guide.

Because, as Hedberg states in the preface: "Stratigraphy is a global subject, and international (global) communication and cooperation are necessary if we are to adequately comprehend the picture of the rock strata of the Earth as a whole, and to restore the history of *how*, *when*, and *why* these strata come to be *what* and *where* they are today", the Guide represents a significant step forward in providing the language of such communication, even if one does not agree with all of its definitions or approaches.

Indeed, as Earl Brabb of the USGS has pointed out, even before publication of the "Hedberg Guide" (as it has come to be known), working drafts of it were serving as an international standard by which to measure proposals for new stages, or to clarify a particular author's intent in discussing litho-, bio-, or chronostratigraphic units (review of Mediterranean Neogene Congress; *Geotimes*, February, 1976). Aspects of the Guide, particularly chronostratigraphic units, are unacceptable to a small but vocal number of workers, located mainly in Europe.

Disagreements are not easily resolved, because different philosophical views of geologic time, rocks, and fossils are involved.

Some will notice that there is little treatment in the Guide of the special stratigraphic problems of Precambrian stratified units or division of Precambrian time; magnetostratigraphy; geochronology or geochronologic units; or of the problems of definition of and classification of stratigraphic units of the deep ocean floors. These, however, are all areas which are currently under study by international groups as noted above: thus extensive treatment in the Guide would be premature at this time.

Publication of this first complete edition of the Guide is a major achievement, due in significant part to the limitless enthusiasm, skill, and patience of its editor, Hollis Hedberg.

Hard-covered and attractively bound, the Guide is remarkable value at \$9.50. It requires a place on the shelf of anyone interested in stratified earth materials or earth history on any scale.

MS received May 31, 1976.

Archaeological Sediments: A Survey of Analytical Methods

Myra L. Shackley
Halstead Press,
a Division of John Wiley and Sons Inc.,
159 p., 1975.
\$21.50

Reviewed by R. H. King
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An important trend in recent archaeological research has been the application of field and laboratory techniques from other disciplines, particularly geology and soil science. In her book Myra Shackley reviews those analytical techniques which she considers best suited to the study of archaeological sediments. It is a book written by an archaeologist for archaeologists and is intended to act as a guide to the techniques and technical literature on the subject.

To this end the author has adopted a "cookbook" approach in the presentation of selected analytical methods in the stated hope that this will make them more intelligible to the non-specialist. In this respect the author succeeds admirably. The book is well written, in clear and concise terms. The work is well referenced and up-to-date, and much of the technical review is based on personal experiences with considerable use being made of selected case studies.

The book is organized into twelve chapters. In the first, which serves as a general introduction, the subject matter is introduced, terms are defined, and a research methodology for the study of archaeological sediments is outlined. According to the author, an archaeological sediment is broadly defined as any deposit which is directly or indirectly related to past human activities and, as such, includes any soil or sediment which has a bearing on the interpretation of an archaeological site. The second and third chapters are concerned with routine methods of field description, information recording and sediment sampling. In chapter four the various procedures used in the

preparation of sediment samples are reviewed as the basis for subsequent laboratory analyses.

Of the remaining eight chapters of the book five are devoted to a review and evaluation of the various methods which may be used by the archaeologist to investigate sediment particle size distributions. Such a strong emphasis is justified by the author on the grounds that the undertaking of a particle size analysis is without doubt the most useful way of obtaining detailed information about the characteristics of a sediment. This is clearly a debatable point and this reviewer found the single chapter on the chemical analysis of sediments disappointingly brief and one which does little justice to the substantial advances in our understanding of the chemical characteristics of sediments during the last twenty years. Other analytical techniques which are reviewed include the use of both light and scanning electron microscopy in the study of sand grain textures, and the uses of binocular and petrologic microscopes in sedimentary petrology, with an emphasis on sediment micromorphology.

The strength of this book lies in its presentation of available analytical techniques in terms that will doubtless appeal to archaeologists. Its weakness lies in what this reviewer regards as an unnecessary concentration on the physical characteristics of sediments and its rather cursory examination of their chemical attributes. The Appendix, which contains a list essentially restricted to British instrument manufacturers and suppliers, will be of only limited use to the North American reader. Nevertheless, we are indebted to Dr. Shackley for her careful researching and writing of what is otherwise a most useful book.

MS received May 25, 1976.

Glaciofluvial and Glaciolacustrine Sedimentation

Alan V. Jopling and Barrie C. McDonald
(editors)
*Society of Economic Paleontologists
and Mineralogists Special Publication
No. 23, Tulsa, Oklahoma, 320 p., 1975.*
AAPG-SEPM members \$13.00,
All others \$15.00

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This volume will appeal to specialists in several different fields. There are 14 papers. The first two are review papers, and the other 12 present results of original research. In the first of the 'research' papers, Ostrem discusses hydrology and sediment transport in meltwater streams and lakes in Norway. Four papers on ice-contact deposits follow: McDonald and Shieltis describe and interpret faults in stratified drift; Banerjee and McDonald give criteria for the recognition of sediments produced as a result of open-channel, tunnel, and deltaic sedimentation in eskers; Saunderson describes facies changes from stream-laid esker deposits to lake-bottom sediments in the Brampton esker; and Rust and Romanelli discuss subaqueous outwash deposits near Ottawa.

Outwash deposits are next to be considered: Boothroyd and Ashley give an excellent account of an investigation of modern outwash fans in Alaska; Clague calculates the palaeodischarge of late-Wisconsinan streams in the Rocky Mountain Trench; and gravel fabrics in modern outwash streams are shown by Rust to be current indicators.

The last four papers deal with lake deposits: Gustavson shows that sediment transport in summer in Malaspina Lake, is largely by continuous density underflows and interflows; Gustavson, Ashley, and Boothroyd relate sequences in glaciolacustrine deltas and lakes to seasonal changes in flow conditions; fining-upwards sequences in glaciolacustrine deposits of Alberta and British Columbia are considered by Shaw to have been

deposited in deltas during ice-front retreat; and Ashley gives a fascinating account of the textures of varves in Glacial Lake Hitchcock.

The editors should be commended on their selection and arrangement of these papers. Normally I do not read symposium volumes from beginning to end, but I enjoyed thoroughly my trip from the snout of Nigardbreen glacier to the depths of Glacial Lake Hitchcock, and not once was I tempted to stray from the path mapped out by Jopling and McDonald.

The first two papers of the volume, I've left to the last. The introductory paper, by Jopling, reviews the history of studies of stratified drift, and it was sobering to find out just how much excellent sedimentology was done in the 19th century! I regret that Jopling chose not to list all of the references that he cited because he has tapped some interesting sources. The second paper, by Church and Gilbert, is an 80-page review of hydrology and sediment transport, with reference to glacial environments. Most of the material in this paper has been dealt with better elsewhere, and little has been gained by repeating. The best part is that dealing with the authors' studies of sandurs and lake sedimentation, and it is a pity that they did not expand this.

The presentation of the volume is good, errors are few, and the illustrations are clear and understandable. Not the least of my pleasures in reading the book came from my exposure to more of the beautiful vocabulary of glacial geology. *Esker* has long been one of my favourite words, but now it must compete with *jökullhlaup*. You don't know what a *jökullhlaup* is? Buy the book!

MS received May 25, 1976.



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