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BOOK REVIEWS

INTRODUCTION TO ORE DEPOSITS. By Ludwig Baumann. Halsted Press (John Wiley and Sons), 1976. 131 pages $16.50.

This book is based upon a course presented in 1969 at the University of St. Andrews. The author in ten lectures gave an introduction to the process of deposit formation with special regard to the formation of ores. The book is divided into three parts: (1) formation of ore deposits by magmatic processes (57 pages); (2) formation of ore deposits by sedimentary processes (41 pages); and (3) metamorphic transformation of ore deposits (10 pages). In addition, the volume contains a three-page bibliography, a nine-page appendix listing the metal contents of the most important ore minerals, and a four-page general index.

It is very difficult, not to say impossible, to provide an adequate and balanced introduction to ore deposits in so few pages. Lack of such balance becomes evident when one compares the section on magmatic to those on metamorphic and sedimentary ores. The treatment of sedimentary ores is much better than that of magmatic and metamorphic ores, but still does not really discuss the physical chemical aspects of ore formation in sedimentary environments. The author uses the various stages in the development of geosynclines to illustrate relations of ore deposits to tectonics and magmatic activity. He does not include plate tectonic theory and the relations between magma generation and ore formation in subduction zones and at spreading centers.

In this reviewer's opinion, an introductory text on ore deposits, such as this one is intended to be, would gain substantially if it contained (1) an introduction devoted to the development of the study of ore deposits as well as a discussion and evaluation of the various existing classifications of ore deposits; (2) an introductory-level chapter on lithological, structural, and stratigraphic controls of mineral-deposit formation and localization; (3) a separate chapter on the mechanisms of transport and deposition of ore minerals and on the physical chemical aspects of wall-rock alterations.

The references listed are not always up-to-date. For instance Goranson (1936) is not the last word on the solubility of water in silicate melts; our concepts of the division of the earth's crust have changed much since the publication by Borchert (1960); no reference is made to recent studies of sulfide liquid immiscibility.

In spite of certain drawbacks I find the book interesting. It is printed with a good deal of care and attention to quality.

GUNNAR KULLERUD
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DIFFRACTION PHYSICS. By John M. Cowley. American Elsevier Publishing Company, Inc., New York, 1975. xiii + 410 pages. $56.25 (Dfl. 135.00).

This book contains a unified treatment of electron, neutron, and X-ray diffraction physics. Such a treatment is made possible by employing from the beginning the Fourier transform rather than differential equations. The work reflects the author's interests in electron microscopy and the study of disordered or imperfect crystals, fields of research that are becoming increasingly important in mineralogy. This book is recommended for those with some previous knowledge of diffraction techniques who wish to master the associated theory sufficiently to either participate in or evaluate research in these areas.

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FLUID INCLUSION RESEARCH. Proceedings of COFFI. Volume 7, 1974. Edited by Edwin Roedder. University of Michigan Press, Ann Arbor, 1976. 287 pages. $6.00.

As stated in the preface "The purpose of the publication is to provide English abstracts or annotated bibliographic citations of all items from the world literature published during the volume year that either contain fluid inclusion data or are pertinent to some aspect of fluid inclusion work. This covers all types of fluid inclusions (aqueous, organic, silicate melt, sulfide melt, gas, *etc.*), causes and mechanisms of trapping (including immisibility), physical, chemical, and isotopic data, and data on experimental studies of systems pertinent to the interpretation of the phase changes occurring in inclusions." A subject index and a deposit index are provided. The present volume and volume 6 are obtainable from the University of Michigan Press for $6.00 per volume, postpaid; reprints of volumes 1 (1968) through 5 (1972) are obtainable at $3.00 per volume (postpaid) from Edwin Roedder, U.S. Geological Survey—959, Reston, Virginia 22092, checks for these reprints to be made out to COFFI.

BRIAN MASON
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APPLICATIONS OF THERMODYNAMICS IN METAMORPHIC PETROLOGY. By Edgar Froese. Geological Survey of Canada, Paper 75–43. 37 pages. $3.00 (Canada), $3.60 (other countries).

This book is a brief (37 page) introduction to classical thermodynamics and its application to metamorphic petrology. It opens with a discussion of thermodynamic fundamentals, moves on to a systematic analysis of reaction equilibria in terms of the Gibbs free energy, and concludes with examples of how these principles can be applied to solid–solid reactions, dehydration reactions, non-ideal solutions, and oxidation/sulfidation reactions. The approach taken is essentially mathematical, but Froese makes a consistent effort to emphasize the physical framework underlying the mathematics, rather than striving for strict mathematical rigor. As a result, there are a few gaps in the derivations which may bother mathematically-inclined readers, but the logic of the subject stands out uncommonly clearly. Particularly helpful are the many illustra-

tions which show graphically the relations between variables, standard states, and so on. All of the examples are drawn from the literature of metamorphic petrology, and provide a good sampling of how thermodynamics can be applied to petrologic problems. Several examples are worked out in detail, and serve as a virtual blueprint for using the standard tabulation of petrologically important thermodynamic data by Robie and Waldbaum.

This is far from a complete book on thermodynamics. The careful reader will probably want to go elsewhere to fill the occasional gaps in the derivations. Several important subjects—most notably the thermodynamics of ionic species in solutions—are completely ignored. But the book does present many important topics clearly, and in a familiar petrologic context. It should prove valuable as supplementary reading for students taking a course in classical chemical thermodynamics, as an aid in bridging the gap to petrologic problems. And it might be very useful as a review of thermodynamics for students or professionals interested in applying thermodynamics to metamorphic petrology.

GEORGE W. FISHER
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TEKTITES AND THEIR ORIGIN. By John A. O'Keefe. Elsevier Scientific Publishing Company, Amsterdam, 1976. 254 pages, 44 figures, 21 plates, 17 tables. $36.50.

During the pre-Apollo years of the 1960's, one intriguing hypothesis was that in tektites we already had samples of lunar rocks. One of the most eloquent protagonists of this idea was John O'Keefe, and I still recall the exciting debates on this topic that were a feature of the annual meetings of the American Geophysical Union. The Apollo 11 landing appeared to deal a death-blow to this hypothesis; as C. C. Schnetzler expressed it in an article titled "The lunar origin of tektites: R.I.P." (*Meteoritics, 5,* 221, 1970): "The lunar origin of tektites, a controversial and stimulating theory on the scientific scene, died on July 20, 1969. The cause of death has been diagnosed as a massive overdose of lunar data."

Perhaps, however, the reported death has been somewhat exaggerated. John O'Keefe, in the present book, argues forcefully that tektites are the produce of lunar volcanism. He reaches this conclusion largely by a process of elimination; quoting Foucroy, . . . ,"It is only by eliminating the absurd or the impossible that one is forced to accept what would at first have seemed almost unbelievable," he shows the weaknesses in all other theories of tektite origin and then states, "We are thus forced to accept the conclusion, which at first seems incredible, that tektites, despite their remarkable resemblance to terrestrial rocks, do not originate on the earth."

Despite John O'Keefe's masterly command both of the facts and the deductions that can be drawn therefrom, I doubt that this book will be accepted as the last word on the tektite problem. Rather it serves the worthwhile purpose of showing that the origin of tektites, far from being settled by the Apollo landings, is still very much of an unsolved problem. And it provides a comprehensive and well-organized summary of the facts on tektites—their distribution, forms, internal structure, physical properties, chemical composition, and ages; Dr. O'Keefe's review of the very extensive and scattered literature (I estimate that his list of references runs to 700–800 items) is invaluable for any future research. This book fills a real need as a source of information for anyone interested in tektites, those fascinating and still enigmatic objects.

BRIAN MASON
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SEMI-CONDUCTING ORE MINERALS. By R. T. Shuey. Elsevier Scientific Publishing Company, Amsterdam, 1975. xii + 415 pages. $22.95.

This is an interesting and important book which discusses the structure, conductivity, and heterogeneity of ore minerals and then summarizes the available data on a variety of elemental, sulfide, and oxide ore minerals. The contents include:

Part one: Principles. Chapters on (1) electronic structure, (2) conduction mechanism, (3) other electronic properties, (4) heterogeneity and the semiconductor-electrolyte interface.

Part two: Elements. Chapters on (5) bismuth, (6) copper, (7) graphite

Part three: Sulfides. Chapters on (8) arsenopyrite, (9) bornite, (10) chalcocite, (11) chalcopyrite, (12) covellite, (13) galena, (14) molybdenite, (15) pyrrhotite, (16) pyrite, (17) sphalerite, (18) miscellaneous sulfides

Part four: Oxides. Chapters on (19) cassiterite, (20) cuprite, (21) hematite, (22) magnetite, (23) pyrolusite, (24) rutile; subject and mineral indices.

The discussions of electronic structure and properties take a pragmatic approach and are well written and understandable by those whose background includes basic physics. The chapters on individual minerals (8–24) actually contain information on many more minerals than the chapter title indicates, because structurally related minerals are also often considered (*eg.* löllingite and safflorite with arsenopyrite and cattierite, vaesite and cobaltite with pyrite). Topics typically included in these chapters are: occurrence, related minerals, resistivity and type, structure, bonding, bond structure, energy gap, mobility, carrier concentration, defect ionization, nonstoichiometry impurities, electrical properties of related minerals.

This book will serve as a useful compendium for mineralogists, chemists, and physicists desiring information on the electrical behavior of minerals.

JAMES R. CRAIG
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THE PHYSICS AND CHEMISTRY OF ROCKS AND MINERALS. Edited by R. G. J. Strens. John Wiley and Sons, New York, 1976. 697 pages, $45.00.

Picture a book whose 41 chapters are written by 64 authors representing such diverse areas of the world as Australia, Thailand, France, Germany, Switzerland, the United Kingdom, Canada, and the United States. The setting for *Physics and Chemistry of Rocks and Minerals* was a NATO symposium held at the University of Newcastle upon Tyne, 22–26 April 1974. The content is an impressively well organized and coherent set of advanced scientific papers whose theme takes a quick turn to the physics and chemistry of processes of the deep earth. For the most part, the studies reported

were conducted under high pressure and high temperature conditions.

The format of part I begins with plastic behavior of minerals and of rocks, followed by papers on the elastic, electrical, electromagnetic, and convection properties of minerals and rocks. Less systematic, but by no means less thorough, is part II, in which are concentrated studies of high pressure and temperature properties of minerals. Modern studies of thermochemistry, crystal structure, element partitioning, and electronic properties are represented in part II, and there is an evident underlying objective in many of the papers, namely, the challenge of understanding the intricate changes in minerals as conditions of pressure and temperature to which they are subjected become intensified. The response of individual atoms and coordination polyhedral groups within a crystal to the onset of melting and solid phase transformations is the focus of several studies.

My impression of the book as a whole and of most of the individual papers is favorable, although a few of the shorter papers might have been excluded advantageously. The price of the book is high at $45.00, but this averages to less than 6.5 cents (U. S.) per page. Rarely can one purchase a set of advanced papers on any subject with as complete a coverage or with as high a level of discussion.

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CRYSTAL GROWTH AND CHARACTERIZATION. Edited by R. Ueda and J. B. Mullin. Proceedings of the Second International Spring School on Crystal Growth (ISSCG2), Japan, 1974. North-Holland, Company, American Elsevier, Inc., New York, 1975. vii + 419 pages. $33.95.

The chapters in this book are based on the lectures of the instructors at the spring school, a list that includes some of the most prominent names in the crystal-growth field. The material is designed for the individual that would like to familiarize or bring himself up to date with the recent advances in techniques for growing and characterizing crystals of economic value such as Si, Ge, Ga, As, Al_2O_3, ruby, YAG, *etc.* The only materials of geologic interest are garnets and spinels, and even they are not typical natural compositions.

In spite of the book's specific orientation, there is much for the geologist. The desire to understand more fully the details of the crystal growth processes in natural rock melts and how they are reflected in mineral metastability, zoning, shape, and in rock textures has generated an interest in the remarkable recent advances in understanding the crystal growth process in the Materials Sciences. This book summarizes much of the recent work in crystal growth from the melt, flux growth, epitaxy, vapor growth, and the characterization of crystals by such techniques as optical, X-ray, SEM, TEM. A first glance at this book points up the continuing realization that higher mathematics is an increasing need for geologists. The complexity of treating crystal growth in even simple systems is pointed up by Jackson's concluding statements (chapter 3) that the methods "of generating theoretical descriptions (of crystal growth) are cumbersome at present." He hopes for "simpler more tractible formalisms." The mathematical formalisms presented are not readily adapted from the simple unary or binary systems described here to the 9 or more component systems with which the geologist has to deal. Chapters by Jackson, Chernov, Pfann, Cockayne, and Carruthers and Witt, however, give good physical descriptions of melt growth in geologic systems.

The crystal-growth techniques described here could have wide application to the growth of large single crystals for geophysical properties. For this purpose, it is not necessary to model the growth process as nature may have done it, and all the clever techniques described here could be tried for growing crystals of particular interest.

The chapters on crystal characterization treat in detail the methods for recognizing crystal imperfections such as lattice misfits, the nature of surfaces, dislocations, inhomogeneities, and microstructures. This material would complement an advanced mineralogy text for the study of mineral features rarely treated extensively in routine mineralogic investigations. It will be of particular interest to characterizing crystals for physical property measurements.

The overall quality of the printing is subpar compared to the cost. The economy of using original typed pages instead of typeset has lead to more typographical errors than normally expected. The figures presented by some of the authors display only average hand lettering and the reproduction of photographs is less than would be desired.

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ELECTRON MICROSCOPY IN MINERALOGY. Edited by H.-R. Wenk. Springer-Verlag, New York, 1976. xiv + 564 pages, 272 figures. $39.40.

Because of the technical problems involved in thinning larger specimens, the clay minerals, colloids, and minerals in biological systems were being studied by transmission electron microscopy and diffraction before most minerals of igneous and metamorphic origin. But with the important development and subsequent commercial availability of ion-beam thinning technology in the sixties, spurred on by the Lunar Program, the barrier to direct electron optical study imposed by specimen preparation was greatly reduced. Coupled with the higher voltage, higher resolution, and goniometer stage flexibility of the newer transmission electron microscopes, this breakthrough opened up the field to all petrologists and mineralogists. Thus a book with both the broad title *Electron Microscopy in Mineralogy* and the avowed purpose expressed on its cover of serving as both a textbook for advanced mineralogy and a complete reference handbook would be timely. Yet this book was unabashedly directed by its seven editors and sixty contributing authors toward igneous and metamorphic petrology. Following the currently fashionable symposium format, it represents an amalgamation of assorted papers on this subject with no coverage outside these fields and little mention of surface studies by the replica technique or with the scanning electron microscope. One must therefore objectively view its inclusive title and stated purpose as a little inappropriate and generally misleading.

Nevertheless, all mineralogists with any interest in transmission electron microscopy and electron diffraction applied to thin foil specimens will find useful the reviews of theory and technique of microscopy and diffraction as well as the discussions of thin-specimen experimental methods, the often spectacular lattice imaging studies, analytical microanalysis–microscopy, and particle

track studies. Most of the remaining contributions are varied applications representing assorted papers given at several recent symposia—indeed some have been published in similar form elsewhere as part of such symposia.

The applications strength of the book lies in the quality collection of contributed papers on exsolution in feldspars and pyroxenes, and anyone with an interest in these mineral groups will find the book useful. As coordinating editor H.-R. Wenk points out in his introduction, mineral structures and textures are not easily visualized from diffraction patterns. And while seeing may not always be believing because transmission electron image formation is a function of diffraction contrast, it can help to understand the low spatial resolution of x-ray diffraction data by providing direct visual evidence—especially when this visual evidence is combined with electron diffraction and microanalytical data from areas less than 0.1 μm in size.

The book is illustrated with over 400 quality-reproduced photomicrographs and diffraction patterns. It is generally free of misspellings and printer's errors, reflecting an editorial attention to proof-reading. It contains a subject index, but as is common with the symposium format, the references follow each contributed paper rather than forming one complete bibliography.

KENNETH M. TOWE
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MINERAL-FUNDSTELLEN, Band 4: SKANDINAVIEN. By Hans-Jurgen Wilke. Christian Weise Verlag, Munich, 1976. 370 pages, 16 color plates. DM48 (approx. $20).

This one of a series of guidebooks to mineral localities in specific regions by this publisher; guides have also been published for Tirol–Salzburg–Sudtirol, Baden–Württemberg, and Steirmark–Kärnten. The book begins with a summary of the geology of Scandinavia (14 p.), and is followed by detailed accounts of 24 Norwegian, 38 Swedish, and 14 Finnish localities; a single locality may include several individual collecting locations, each carefully described, and pinpointed on accompanying maps. For each locality the author has noted the date of his latest visit, most between 1970 and 1975; he thus vouches for the reliability of his information. He also provides useful lists of German–Norwegian, German–Swedish, and German–Finnish words and phrases for the mineral collector. The book has an excellent bibliography and index.

This book is a model of its kind, and the author is to be congratulated. However, reading it raised a disturbing question in my mind. Many of the localities described are of great historical and scientific significance, and if despoiled cannot be regenerated; should they be protected from overzealous collectors and commercial exploitation, and if so, how?

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LIST OF BOOKS RECEIVED

GEOLOGICAL PROSPECTING OF PETROLEUM. By Heinz Beckman. Vol. 2, Geology of Petroleum. Distributed by Halsted Press, New York, 1976. 183 pages. $6.95/paper.

STRIP MINING OF COAL. Environmental Solutions. By William S. Doyle. Noyes Data Corporation, Park Ridge, New Jersey, 1975. vii + 345 pages. $32.00.

FUNDAMENTALS OF ROCK MECHANICS. By J. C. Jaeger and N. G. W. Cook. 2nd. Ed. Chapman and Hall, London, 1976. Distributed by Halsted Press, New York. xviii + 585 pages. $12.50/paper.

PRACTICAL X-RAY SPECTROMETRY. By R. Jenkins and J. L. De Vries. Springer-Verlag, New York, 1975. 189 pages. $11.00.

PETROLEUM ENGINEERING. By Alfred Mayer-Gurr. Geology of Petroleum Series, Vol. 3. Distributed by Halsted Press, New York, 1976. 183 pages. $6.95/paper.

SEISMIC ZONING OF THE USSR. By S. V. Medvedev. Keter Publishing House Jerusalem Ltd, 1976. Distributed by Halsted Press, New York. v + 533 pages. $58.50.

GEOTHERMAL ENERGY AS A SOURCE OF ELECTRIC POWER. By Stanley L. Milora and Jefferson W, Tester. The MIT Press, Cambridge, Massachusetts, 1976. ix + 186 pages. $14.95.

SUBSTITUTE NATURAL GAS MANUFACTURE AND PROPERTIES. By W. L. Lom and A. F. Williams. 244 pages. $35.00