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BOOK REVIEWS

STUDIES IN EARTH AND SPACE SCIENCES; A MEMOIR IN HONOR OF HARRY HAMMOND HESS, 1906–1969. Edited by Reginald Shagam and others. Geological Society of America Memoir **132,** 1972. vii + 683 pages. $22.00.

Harry Hess would have been pleased with this volume. From mineralogy to lunar geology it spans the full range of his own efforts, as well it might be expected to, considering his influence on its authors. Dynamic and imaginative interpretations of data, his hallmark in life, become his legacy here. It is an exciting book with broad appeal.

The volume begins with 17 articles on geotectonics. Topics discussed include plate motions and mantle convection, poles of rotation and paleopoles, the origin of lithosphere behind island arcs and the genesis of oceanic crust, the origins of active continental margins, continental fracture zones and major rifts, possible uncoupled convection and the generation of orogenic belts. Most are excellent articles, but one that particularly appeals to this writer is "Freeboard of continents through time", by D. U. Wise, describing a model of the earth that accounts for the nearly constant fine adjustment between the volume of ocean basins and the volume of ocean waters.

The section on ultrabasic rocks contains eight articles. Topics include dynamic interpretations of the petrology, distribution, and emplacement of ultrabasic rocks. There is a comparison of the Troodos massif with the seismically determined model of oceanic crust, which may yet be found to consist of partially serpentized peridotite, as Hess suggested. In an elegant summary of the genesis of St. Paul's Rocks, Melson, Hart, and Thompson conclude that it is an upper mantle-derived ultrabasic complex intruded largely in the solid state. An 835 m.y. K-Ar apparent age on hornblende from these rocks is inconsistent with their nearness to the Mid-Atlantic Ridge in the current model of seafloor spreading. On the continents, some remarkable occurrences of explosively generated serpentine breccia deposits described by Lockwood are perhaps more common than the literature suggests. Deformation and metamorphism would easily mask their essentially sedimentary nature. In other articles a primary peridotite magma is described, and Alaskan type zoned ultramafic complexes are postulated to originate by fractional crystallization and flow differentiation of basaltic magma in the feeder pipes of volcanoes.

Eleven articles on Caribbean geology continue Hess's program of studies that inspired graduate students at Princeton for nearly a generation. This section includes regional syntheses of the Puerto Rico Trench and negative anomaly belt, crustal evolution, several articles on the southern Caribbean region, and an excellent summary by Donnelly on the progression from deep water to subaerial volcanism in the Virgin Islands. An interesting report on the Venezuelan Andes provides new data supporting a link between the Appalachian mobile belt and an orogenic sequence underlying the Andean system.

Under petrology and mineralogy there are seven articles ranging from a discussion of "Al^{IV}-Si^{IV} disorder in sillimanite and its effect on phase relations of the aluminum silicate minerals," by Hugh Greenwood, to "Differentiation trends and parental magmas for anorthositic and quartz mangerite series, Adirondacks, New York," by A. F. Buddington. A review of pigeonitic pyroxenes by G. Malcolm Brown confirms through structural and experimental thermal studies some of Hess's predictions on the processes of subsolidus exsolution and inversion. An article by G. B. Hess discusses "Heat and mass transport during crystallization of the Stillwater Igneous Complex," a result of collaboration with Harry Hess that began many years ago.

Several articles on deformation of materials and environmental geology are included. An article by David B. MacKenzie dealing with "Peridotite fabrics and velocity anistropy in the earth's mantle" follows up a line of research initiated by Hess in 1964. Such studies may have the potential for an interesting new look at the composition and variability of the upper mantle.

Finally, four articles on space science explore "Crystallization histories of two Apollo 12 basalts" (L. S. Hollister and others), "Calcium in chondritic olivine" (R. T. Dodd), and the question, "Are lunar rilles inverted eskers?" (C. E. Helsley). The last note describes the Hess Lunar Crater, formally named at the 1970 International Astronomical Union meeting at Brighton, England.

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METEORITES AND THEIR ORIGINS. By G. J. H. McCall. John Wiley and Sons, New York, 1973. 352 pages. $12.95.

The author has tried "to condense the vast spectrum of meteoritics into a single readable volume . . . ," divided into 23 chapters, and states that this book is intended as a text for university students, professional and amateur scientists alike. This is indeed a worthwhile intention and, knowing McCall's reputation as a scientist who, over the years, has contributed extensively to meteoritics, largely by the description of new Australian meteorites, made me read the book eagerly and with great expectations. Unfortunately, the book is a great disappointment and has many serious shortcomings.

(1) The author's heavy reliance on older textbooks and review articles rather than on the original literature results in many serious shortcomings and, in particular, in a number of chapters being sadly out-of-date. For example, Table 11 on elemental abundances in meteorites lists data from Levin (1956), who in turn draws heavily from the Noddacks! Table 15 is similarly out of date. Since those data were obtained, a generation of cosmochemists has obtained new, better numbers with new, improved analytical tech-

niques. Furthermore, the reliance on review papers has resulted in a number of factual errors; for example, the porosity data on page 150 are not after Wood, but from Elexeyeva (1960); Table 14, page 157 is not from Wood, but from Keil (1962); and Figure 18, page 156, is after Keil (1962), not Keil and Fredriksson.

(2) The author's personal biases and prejudices are very apparent in the text. This is unfortunate in the case of a beginner's textbook, where the student is supposed to be presented with a balanced account, with all points of view represented. The author's biases are particularly apparent when discussing the origin of lunar and terrestrial craters (chapter 20): his efforts to deny the impact origin of Cañon Diablo—for example, on the basis of its relative proximity to volcanic pipes in Arizona (similar to the Lonar, India, crater, only there the volcanic pipes are much older than the crater!)—cannot be entertained seriously (p. 251, 255). Statements like "And the possibility of material simulating meteoritic iron being ejected from deep within our own planet cannot be entirely overlooked" (p. 255), made in an apparent effort to discard the occurrence of meteoritic iron as evidence for impact origin of terrestrial impact features, are unjustified. In fact, the entire chapter 20 is a very biased account, including the quoted (or not quoted) references. A further bias towards neglect of modern physico-chemical measurements appears in the much too brief treatment of trace element, major element, cosmic ray-produced nuclide, and other data.

(3) The book indicates poor familiarity of the author with the original literature, which has resulted in many false, half-true, or warped statements of facts, as well as in the neglect of many important new results. For example, when discussing where meteorites originate (chapter 3), the important orbital Monte Carlo type calculations by Arnold, Anders, Wetherill, and others are not mentioned. One of the most important recent advances in iron meteorite research, namely the determination of cooling rates and speculations on sizes of parent meteorite bodies (Goldstein) are not discussed. p. 55: When discussing melting crusts, no reference is made to the classical paper by Ramdohr (1967). p. 88: No meteorite has enstatite entirely composed of $MgSiO_3$; there is always some substitution of Fe and Mn for Mg. p. 89: The statement that ". . . amphibole, hornblende, are not found at all . . . " in meteorites is incorrect. p. 90: Native copper not only occurs in irons and chondrites, but the largest pieces were found in the achondrite Norton County. The occurrence of native gold is questionable (probably TiN). p. 91: Merrillite probably does not exist in meteorites, and the most abundant phosphate is whitlockite (not listed). p. 92: Schreibersite is also present in enstatite chondrites; alabandite (MnS) does not occur, only ferroan alabandite (Fe,Mn)S; daubreelite occurs not only in one, but in many enstatite chondrites; sphalerite also occurs in irons. p. 102: The Ni-Fe phase diagram is unfortunately not used to describe the origin of the Widmanstätten structure. p. 104: No mention is made of the important silicate inclusions (pyroxene, olivine, feldspar) in irons. p. 114: Buseck's proposition that pallasites may come from an area of essentially zero gravity and, hence, possibly the very core of a parent meteorite body, is not mentioned. p. 121: The statement (without reference) "Of late a strange hypothesis of derivation of mesosiderites by spalling of a silicate material by the agency of iron meteorites from the lunar surface has been given surprising credence in America" does not at all reflect the true state of the matter in the U.S. post-Apollo era. p. 127: Amphoterites are not viewed as part of the hypersthene chondrites (*i.e.*, L-group chondrites) any more, but form a separate group, the LL-group chondrites. p. 129: Olivine is not absent from enstatite chondrites. Important minerals such as sinoite, perryite, schreibersite, niningerite, are not listed. There are other enstatite chondrites besides St. Mark's with good chondritic texture, p. 133, 172, 319: Jarosewich (not Jaresowich) is consistently misspelled. p. 136, 137: Sulfates are not mentioned. p. 139: It was shown years ago (Keil, 1968) that Pesyanoe does not contain magnesium sulfide (MgS) but ferroan alabandite (Fe,Mn)S. In fact, MgS does not exist as a meteoritic mineral. p. 157: Carbonaceous chondrites do not display comparable *metal* contents to common chondrites (they have comparable *total iron* contents). p. 158: New data show no major discrepancy between chondritic and solar iron abundances. Primordial rare gases are not ". . . virtually absent from the common chondrites" (*e.g.*, Pantar, Tabor). p. 162, 163: The pioneering work of Wasson and coworkers on Ga-Ge groups is not referred to in the text (although there is a reference in the list of references). p. 182: The light inclusions in Allende *are* exotic in the sense that they formed under different physico-chemical conditions than the host. p. 188: The statement "Never do we find the olivines and pyroxenes of the common chondrites, which contain mineral species containing 20–30 percent of the Fe ion . . ." (in carbonaceous chondrites type II) is wrong. p. 191: No mention is made of the constrained equilibrium theory of Blander and Adel Gawad (1969) nor of the lightning hypothesis of Whipple (1966). p. 206: Olivine-bronzite and olivine-hypersthene chondrites *are identical* to H- and L-group chondrites, respectively. p. 209: The statement ". . . there is some doubt about the validity of probe results of this kind at the present time . . ." (referring to electron microprobe analyses of silicates) is unjustified and not in tune with results published in the modern literature. p. 290: von Engelhardt (not von Englehart).

In addition, the book appears hastily written and poorly thought out in many places. For example, many of the plates are nearly useless because they have no scales. Also, figures and plates are not specifically referred to or explained in the text, which makes understanding of the material very difficult, and hence, the author loses the full impact of the illustrations (*e.g.*, Figs. 5–7, 9–18, plate 39). Symbols in figures are often not explained (*e.g.*, Fig. 4, the vertical axis is altitude; v/v_0 is the ratio of initial to remaining velocity; i is the angle of incidence). Statements like "(see Heide's curve)" are misleading and confusing and should be replaced by "(see Fig. 4)." Furthermore, the list of references is incomplete, with authors referred to in the text not being listed in the references [*e.g.*, chapter 3: Crommelin, J. H. Oort, Schiaparelli, Leverrier, Peters, Weiss, Fesenkov, La Paz, Jacchia; p. 88: Koksharov; p. 90: A. B. Edwards; p. 116: Binns; p. 119, 132: Poldervaart; p. 120: Powell; p. 145: Lacroix; p. 186: Anders; p. 187: Ringwood; p. 207, 208: van Schmus and Wood; p. 214: Claus and

Nagy (1961); p. 215: Nagy (1968); p. 216: Hyatsu (1964), Oro *et al* (1966); p.. 223: Fireman, Felice, and Whipple; p. 232: Reynolds; p. 233: Krummenacher *et al*]. Also, in Table 8, it is not indicated whether "dash" (—) means not determined, not found, or both.

There are also a number of printing errors in the text; for example, p. 19, 1492 (not 1462); p. 32, La Paz (not Lapaz); p. 84, Table 4, the numbers for U.S. meteorites do not add up correctly; p. 91, apatite is $Ca_5(PO_4)_3Cl$; p. 92, daubreelite is $FeCr_2S_4$. Finally, there are a number of unjustified claims in the book; for example, there is little evidence in the book that "This then is a post-Apollo 11 review of meteoritics" (p. 15). All in all, the book, unfortunately, has so many serious shortcomings that I cannot recommend it, and it is hoped that the author, who enjoys a fine reputation as a contributor to the description of meteorites, will be given an opportunity to completely revise the book, should a second edition be contemplated.

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EXPERIMENTAL PETROLOGY: BASIC PRINCIPLES AND TECHNIQUES. By Alan D. Edgar. Clarendon Press, Oxford, England, 1973. 217 pages. £5.75.

How does the novice become initiated into the arts and practices of experimental petrology? Until recently, descriptions of the techniques and principles of experimental mineralogy were scattered throughout the literature of petrology and ceramics. There was no single, comprehensive source of information on this diverse but important topic. But nature abhors a vacuum, and publishers adore an unsatisfied need. Now two books, both in English, have recently appeared. The publication of Edgar's book, reviewed here, follows the appearance of *Research Techniques for High Pressure and High Temperature,* edited by Gene C. Ulmer and published in 1971 by Springer-Verlag at $10.00.

It is inevitable that the two books will be compared. In Ulmer's book, after an editorial introduction and review, there follow eleven chapters, each written by experts on some aspect of experimental geochemistry and mineralogy at high pressures and temperatures. The multi-author approach has the advantage that the authors write from first-hand experience and knowledge. However, the chapters are quite varied in scope, ranging from reports of specific investigations to major review articles.

On the other hand, Edgar's book has the advantage of the uniform approach and level that single authorship can bring. The book is much narrower in scope than the title might suggest at first sight. It deals specifically with methods of investigating phase equilibria, by quenching techniques. Experimental work on the physical properties of minerals, on petrophysics and textural relations of rocks, on solution chemistry, and on differential thermal analysis have not been included. The emphasis is on the experimental investigation of silicate systems in the range of temperatures and pressures pertinent to the formation of igneous and metamorphic rocks in the crust and upper mantle.

After an historical review of this kind of experimental petrology, there follows a short discussion of phase rules and phase diagrams needed to present and interpret experimental data. This brief discussion is too concise to serve as an introduction to phase diagrams but perhaps could provide a quick refresher course on this aspect of physical chemistry. In Chapter 3, preparation of starting materials is described; glasses, gels, dry and wet mixtures, and natural starting-materials are all considered. Sufficient detail is included to make it possible to follow the recipes, in most cases.

In Chapters 4 to 7, different types of experimental apparatus used at progressively higher pressures are discussed. Experiments at atmospheric pressure, in externally heated pressure-vessels, in internally heated pressure-vessels, and in solid-media presses for pressures above 10 kilobars, are each described in turn. Chapter 8 deals with the control of oxygen fugacity using buffering techniques. The final chapter, entitled, "Problems of Applying Experimental Results," has a rather curious title. It deals with methods of identifying phases and of determining that equilibrium was established. Thus, rather than dealing with the application of the results, it is chiefly concerned with how the experimenter determines what results he has achieved.

Judging from the fact that Edgar makes only one reference to his own work, it is evident that the author did not originate the apparatus or techniques discussed. However, he has made a good attempt at evaluating and reviewing the techniques of experimental igneous and metamorphic petrology at an elementary level. Although the approach is derivative, there does not seem to be any comparable synthesis in print. As such, it complements, but does not replace, Ulmer's more advanced and specialized book. The novice experimental petrologist will need to consult both texts. In the opinion of the reviewer, however, because of the cost, mechanical sophistication and potential hazards involved in much of experimental petrology, the novice operator should plan to spend some weeks in a functioning laboratory before attempting to start on his own. Experience is the best teacher.

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CRYSTAL GROWTH: AN INTRODUCTION. Edited by P. Hartman. Volume 1, North Holland Series in Crystal Growth. North Holland Publishing Co., Amsterdam, 1973. xi + 531 pages. $24.00.

Although late in coming, the past few years have seen the publication of several books dealing with the subject of crystal growth. Some have provided a general overview of the entire field, while others have been topical, offering detailed discussions of specific subject matter, *i.e.,* solution growth, melt growth, *etc.* The present publication represents the first in a new series of monographs to be known as the North Holland Series on Crystal Growth. While the planned series will reportedly deal with reviews of a particular topic by a single author or group of authors working together, the contents of the first volume were derived from a series of lectures given at the International Summer School on Crystal Growth held at Noordwijkerhout, The Netherlands, in 1971. It covers both theoretical and practical aspects of crystal growth. The book is divided into four parts: nuclea-

tion and epitaxy, techniques of crystal growth, theory of crystal growth, and properties and observations of dislocations. The individual chapters were authored by thirteen internationally prominent scientists with strong expertise in their respective areas of specialization.

It is apparent that the intent of the authors was to provide a comprehensive review of the crystal growth field. In this regard, however, the book does not live up to its potential. The subject matter is unevenly treated, with theoretical subjects dominating practical aspects of crystal preparation by almost two to one. Crystal defects, with the exception of a thorough article by A. R. Lang on dislocations, are rarely mentioned.

The lack of effective balance in subject content is evident in the comprehensive article by S. Toschev on homogeneous nucleation. While occupying about ten percent of the total text, homogeneous nucleation in the author's own words is a "comparatively rare occurrence," and it is hard to understand why such extensive coverage of this material was included in an introductory text. I believe, therefore, that this book is not, as promoted, an appropriate introduction to crystal growth.

While the title may be misleading, the actual treatment of the material presented is interesting and informative. Subjects covered include chemical transport reactions (H. Schafer), crystal growth by means of multiphase equilibrium (A. Rabenau), hydrothermal growth (R. Laudise), and hydrothermal synthesis in acid solutions (A. Rabenau). Melt growth was discussed briefly (D. T. J. Hurle), and a chapter was included on industrial mass crystallization (M. A. van Damme-van Weel). Theories on heterogeneous nucleation were reviewed (B. K. Chakravorty) along with the special case of epitaxy, which includes a discussion of epitactic layers resulting from metal corrosion (M. Gebhardt). Theoretical treatments of crystal growth processes were concerned with growth kinetics (P. Bennema and G. H. Gilmer), structure and morphology (P. Hartman), and morphological stability (R. F. Sekerka). A strong emphasis was placed in this section on various approaches to the subject of equilibrium crystal forms.

For the thoughtful researcher with some prior crystal growth background and experience, the articles in the text provide much important theoretical background material leading to a firm understanding of the basic principles underlying crystal growth processes. What it will not provide is sufficient information and guidelines allowing for the preparation of single crystals or epitaxial layers.

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THE MINERAL POSITION OF THE UNITED STATES, 1975–2000. Edited by Eugene N. Cameron. Published for the Society of Economic Geologists Foundation, Inc., by the University of Wisconsin Press, Madison, Wisconsin, 1973. xvii + 159 pages. $10.00 (cloth), $1.50 (paper).

Serious future difficulties in meeting demands for many critical mineral resources have lately been overshadowed by shortages in energy resources. This collection of papers broadly summarizes the mineral resources production and development outlook for the next quarter century. The individual authors anticipate problems with the current mineral policies and with the decisions that must be forthcoming to deal with changes in availability of and demand for mineral resources.

The book is the written text of the eight-paper symposium sponsored by the Society of Economic Geologists which was presented at the National Convention of the Geological Society of America on November 15, 1972, at Minneapolis, Minnesota. The speakers, appropriately chosen to give an overall view of the minerals picture, included three distinguished university professors, three directors of governmental agencies, and three executives from industry. Eugene N. Cameron, Van Hise Professor of Geology at the University of Wisconsin and past President of the Society of Economic Geologists, developed the symposium and edited the book.

The volume is introduced by Elburt F. Osborn, President of SEG (1972) and Director of the United States Bureau of Mines. Osborn keynotes the problem as one involving decreased domestic supply of primary minerals complicated by concerns for the increasingly serious balance of trade, for occupational health and safety, and for the environment. He summarizes recent federal legislation directed toward developing new mineral policies.

The first paper, by James Boyd, Executive Director, Natural Commission on Material Policy, emphasizes the importance of minerals in all aspects of the economy. He stresses the interchangability of mineral sources in the search for material properties needed to produce a desired product. Shortage crises can be avoided through early recognition and implementation of proper policy changes in research, exploration, and production.

Cameron, in his own presentation, studies the relation of the U.S. contribution to national and world mineral policies, reflects on past policies with regard to imports and exports, and discusses the changing U.S. position in the world mineral market as major world supply regions change and as demand from other world markets increases. Although the United States has continued to produce about 85 percent of the minerals it consumes (in total dollar value) the ratio between minerals imported *versus* exported has gone from one-to-one earlier in this century to three-to-one recently. Most of the discrepancy has developed since 1945, a period in which U.S. production has more than doubled. Cameron examines the problems of measuring a deteriorating self-sufficiency position in light of possibile domestic production at higher costs, recycling, and interdependence in the use of one material as it affects production of others. Listing forty-one mineral commodities, Cameron shows improvements in U.S. self-sufficiency ratings for some minerals, but the most outstanding changes are large drops in self-sufficiency in rutile, fluorspar, potash, zinc, barite, bauxite, iron ore, gypsum, and petroleum. During the period since 1945, world production (measured in tons) has doubled once every seven to eight years, while U.S. influence in international trade of minerals has rapidly diminished; the nation's role as supplier is less important and it must compete more for imports.

John D. Morgan, Jr., Assistant Director, Mineral Position

Analysis, Bureau of Mines, examines the future mineral supply and demand outlook (including energy sources) and predicts serious deficits by the year 2000. Demand doubled (in tonnage) between 1950 and 1971; Morgan predicts demand will almost triple between 1971 and 2000 with the deficit between domestic supply and demand rising from 8 to 64 billion dollars measured in dollars at 1970 prices (36 billion in the metals supplies and 22 billion in energy supplies). Morgan spends a good deal of effort on the problems involved in projecting data with regard to changing economy, population, environmental pressures, world market demand, and substitution of materials for a given need. He stresses we must not underestimate the demand and lists detailed supply and demand data projected to 1985 and 2000 for fifty-one individual commodities in both weight and dollar amounts.

Vincent E. McKelvey, Director of the U.S. Geological Survey, examines the mineral potential of the U.S., summarizing the resource evaluations now published in *USGS Professional Paper* **820**. The attempt to assess total resources of the U.S. includes consideration of potential resources of good quality which are still undiscovered and of known resources of poorer quality that may someday be producible. In a number of examples he discusses the possibilities of discovering new deposits in specific locations, the speculations being based on the geology of known deposits. For example, he lists areas where geologists are hopeful of finding new sources of copper, barite, and manganese. He believes that ample raw materials are indeed geologically available.

David Swan, Vice-President, Technology, Kennecott Copper Corporation, discusses the trends of population growth, pollution, recycling, new materials technology, and new exploration technology on the minerals outlook. Obviously demand cannot continue an exponential climb indefinitely; Swan tries to identify when and how demand will pass to linear growth.

Peter T. Flawn, Executive Vice-President and Director, Division of Natural Resources and Environment, The University of Texas at Austin, weighs the future impact of environmental concerns on the minerals industry, predicting generally negative and depressing effects, particularly in exploration. Hopefully, research stimulated by environmental concerns will help solve mining, pollution, and waste disposal problems, thus allowing mineral production to continue with relatively less severe cost increases. It is critical to arrive at a proper balancing of the costs *vs* the benefits of environmental controls and to establish proper policy based on holding that balance.

Stanley Dempsey, Division Attorney, Climax Molybdenum Company, discusses land management and mining law. He wishes to show that mineral policy goals and mining law based on these policies can be adjusted to achieve the nation's supply goals. Careful consideration of consequences must accompany moves to restrict mining ventures in land use policy. Mining law needs revision with regard to prediscovery protection and mine dump waste disposal. Dempsey feels that land laws reflect a deficient public policy which should be changed so that there is less constraint on mining activities, even on the local urban sand and gravel pit.

John Drew Ridge, Professor of Economic Geology, The Pennsylvania State University, examines the changing outlook for foreign mineral exploration and production by United States interests. As other nations increase their consumption per capita, their demands will be met at U.S. expense. He assesses the alternate sources the U.S. must have to overcome growing foreign dependency on individual nations. It is becoming increasingly difficult to obtain foreign concessions to explore, mine, and produce. Ridge discusses prospects for agreements with individual countries at length; the list of very good prospects is short. The U.S., he suggests, should not try to obtain outright concessions from other nations but, rather, should be willing to sell its services for exploration and production.

The authors have edited their texts for a reading audience. An index has been included, but unfortunately the volume lacks a bibliography or suggested reading list. Most minerals scientists should already be aware of the resource problems and have more detailed data (in part by these same authors) at their disposal. If a quick, comprehensive summary is needed the price of this book will be well spent. It is critical that this material reach a wide audience; most of the reading is non-technical. It could be added to required reading in courses such as introductory geology, natural resources, economic geography, economics, and political science. The paperback edition is a bargain which should be recommended to concerned individuals including lawyers, environmentalists, editors, planners, high school students and college undergraduates.

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MARINE EVAPORITES: ORIGIN, DIAGENESIS, AND GEOCHEMISTRY. Edited by Douglas W. Kirkland and Robert Evans. Dowden, Hutchinson, and Ross, Inc., Stroudsburg, Pennsylvania, 1973. xv + 426 pages. $20.00.

One normally begins a review of a collection of papers somewhat apprehensively. What has been included and more importantly what has been omitted is always a matter of personal judgment. However, this book is one of those rare delight-of-delights. It is one in a series titled *Benchmark Papers in Geology*, and captures the intent of the series well —namely to combine under one cover a collection of classic and recent papers highlighting developments in a particular subject area.

For years data describing evaporites, their diagenesis, and related geochemistry have been widely scattered among foreign and American literature sources. In 31 well-selected articles, the authors have provided for the first time a comprehensive volume on a much debated subject. Data on evaporites formed under different environmental conditions (among them sabkka, shallow lagoon, broad shelf) are presented.

Marine Evaporites contains the classic papers of A. I. Dzens-Litovskii, and G. V. Vasilyev describing the depositional environment of the Kara-Bogaz-Gol, long considered as a type example of lagoonal evaporite deposition. Alderman and Skinner's paper on dolomite sedimentation is included. Among other classic and bellweather papers is

that of Ralph King. His modification of the Bischof-Ochsenius "bar theory" through introduction of the "reflux theory" has survived and been upheld by modern studies. Later papers by Scruton, Masson, Morris and by Dickey, Holser, Thode and Dellwig, which ushered in the modern era of evaporite research, are presented. In this reviewer's mind the editors' selection of "key" papers was astute. To list all these papers here would be unfair to a potential reader of this volume. He should sample them himself in the company of their compatriots.

In brief, this volume of Benchmark Papers is exactly that. The volume belongs in the library of all students of evaporites. For the first time it is "all there" in one volume. While the cost of this volume may seem a trifle high, it is in my opinion a reasonable price to pay for such a collection of papers. Let us hope that future volumes in this series maintain the quality of this one.

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ORES IN SEDIMENTS. *VIII International Sedimentological Congress, Heidelberg, August 31–September 3, 1971.* Edited by G. C. Amstutz and A. J. Bernard. Springer-Verlag, Berlin, 1973. viii + 350 pages, 184 figures. Paperback, $15.30.

This book is the tangible result of the VIII International Sedimentological Congress held in Heidelberg, August 31 to September 3, 1971.

The editors deserve a special thanks from those of us to whom only English is a useful language; except for a few abstracts, the book is published entirely in English even though it is not the first language of the majority of the 47 contributors. The printing and illustrations are good, and while the choice of words is not always the best (for example, "Upper Lake" for Lake Superior), there is little doubt regarding meaning.

As with the products of most symposia, the subjects of the 24 papers are diverse and the treatment uneven. Topics range widely, from placers to metasomatic replacement, and from base and precious metals to iron, manganese, and uranium. The unifying theme is the association of metal concentrations with sediments. Four of the papers deal with clastic accumulations, placers, and iron ores. Four particularly informative papers describe the present-day accumulation of metals in sediments, three of the studies being from areas of active volcanism. The genetic relationship of mineralization to karst formation is interpreted by several authors, and the role of sedimentological facies in governing the localization of metal deposition is documented. One paper considers the control of climatic regimen on the mineralogy and metal content of residual soils and the complementary distribution of metals within the associated depositional basins. There are several good descriptions of diagenetic changes pertaining to metal deposition, but this volume is a better source of interesting problems to be investigated than of definitive answers regarding diagenesis.

This reviewer is not convinced that all the interpretations presented are correct, but thought-provoking alternatives are given to some of the dogmas prevalent in America regarding ore genesis.

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GEOCHRONOLOGY-RADIOMETRIC DATING OF ROCKS AND MINERALS. C. T. Harper, Editor. *Benchmark Papers in Geology.* Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pennsylvania, 1973. xv + 469 pages. $24.00.

In the words of the Editor of *Benchmark Papers in Geology*, ". . . this series is one of collection, sifting and rediffusion . . . we are making a concentrated effort to gather into single volumes the critical material needed to reconstruct the background to any and every major topic of our discipline."

This volume contains a rather impressive collection of forty-three most cited, original papers, selected to illustrate the historical development of the science of geochronology, covering the period from 1906 to 1971. The selections however, are restricted to those papers dealing with the measurement of geologic time based on the accumulation of stable radiogenic nuclides.

The papers, reproduced with original references, are grouped into fourteen sections, each being preceded by a short, concise commentary designed to emphasize historical perspective and role of the research in the growth of the field. Each commentary is followed by additional references to other important articles related to the sectional topics.

The first eight sections comprise some 22 papers discussing uranium-lead methods in geochronology which include measurement of lead isotopes, primeval lead and the age of the earth, isotopic uranium-lead ages, and use of common lead for dating mineralization events. Two sections are devoted primarily to rubidium-strontium radiometric dating and comprise key papers on the radioactivity of rubidium, distribution and behavior of radiogenic strontium in minerals and whole rocks, and interpretation of discordant age measurements. The next three sections contain papers pertinent to potassium-argon techniques and cover the discovery of radiogenic argon, dating of young volcanic rocks and geomagnetic reversals, and the argon-39 method. A final section reviews current applications and interpretation of radiometric age data.

This format for the presentation of already published, but at times difficult to locate, key papers is useful and timely. This series of volumes will fill a void that exists currently in state-of-the-art volumes which are limited greatly in reviewing older but fundamental articles upon which present research is based.

The goals and intent of the series have been admirably achieved by Editor Harper. Reproduction of papers with a variety of typeset and style is remarkably good. This volume should be a "must" acquisition for the library of any geoscientist involved with determining or utilizing radiometric age data.

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