

REVIEWS

REVIEWS: SEDIMENTARY FEATURES OF FLYSCH AND GREYWACKES; SUBMARINE GEOLOGY AND GEOPHYSICS

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SEDIMENTARY FEATURES OF FLYSCH AND GREYWACKES, by Stanislaw Dzulyński and E. K. Walton. Published by Elsevier Publishing Company, Amsterdam, London, New York, 1965, viii + 274 pp., Illustrated, \$17.00.

This volume is the seventh in the series, *Developments in Sedimentology*, published by the Elsevier press. It presents a thorough summary of the numerous studies of sedimentary features in graywackes and flysch deposits during the last fifteen years which reflect intense interest in this area of sedimentological investigation. The authors accept the turbidity current hypothesis of origin for many sedimentary structures associated with greywackes and flysch and interpret these structures in terms of turbidity current action. They state, however, that the "description and discussion of most of the structures taken individually is unaffected by our adoption of hypothesis that flysch sandstones and most greywackes are turbidites.

The first chapter introduces the reader to the historical background of this field of study including the definition and discussion of the principal terms and the turbidity current hypothesis. In the second chapter, *Grain Properties*, the composition, texture, and fabric of greywackes and flysch sandstones are treated. Twenty-five diagrams and analyses are included to illustrate these properties in various turbidites.

External Structures contains more than seventy excellent half-tones and line drawings of current and post-depositional markings. These structures are considered and discussed within the framework of a genetic classification related to turbidity current action. The subjects, *Load, Flow and Injection Structures*, and *Internal Structures*, follow and are dealt with similarly.

The sixth chapter, *Experimental Investigations*, reviews and illustrates the results of numerous experimental studies. The last chapter, *Sedimentary Variation and Palaeogeographical Reconstructions*, includes con-

sideration of rhythmic and repetitive successions, vertical and lateral variation in sediments, and palaeocurrent data and its role in palaeogeographical reconstructions. A terminal bibliography and index are present, and the book is written in a clear and quite readable style.

SUBMARINE GEOLOGY AND GEOPHYSICS, edited by W. F. Whittard and R. Bradshaw. Colston Papers No. 17, published by Butterworth & Co., Ltd., London, 1965, xii + 464 pp., 39 pls., \$21.00.

Seventy-six active research workers from several continents convened at the University of Bristol, England, on April 5th-9th, 1965, to discuss the advancement of research in marine geology and oceanography. At this meeting, the 1965 Colston Symposium, twenty-three papers were presented by thirty-five contributing authors and discussed by the members of the symposium.

Submarine Geology and Geophysics, the Proceedings of the Seventeenth Symposium of the Colston Research Society, reproduces these contributions and the discussions following in their entirety. These articles present the results of a wide variety of submarine oceanic studies.

Four papers deal with general subjects: two with structural theory of the mid-oceanic ridges and coastal margins; one with experimental study of turbidity currents; and, one with various aspects of recent sedimentation. Nine are geologic studies of specific regions. Of the ten more specialized investigations, four are sedimentological, three stratigraphic, two structural, and one is bathymetric. These articles demonstrate both the varied scope of modern oceanographic work and the rapid progress in this field in recent years. An index and an atlas of 39 plates conclude the volume.

Submarine Geology and Geophysics contains notable contributions by distinguished scientists and will prove to be of great interest to geologists, oceanographers and marine biologists.

REVIEWS: MARINE GEOLOGY OF THE GULF OF CALIFORNIA;
MARINE GEOLOGY OF THE PACIFIC; PAPERS IN MARINE
GEOLOGY; STATISTICAL ANALYSIS IN THE GEOLOGICAL
SCIENCES; ELECTRICAL PROSPECTING WITH THE TELLURIC
CURRENT METHOD; PALEOMAGNETISM; ELECTROMAGNETISM
AND THE EARTH'S INTERIOR; ADVANCES IN EARTH SCIENCE;
THE MINERAL RESOURCES OF AFRICA

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MARINE GEOLOGY OF THE GULF OF CALIFORNIA, A SYMPOSIUM; Edited by Tjeerd H. van Andel and George G. Shor, Jr. Published by the American Association of Petroleum Geologists, Tulsa, Oklahoma as Memoir #3, 1964, 408 pp., 17 articles, 27 authors, 2 colored charts, index, \$12.50.

The two editors, both of the Scripps Institution of Oceanography, University of California, at La Jolla have done a magnificent job in leading research expeditions, in determining what needed to be done and getting people to do it, in assembling and editing a tremendous mass of original and previously unpublished work, and in finally getting it through the publishing stages and into our hands. To show the scope of the complete compilation, an abbreviated table of contents includes: geology of bordering areas, oceanographic aspects, bathymetry and faults, gravity anomalies, seismic refraction studies, magnetic profiles, geophysical framework of northern end, structural history and evolution, sea-floor valleys, deltaic progradation of continental terrace, recent marine sediments, laminated diatomaceous sediments, zoogeography of macro-invertebrates, patterns of living benthonic foraminifera, ostracoda, radiolaria. From this it is seen that there is something here for any geologist or geophysicist who needs to know more about the Gulf of California area.

It is a book for which no expense seems to have been spared in its production. There are five larger-than-page-size fold-ins included as well as dozens of page size maps and charts. There are eight pages of sonoprobe and arcer records and fifteen pages of plates of fossils, all printed on a non-glare special paper and inserted but not included within the pagination system. There are five large maps (one in northern and southern halves), with two in color, folded

into a special pocket. Therefore, a really thorough work, having both breadth and depth. And yet, this last set of items . . . the pocket of folded maps and charts . . . has been the cause of the only derogatory criticism heard by your reviewer concerning the publication, for this pocket is not bound into the body of the book but is simply included as a separate entity! It is probable that there was considerable discussion pro and con of this binding method before a decision was reached but, in this opinion at least, the wrong decision was made. It is unfortunate that work of such value, presented so beautifully otherwise, should have been released where much of the heart may so easily be separated and lost from the body. This is a major fault.

The only other complaint is the one always heard when the work, and writings, of so many individuals are joined together within a single pair of covers; *i.e.*, the style, tempo, approach, etc. of the various authors differs and at time even seems to clash, so that there may be a jarring note when reading directly from one paper to the next. There are even some areas of substantial disagreement. This is really not a serious criticism for a user generally pores over a single paper at a time, following its thought in his particular field of interest, rather than skipping about.

Let me rush in to say that neither of these "problems" should deter any geophysicist interested in either the Gulf of California or in marine geophysical case histories from providing honored shelf space for this volume. The articles on seismic refraction, gravity anomalies, and magnetic profiles will be of the greatest interest to exploration geophysicists although the interpretation of gravity and seismic work done in studying the geophysical framework of the

northern gulf province provides classic reasoning from the involved principles. The authors of this last paper are at the California Institute of Technology, the authors of the work on gravity anomalies are at the University of California at Los Angeles, and the authors of the seismic refraction and magnetic profiles papers at Scripps. It all makes for an interesting contrast.

As the editors point out, "the studies presented here have answered a few of the questions asked at the outset and raised many more"; this is almost a literary axiom by which one might measure the worth of a scientific symposium and thus this book has succeeded in its purpose. It will be very interesting to watch further papers resulting from these same studies and expeditions, still in preparation or in press, to see how the conclusions of these additional authors may differ from those included within the work under review. Herein lies the fascination of academic geology and geophysics . . . everyone is entitled to his own opinion, based on the data as he interprets them, until proved wrong by later techniques and developments.

It is a good book. It will serve a valuable purpose in furthering study of recent sediments in a nearly land-locked basin. The regional geology and paleontology included are of great importance in increasing our knowledge of a little known area. The Office of Naval Research, the National Science Foundation, and the American Petroleum Institute deserve our thanks for financing the investigations, the authors and editors for doing the work, and the American Association of Petroleum Geologists for publishing it. Gentlemen, we thank you!

MARINE GEOLOGY OF THE PACIFIC, by H. W. Menard, Published by McGraw-Hill Book Company, New York, 1964, x + 271 pp., \$12.50.

In the author's preface, he makes such statements as "this book is an attempt to analyze what is known of the marine geology of the Pacific Basin with the air of contributing to the solution of some problems of geological interest . . . it is not a general treatise on marine geology, but is confined as much as possible to certain problems which are illuminated by data from the deep Pacific Basin . . . work in other oceans has

been cited freely when it is related to the Pacific Basin problems" and thus it is obvious that he has conscientiously tried to stick to his title. However, the truth is that the Pacific is simply too large and the author's understanding of the multifarious aspects of marine geology too great for him to be able to confine his treatment to less than an overall study of the almost three-quarters of the earth covered by marine waters. As a result, this book is well able to carry its head proudly among its prestigious colleagues of the publisher's "International Series in the Earth Sciences." These are great books . . . but the newest entry will take a place second to none.

The extent of Menard's reasoning on a world-wide scale is clearly shown in his chapter entitled "Geologic History." This is designed as a summary of the geologic history of the Pacific Basin—but it begins with an examination of the possible sources of oceanic water itself, treating them in such a rigorous way that the author's conclusions seem almost self-evident. These are:

- (1) The development of continents by mantle differentiation.
- (2) Sea water is developed through the same mechanism.
- (3) The ocean has accumulated at a fairly constant rate.

If these conclusions are correct, it is safe to restate them as:

- (1) The rates of formation of continents and of water are proportional.
- (2) The rate of continent formation is constant (he figures it to be about $1.8 \text{ km}^3/\text{yr}$ in volumetric change).
- (3) Continents and ocean basins are always in isostatic equilibrium, and continents are at sea level.

These conclusions lead to the possibility of calculating the time involved, the continental thickness, and the area of continents and ocean basins corresponding to any given ocean depth.

Having satisfied himself as to the probable source of the water, the author then deliberates upon the cause and effect of large-scale changes in sea level. The term "deliberates" is carefully chosen, for it represents exactly the way the book is written. It is actually a mental dialogue between the author and an imaginary opposition, just as a chess player must play both sides of the

board before committing himself to a move (or before reaching a "conclusion"). The author presents the data, mulls them over thoughtfully, considers alternate explanations and the reasons for them to be as observed, and then draws a conclusion. It is an excellent technique to maintain reader interest and also to convince the reader of the validity of the reasoning. With regard to sea-level fluctuations, he concludes:

- (1) These can be produced by changes either in the volume of water or in the shape of ocean basins.
- (2) If the volume of water available to the oceanic basins is to be drastically changed, it must be stored in the form of ice, for the atmosphere, even under the most favorable conditions, cannot store enough water to have any geological perceptible effect on sea level. At present, there is sufficient water stored as ice so that complete melting would raise sea level roughly 200 feet, neglecting isostatic readjustment.

The author then investigates evidence involving large-scale fluctuations of sea level during Pleistocene time such as the possibility of subaerial erosion of submarine canyons; he believes that these are primarily cut by turbidity currents. Now, after consideration of the geological history of sea water, of the volume, area, and depth of ocean basins in general, of sea level fluctuations, etc., the discussion begins relating directly to the Pacific Basin. Subtitles here are the pre-Mesozoic Pacific Basin, the Mesozoic-Early Tertiary Basin, and the Late Tertiary-Quaternary Basin . . . but the treatment of these specific topics occupies less than one third of this particular chapter. This has been used only as an example of the author's method but it is typical. Furthermore, it carries the reader along on a high level of interest and enthusiasm while he gains both general principles and specific information. Other chapter headings, indicating the general approach and then the detailed application to the Pacific Basin, are: Normal Basin, Great Faults, Vulcanism, Trenches and Island Arcs, Oceanic Rises, Pelagic Sediments, Manganese Nodules, Turbidity Currents, and Continental Margins.

An outstanding contribution of this book is the set of "page-size" maps of the bathy-

metry of the Pacific Basin. This series, consisting of fourteen maps and a key, presents the various segments in an easily usable, and yet sufficiently large and clear, fashion. The large physiographic map of the northeastern Pacific, included in folded form within the book, is disappointing as it yields little information not better shown on the small-scale maps.

Oceanography is one of our most rapidly expanding "multidiscipline" fields; the work is of such complexity, and of such wide ranging importance, that data are being gathered and studied by geologists, zoologists, chemists, physicists, etc. There will, therefore, be many people very interested in the author's "introduction," which gives an unusually concise review of the development of oceanographic studies . . . as well as a look into the future of marine geology-geophysics studies in the Pacific area. If all the recommendations of the Committee on Oceanography of the National Academy of Sciences are carried out, a relatively detailed map of the whole ocean basin should be available within ten years. While sounding, the ships will also measure the gravity and magnetic fields, so that these parameters will be mapped in detail now impossible. Until the mapping program is completed, this fairly small, eminently readable, well-illustrated text will continue to be "the" authoritative word on the big picture of the biggest oceanic basin of our globe.

PAPERS IN MARINE GEOLOGY, (Shepard Commemorative Volume), edited by Robert L. Miller. Published by The Macmillan Company, New York, 1964, xx + 531 pp., \$20.00.

This is a compilation of twenty-four completely separate and individual papers, written by former students of Francis Parker Shepard as a testimonial and honor to him, and as varied in their content as are their authors' interests. As the editor concedes "the arrangement of papers in this volume is based on the editor's desire to achieve a reasonably coherent organization of the widely diverse subject matter, submitted for inclusion. Almost all of the topics fit rather well under the general subject of marine geology and marine geophysics. In some cases, a paper could as well have gone under any of several topic headings." The head-

ings used are: 1) introductory and general topic 2) contemporary process in coastal and bottom phenomena; descriptive 3) contemporary process in coastal and bottom phenomena; dynamic 4) studies in marine geology with implications in earth history 5) regional studies 6) marine ecology: interaction of marine animals with the physical environments 7) properties of marine sediments and 8) submarine archeology.

The broad range of content of these papers illustrates well the growth of this field of science since publication of Shepard's "Submarine Geology" just sixteen years ago, heralded by Croneis as "the first text in any language on the too little known geology of the water-washed three-quarters of the face of the earth". Just as the importance, knowledge, and use of this infant branch of geology is so rapidly expanding, so is its special literature. These are of particular importance at this time as exploration geophysicists become more and more involved in the search for oil under the continental shelves. An example of such potential use of this information to geophysicists might include the sediment distribution map of the northeastern Gulf of Mexico, from the paper by Ludwick. In fact, this entire paper could be very helpful in aiding understanding of the low-velocity layer in offshore southern Louisiana.

Inclusion of seven papers as regional studies increases the value of the book as an exploration tool, although most of the areas discussed are not thought to be highly prospective for petroleum, *i.e.*, Bering Sea, Chukchi Sea, Gulf of Aqaba, Moriches Bay (Long Island, New York), and the arctic beaches of Alaska. One long paper (44 pp.) by Moore, entitled "Acoustic-Reconnaissance of Continental Shelves: Eastern Bering and Chukchi Seas" will prove of special interest to those planning shallow-sea use of the Sonic Profiler, with both Sonoprobe (high frequency) and Arcer (low frequency) energy sources. This paper provides examples of their use in reconnaissance of Recent sediments and their internal structures over very large areas. An appendix to this paper, giving written descriptions of conclusions from Sonic Profiler records, together with reproduction of the records themselves in very condensed form, is of particular value. So also is an extensive bib-

liography on this subject. In fact, each paper is followed by its own bibliography so that the total represents a very significant number of references in the field of marine geology.

Unfortunately, the index is poor. It may be that this reviewer is too prone to find fault with indices . . . however, the use of a reference book in only infrequent study demands a detailed index if optimum results are to be obtained. Few of the current crop seem to have this. The papers themselves are largely descriptive rather than quantitative, read easily and interestingly, and are strangely uniform in writing style to have been produced by so many authors.

STATISTICAL ANALYSIS IN THE GEOLOGICAL SCIENCES, by Robert L. Miller and James Steven Kahn. Published by John Wiley & Sons, Inc., New York, 1962, xii + 483 pp., \$12.75.

The dust jacket of this book carries the notation "this is the first book on statistical analysis in the geological sciences for the earth scientist. It features a logical and lucid development of both theoretical statistics—showing what it can and cannot do for the experimentalist—and applied statistics, using real problems and data . . . the book translates into understandable language material in theoretical and applied statistics which, at times, may be difficult for the practicing geologist or student of geology to grasp". From this statement, it seems evident what the purpose of the book was to be, rather than what has been achieved. The subtitle of the book, carried at the top of all even-numbered pages throughout, is "statistics for geologists"; it could better have been "geological applications of statistics for statisticians", for the book is one for students of statistics rather than students of geology. It is this reviewer's opinion that the level of the work is such that it would be non-understandable to anyone without at least several courses in statistics as a background.

There can be no doubt that a text is needed which would fulfill the stated purpose of this one. Geology long was a purely descriptive science but in late years has been becoming more and more quantitative in its methods. This is good for it is only as numerical repeatability is reached that it is

possible to understand the success or failure of experiments. It is good due to the number of variables which must always be considered in any "natural" change, whether that change is in evolution of life forms, in deposition or erosion of sedimentary layers, or in petrogenesis. And, where more variables are present than can ever be accounted for, the final answer must lie within a probability range rather than being exact. As the authors say, "the foundations [*sic*] upon which the theory of statistics rests is the theory of probability". So it is evident that a statistical approach to geological problems is both necessary and desirable. The literature of the past twenty-five years is replete with instances where this approach has been used, often successfully. The book in hand will aid that effort and will fill a niche for the specialist, the statistician, and the advanced student of both disciplines . . . but it is not for the practicing geologist, paleontologist, or student of those sciences. Whether a more basic text on statistics or a simplified text on "statistics for geologists" is the answer may depend upon the user.

A comprehensive bibliography is included, contained both as footnotes to the text and in the form of an annotated bibliography at the end of each chapter in the text.

ELECTRICAL PROSPECTING WITH THE TELLURIC CURRENT METHOD, by M. N. Berdichevskiy [1960]; translated from Russian and edited by George V. Keller. Published in the Quarterly of the Colorado School of Mines, Golden, Colorado, Vol. 60, No. 1 (January, 1965), vi + 216 pp., \$6.00.

This book, prepared as a textbook for Russian students in geophysics and as a ready-reference for geophysicists engaged in either general geophysical and geological regional exploration or in the specific application of telluric currents, fulfills these purposes admirably. It will be of interest to English-speaking persons in these same categories for, while there has been much less use made of this technique in the English-speaking world, the conclusion may be that we could be missing something of value.

The format is ideal for the combined text-reference book. The material is divided into three essential parts, *i.e.*, a long theoretical treatise regarding the physical principles in-

involved (three chapters, 100 pages), a medium-length discussion of the organization, instruments, and work of a telluric current field party (three chapters, 75 pages), and a short review (one chapter, 31 pages) of case histories showing actual field use in Russian exploration. These are followed by a bibliography of 64 references used by the author, almost all from the Russian literature. Appended to this bibliography is a special bibliography, prepared by J. L. Pritchard, of 120 "suggested references for magnetotelluric studies", almost all of which come from English-language journals. There is no index provided but the table of contents has been subdivided in such detail that its use as a fast reference, while not as good as an index, is probably adequate. As published in English, the book is in paper wrappers.

For use as an introductory text to this subject for American advanced undergraduates in geophysics, it is unfortunate that Dr. Keller did not add a chapter of "editorial comment" to the technical body of the book. Such things as the historical use of telluric currents in the exploration of sedimentary basins for possible oil-bearing structures (from 1941 to 1955, Compagnie General de Geophysique reported 565 crew months of activity in telluric prospecting, mainly in France and Africa; telluric currents were first used in the Soviet Union in 1954 with use expanding rapidly to 24 field parties in 1959; *etc.*) contribute greatly to placing the technique in its proper perspective for students. While used relatively infrequently within the United States, telluric current surveys have been used in petroleum exploration. No references are made to these in the bibliographies; are any case histories available and could they have been included?

Obviously, the reviewer is going too far afield and is asking too much of the translator. But the book under review is of such value, it offers so much information previously unobtainable in English (and with only generalized treatment in French) that the appetite is whetted rather than being appeased. This is healthy but irritating to a hungry man. Right now, exploration geophysicists are "hungry men" for the conventional fields of seismic, gravity, and magnetics have been so thoroughly exploited that use of a new parameter is most invit-

ing. While telluric currents do not constitute a new parameter, possibly this book will open new angles of approach to their measurement, interpretation, and use.

PALEOMAGNETISM (and Its Application to Geological and Geophysical Problems), by E. Irving. Published by John Wiley and Sons, Inc., New York, 1964, xvi + 399 pp., \$19.50.

Professor Irving says in his preface that he has "tried to summarize our present knowledge of paleomagnetism and to outline its relation to some other studies in the Earth sciences". The extent to which this purpose has been achieved is evident in the first full-length textbook of this important multidiscipline subject, backed up by a listing of 652 calculated paleomagnetic results of outcrop studies. Of this impressive number of recorded measurements available to the author, some 536 were known before November 1962 while the additional 116 became available between then and October 1963 (the period during which the book was written). This is not a simple tabulation of results; these include the geographic location of the sampled outcrop, the rock unit, geologic age, direction of magnetization, location of the paleomagnetic pole, and detailed explanatory notes concerning the sampling, measurement techniques, etc. Thus, the complete listing occupies 68 pages of the book. These figures are cited here for several reasons: to indicate the quantity of data upon which the techniques of measurement and the conclusions reached within the body of the book rest, to indicate the thoroughness with which the author followed the developments of others, and to show the rate at which knowledge in this field is accumulating.

When a bibliography of 22 pages of double-column entries and an excellent index of 15 pages similarly doubled are added to the above, it is evident that this book really is designed both to summarize current knowledge and to provide an extremely useful tool for anyone working in this field. To have more than one-fourth of a book consist of summarized data, bibliography, and index is most unusual and should be greatly appreciated by both the specialist and the student; this could well be used as a model for technical authors.

The body of the book, some 300 pages after removing that already discussed, is exceptionally well organized and "keyed" for easy reference. It is divided into ten chapters, *i.e.*, introduction, magnetic properties of rocks, general features of the geomagnetic field, directions of magnetization and their analysis, the reliability of paleomagnetic observations, paleomagnetically determined field directions, reversals of magnetization, intensity of the paleomagnetic field, paleolatitudes and paleomeridians, and special problems. The author has used an average of slightly over thirteen subheadings per chapter (roughly one every three pages) which are carried in the table of contents; this, plus the unusually fine index, makes this book the easiest to use for rapid reference encountered by this reviewer in a very long time. Congratulations are certainly in order for both the author and his publisher. But, of course, organization cannot be an end unto itself. How good is that material which has been so carefully presented?

Professor Irving is regarded among his colleagues as one of the leading men in the world in his specialty of paleomagnetism... and the degree of knowledge, the refusal to take a position regarding a hypothesis until it has been subjected to various rigorous tests based on non-overlapping techniques, and the facility and apparent ease of writing show why such regard is well merited. He says that "I have written this book in a manner which may be followed by a geologist equipped with an elementary text on magnetism or by a physicist who has at hand a dictionary of geological terms". Frankly, this is an overstatement for either the geologist or the physicist would be keeping their auxiliary reading "red hot" in trying to follow the text but, for the geophysicist, it is straight forward and clear. While the mathematics is kept to a minimum, it is never slighted when deemed necessary. The same is true of the discussion of geologic ages, mineral names and characteristics, rock structure, etc.

Paleomagnetism is often thought of by geologists as almost "synonymous" with continental drift, for the study of the earth's paleomagnetic fields has provided strong evidence to support that hypothesis and has caused a resurgence of interest in it. While Irving acknowledges this, he makes no ef-

fort to capitalize on this facet of his subject; the term "continental drift" does not appear in his table of contents and, while included in the index, it is not given prominence. But there can be no doubt as to the author's convictions in regard to drifting; he says "the high dispersion of poles from rocks of Permian to Lower Tertiary age from different regions is in marked contrast to the good agreement among results from the same region, the latter being indistinguishable from that found in the Upper Tertiary and Quaternary. This is consistent with the hypothesis that the paleomagnetic field, relative to individual regions, has been dipolar, and that the regions in question have moved relative to one another. If this hypothesis is correct and further that the paleomagnetically determined directions are true field directions, then continental drift has certainly occurred. The disagreement between poles, say from Australia and the northern continents, is too large and systematic to be due to sampling inadequacies or to inaccuracies in geological dating."

The study of paleomagnetism has revealed phenomena which had not been even suspected previously, such as paleo-reversals in the geomagnetic field. To this reviewer, the chapter devoted to this topic is one of the most interesting in the book. It was found that roughly one-half of all rock specimens studied, whether igneous or sedimentary, had negative (or normal) polarity and the other half had positive (or reversed) polarity. Stratigraphic sequences, based mainly on evidence of superposition of beds, were studied and sequences of alternating polarities were observed. Many examples from various countries are given; results on radiometric determinations from volcanics in the Hawaiian Islands suggest that the most recent reversal occurred one million years ago and the penultimate reversal about two and one-half million years ago. This has been confirmed by other authors on samples from the western United States, Africa, and Europe. These data are checked, other possible ways to produce such a reversal (*i.e.*, internal rock "self-reversal" with time and chemical change, rather than external geomagnetic field reversal) are discussed, field and laboratory experiments were devised and carried out, and a most thorough study of

all aspects of the problem shown—before Irving comes to the conclusion that there must undoubtedly have been external geomagnetic field reversals. His treatment is so definite, the evidence so clear, that the reader feels as though he has drawn his own conclusions. The rest of the book is equally well done; it is highly recommended.

ELECTROMAGNETISM AND THE EARTH'S INTERIOR, by T. Rikitake, American Elsevier Publishing Co., Inc., New York City, 1966, xi + 308 pp., \$22.50 (published as Vol. 2 of the series "Developments in Solid Earth Geophysics").

This book grew from the author's lecture notes for an advanced course in geophysics at the University of Tokyo; thus the assumption is made that the reader has a competent working knowledge of the fundamentals of geomagnetism. The objective was to summarize the current state of knowledge on the geomagnetic field resulting from changes in the earth's interior. Before going further, this reviewer would like to say that, in his opinion at least, this purpose has been achieved in a most thorough and comprehensive manner. Mathematical confirmation of all ideas has not been neglected (in Chapter 7, "Theory of Secular Variation", there are ninety-eight lines of equations in less than twenty-one pages) but the proof is never allowed to obfuscate the physical concepts. The coupling between core and mantle which is illustrated in the rigid-sphere model, and its variations which lead to development of the westward drift of the geomagnetic field, stands out as an almost "obvious" pointer to the belief that the major parts of the non-dipole field and its secular variation originate within the core. A similar treatment, *i.e.*, history of development of presently accepted theories, model studies of them, and mathematical testing of the models, is given to daily variations and those other changes in the geomagnetic field, the primary causes of most of which originate outside the earth. This technique of showing the strengths and weaknesses of theories postulated to explain fundamental data regarding the geomagnetic field, its constancy and its variations, is most convincing. However, the earlier treatment of historical ideas

concerning the origin of the earth's magnetism was equally well handled. The reasons for discarding such theories as permanent magnetism, free decay of electric current, geomagnetic effect, rotating charge, electromagnetic induction by magnetic storms, thermoelectric effect, Hall effect, compression effect, etc., are presented and evaluated. The basic idea of the dynamo, and particularly the disk dynamo model of Bullard, is explained and treated mathematically. Since the Bullard model involves two types of motion and four types of magnetic field, the treatment becomes so complicated that there is no analytical way to solve them together with the boundary conditions. Bullard and Gellman solved them with a numerical approach and their work proved the possibility of a homogeneous dynamo which could be workable in the earth's core.

After detailed and thorough study of these evolving theories, the reader begins to get a rather comfortable feeling that now most is known and only small gaps remain to be filled in . . . then he arrives at the last chapter. This chapter, 33 pages long, deals only with local anomalies of geomagnetic variations. While most of the knowledge concerning these comes from Japan and Germany, it probably is only because most of the interest (and thus observation) has centered in those areas. Anomalies discussed here are from those countries, plus Italy, Czechoslovakia, Hungary, Rumania, Canada, the United States, and Australia. Since these are so widespread, their importance is obvious; however, it will be difficult to evaluate very accurately the significance of the conductivity anomalies to geophysics until more observations are accumulated.

This book explores a field which has been left relatively untouched, except in numerous rather short papers, since the appearance of the voluminous (1049 pp) "Geomagnetism" of Chapman and Bartels in 1940. It is well written, sufficiently illustrated (159 line-drawing figures), and the extensive bibliography of twelve pages provides immediate reference to the background information. It is expensive but probably this is necessary because of the rather limited market. Certainly it is a book which must be a part of the working library of any geophysicist dealing with the magnetic field of the earth.

ADVANCES IN EARTH SCIENCE (Contributions to the International Conference on the Earth Sciences, Massachusetts Institute of Technology, September, 1964); edited by P. M. Hurley, M.I.T. Press, Cambridge, Mass., 1966. xiv + 502 pp., \$20.00.

The book is appropriately dedicated to Cecil H. Green, including as it does the papers of a conference held in connection with the dedication of the Cecil and Ida Green Building housing the earth sciences at M.I.T.; the extent of the honor to Mr. Green is made apparent by the caliber of the authors represented. The Conference was divided into four broad groupings, i.e., the earth's environment, atmospheric motions, dynamics of the oceans, and the solid earth, and outstanding leaders in each field discussed their specialties. The list reads like the "Who's Who" of contemporary academic geophysics. There are three papers under each of the divisions except that of "the solid earth", which required two three-paper sessions.

The publisher states that "this is a major book on geophysics presented in a form that is understandable to the non-specialist. Yet, since theoretical treatments form the bases of this work, it should prove a valuable addition to every geophysical library of importance as well." Thus, this must be understood as the goal of the Conference; the opportunity for practitioners in the extremely broad spectrum of modern geophysical activities to get together and let each other (and possibly some few of the general public) know what is being done, how far it has progressed, and what may lie ahead. But, by "non-specialists", the organizers only meant that a solid-earth geophysicist might understand what the astronomer was doing or the oceanographer might become more conversant with atmospheric physics . . . there could have been no idea that these papers would explain the work or conclusions of any of their authors to any large segment of the population. In other words, this is far from a popular approach to the subject of advances in the earth sciences. It is a book by geophysicists for geophysicists but not restricted on either end to a definite subdivisional branch of this growing multidiscipline. Dr. Frank Press made

this clear when he introduced his paper with the remark, "I assume that I address an audience of physical scientists rather than specialists in seismology." In this light, the book is a great success. Most of the papers may be read with interest by a reasonably up-to-date physical scientist, although he may prefer to skip some of the derivations and proofs offered. As an example, the three papers of most interest to this reviewer (essentially an exploration geophysicist and geologist) were "the Moon and the Planet Mars" by Gerard P. Kuiper of the University of Arizona, "Sedimentary Record of Long-Period Phenomena" by Gustaf Arrhenius of the University of California, and "Seismological Information and Advances" by Frank Press, then of California Institute of Technology but now at M.I.T. However, concurrence must be given to Dr. Press's statement "if a modern history of geophysics is written, I hope that it will include exploration seismology so that we can recognize these developments (i.e., extending the spectral band of seismic waves, introducing digital techniques and array concepts, etc.) and give due credit to our colleagues in the oil business for anticipating many of them." Seems reasonable enough!

THE MINERAL RESOURCES OF AFRICA; by American Elsevier Publishing Co., New Nicolas deKun, American Elsevier Publishing Co., New York City, 1965, xxv + 740 pp., \$40.00.

Even if the price looks enormous, don't stop but read on—this is a huge book, in page size (7½"x11¼"), in number of pages as shown above, in coverage (all countries of Africa treated individually and then all economic minerals reviewed individually), and in value. A book of this type and of this scope is not needed by all geologists or even by all companies engaged in geological work. However, for those engaged in exploration for and exploitation of minerals other than petroleum, and particularly for those in a worldwide search, this book will be a necessity. Of course, it is not a text-book or even a cohesive unit . . . it is an encyclopedia . . . but an encyclopedia crammed with facts, figures, tables, maps, and references in a quantity seldom equalled and never surpassed in the geologic literature.

The author was able to draw upon his fifteen years of personal experience in Africa, upon the geological surveys and mines departments of the various countries, upon many individuals with whom he had worked, and upon numerous unpublished reports to which he was given access. While the distillation of these data by the author must have been a most time consuming, albeit interesting chore, the concentrated residue which is herein presented is of value sufficient to make it all worthwhile. As he points out, Africa appears to have been the early home of man, the use of metals dates back farther here than in other continents, and for more than a thousand years the gold trade has flourished on these coasts. And now again, the main base of the new national economies, at least in the wealthier countries, is formed of minerals and metals.

A book in which the table of contents, list of figures, and list of tables require eighteen pages, the index forty-four pages, the bibliography another thirteen pages, and an appendix of "companies, individuals and organizations engaged in or having interests in the cement, mining, petroleum and power industries of Africa" (with postal addresses) another forty-five pages, is of necessity quite a book. A total of one-sixth of a reference work made up of such "directive" information is most unusual as well as most welcome. It should be mentioned that the appendix and index are in smaller type than the text, so that even "one-sixth" is a conservative figure! The cross-indexing by countries as well as by minerals is most helpful; it is well done and most thorough. The paper is good, the type-faces used are attractive and clear, the dividing and subdividing emphasizes as well as separates, and the entire format is well chosen. Unfortunately there are two important defects which mar this otherwise unusually fine book: the figures, all 136 of them, are poor, being line drawings which are oversimplified and then reduced to a miniscule size and the price is so great that few individuals will purchase it. It is probable that nothing could be done about the second, for the manufacture of a book of this size and quality for a limited market must necessarily be costly. However, since this price already had to be so high, why not have made it a

little higher and used better illustrations? Page-size maps and cross-sections, possibly even a few fold-in sections, reproduced from actual originals or even somewhat simplified, would have added so much to the value of

the final product. But the text alone, and the ease of finding what is desired, will make this volume indispensable to the economic geologist interested in the worldwide scope of the minerals industry.

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NO. 1—page 3, Table 1. The abundance symbols in Table 1 are based on the numbers of specimens per kilogram. (This information was inadvertently omitted by the editors).