

BOOK REVIEWS

IGNEOUS PETROLOGY. By Ian S. E. Carmichael, Francis J. Turner, and John Verhoogen. International Series in Earth and Planetary Sciences, McGraw-Hill Book Company, New York, 1974. xiii + 739 pages. \$22.50.

This book is a completely rewritten and greatly expanded version of the first 15 chapters of *Igneous and Metamorphic Petrology* by F. J. Turner and J. Verhoogen. Several changes have resulted in a significantly improved book. The most important is overall emphasis. Whereas the older book is predominantly descriptive, the new volume places more emphasis on principles. Much of the descriptive material is still retained in the latter part of the book, but it has been reorganized and slightly condensed. The first part of the book includes chapters on the properties of liquids and solids (including welcome sections on nucleation and growth of crystals and thermal and kinematic properties of liquids), crystallization paths in low pressure phase diagrams, and magmatic gases and volatile components. Also, there are useful sections on a variety of other topics such as classification of igneous rocks, the bearing of trace elements on theories of magmatic evolution, and the use of radioactive isotopes as tracers. The application of thermodynamics is more extensive than in the earlier book, and thermodynamic concepts have been woven very effectively into the geological discussion. In Chapter 5 on low pressure crystallization paths, the authors have done a very nice job of integrating natural rock sequences with crystallization paths on relevant three and four component phase diagrams. The section in the earlier book on introductory thermodynamics has been deleted and the authors have assumed a knowledge of this material as well as basic principles of phase equilibria. The descriptive part of the book contains chapters on basaltic associations of ocean basins, continental tholeiitic provinces, continental mafic magmas from deep sources (kimberlites, nephelinites, etc), andesites and associated volcanic rocks of island arcs and continental margins, and rocks of continental plutonic provinces (granitic batholiths, anorthosites, ultramafic rocks). A final chapter discusses the upper mantle as a source region for magmas.

Two minor changes that I like are inclusion of all the references in a single alphabetical listing at the end of the book and separation of the author and subject indexes. (A defect is a curious decision not to index the frequent references to the authors' own papers.) The text is written with a good prose style that flows easily and does not get in the way of the material being discussed. The publishers have done an excellent job of preparing the book; I detected only a few proofreading errors.

This book is the only modern text that attempts to present an introduction to the whole field of igneous petrology at an advanced level, and to a considerable degree, the authors have succeeded. Nevertheless, there are some serious flaws. One of these is inadequate referencing of the literature. Space does not permit a comprehensive listing, but a couple of examples will illustrate my point. On p. 64, they discuss computerized mass-balance methods for testing the validity of fractional crystallization models that derive one lava from another by removal of phenocryst minerals. No reference is made to any of the major-element studies of this sort that have recently appeared in the literature. An uninformed

reader desiring further information would be stymied. On p. 347, it is stated that the frequently referenced geotherms of Clark and Ringwood are no longer considered to be valid because radiative heat transfer in the deep mantle is not as important as it was once thought to be. Again, no references are made to the literature. An advanced text of this sort should serve as an entrance to the literature, and it is unfortunate that instances in which it fails in this regard are not isolated.

In one case, the problem of inadequate referencing of the literature is compounded by a confusing presentation. On p. 107, Kushiro and Yoder are mentioned as having studied the transition boundaries between plagioclase peridotite, spinel peridotite, and garnet peridotite. Several other investigators who have also studied these reactions are not mentioned, a defect that would not be too serious were it not for the fact that there are significant disagreements among various workers about the positions of the transition curves. The disagreements are, to some extent, illustrated by three different figures showing conflicting positions for the stability fields (Fig. 3-10 on p. 119, Fig. 12-11 on p. 610, and Fig. 13-1 on p. 624). Strangely, there is no explanation for the conflicting diagrams. For Figure 3-10, reference is made to a 1974 paper by Carmichael and Wood (unlisted in the references at the end of the text); for Figure 13-1, a secondary reference is given; and for Figure 12-11, the diagram is stated to be modified after a 1967 diagram by O'Hara. Actually, the strongly curved spinel peridotite to garnet peridotite transition curve in Figure 12-11 can be recognized as originating from a 1971 paper by O'Hara, Richardson, and Wilson, but no credit is given. The text gives no indication that the curvature of this line is controversial and results in a strikingly different low-temperature extrapolation from that given by other investigators.

A few incorrect statements and errors on diagrams are scattered through the book. On p. 221, the solidus in Figure 5-1 is defined incorrectly and includes only that portion of the solidus with one crystalline phase in equilibrium with liquid. In Figure 5-1, p. 222, the liquidus minimum (M) on the $\text{NaAlSi}_3\text{O}_8$ - KAlSi_3O_8 side is drawn incorrectly in that it does not coincide with the lowest temperature on the solidus curve. On Figure 5-26 (the system Mg_2SiO_4 - $\text{CaMgSi}_2\text{O}_6$ - SiO_2 at 1 atm, p. 267), the primary phase field of protoenstatite is not shown. On page 266, the incongruent melting of enstatite is stated to be eliminated at pressures greater than 7 kbar. Later, on p. 626, it is stated that the incongruent melting of enstatite is eliminated at pressures above 5 kbar. The sources of these values are not given, and in any case, they are both incorrect. In 1964, Boyd, England, and Davis determined experimentally that enstatite begins to melt congruently at some pressure less than 5.4 kbar and estimated from thermodynamic calculations that the most likely pressure was about 2.3 kbar. On p. 354, it is stated that "In dry systems . . . melting temperature increases with increasing pressure." As a generalization, this is incorrect. For example, in the system $\text{NaAlSi}_3\text{O}_8$ - SiO_2 , one portion of the solidus curve for certain compositions has a very steep negative dT/dP slope. On p. 626, it is stated that quartz-normative basalts can be derived by partial fusion of peridotite only at pressures below which pure MgSiO_3 begins to melt congruently. This is incorrect; the addition of other components can (and does) change

the phase relations to permit the derivation of quartz-normative basaltic liquids above this pressure.

Perhaps the most serious flaw of the book is the omission or cursory treatment of some important topics. In a book of this type it is clearly necessary to be selective, but a few of the priorities are startling. For example, 5 pages (p. 236–241) are used to discuss in detail the origin of the rare comendites and pantellerites, while about equal space is devoted to a largely descriptive account of mid-ocean ridge tholeiites (p. 374–378, 651). Nowhere is there a discussion of the various conflicting ideas for the origin of mid-ocean ridge tholeiites. Surely, a rock type that may cover 50 or 60 percent of the earth's surface deserves more. Another example is the treatment of ophiolites. If these bodies represent sections of oceanic crust, as many investigators believe, their study will help unravel the origin of 60 percent of the earth's crust, yet discussion of ophiolites is restricted to one paragraph on p. 606 and another paragraph on p. 616. Mention of ophiolites as possible sections of oceanic crust is reduced to two sentences, and one of the references cited on this subject (a 1973 paper by Presnall and Bateman) contains no discussion of ophiolites whatsoever. Finally, experimental studies of systems at very high pressures (above 10 kbar) are, in my opinion, not adequately treated. Since 1960, there has been a flood of papers in this area and much of the current excitement in igneous petrology concerns phase equilibrium relationships at mantle pressures. The decision to emphasize low pressure phase diagrams results in a failure to capture much of this excitement. Three important topics not discussed at all are pegmatites, lunar petrology (in the preface, it is stated that a discussion of these two topics is beyond the competence of the authors), and the bearing of thermal divides on theories of origin for alkaline and tholeiitic basalts.

Despite these criticisms, I like the book. It presents very good discussions of a wide variety of subjects. It would be a good text for an advanced course in igneous petrology, but students should be made aware of the fact that it does not serve as an adequate introduction to certain areas of the petrologic literature. The same criticism applies to the use of this book as a reference. With this qualification, it is a high quality book that I would recommend to all serious students of igneous petrology.

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CRYSTALLIZATION PROCESSES UNDER HYDROTHERMAL CONDITIONS. Edited by A. N. Lobachev. Translated from Russian by G. D. Archard. Consultants Bureau, Plenum Publishing Corporation, New York, 1973. viii + 255 pages. \$29.50.

This collection of articles related to crystal growth under hydrothermal conditions is essentially a continuation of an earlier collection which appeared in 1968 entitled *Hydrothermal Synthesis of Crystals* and describes the continuing active research by Soviet scientists in this field.

A background chapter by Dem'yanets and Lobachev details the empirical generalizations which one must consider when attempting crystal growth of a material by the hydrothermal technique. It is followed by twelve articles by various authors describing the growth of specific compounds, in particular, oxides, chalcogenides, chalcogenides, carbonates, silicates, and germanates. A number of the chapters concerned with specific compounds are in fact continuations of work initially discussed in the previous volume. The final two chapters discuss instrumental problems, the control of growth, and the design of autoclaves.

The title of this book may be misleading; it is not a textbook and, aside from the first and last two chapters, is mainly a description of ongoing researches in hydrothermal crystal growth. As such, many of these chapters should rightfully appear as journal articles. However, the reviewer does find a collection of articles on the application of a specific technique useful and, as such, this book would be a valuable addition to the libraries of workers active in the field.

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MINERALY ILASTE (Clay Minerals). By Leszek Stoch, published by Wydawnictwa Geologiczne, Warsaw, 1974. 503 pp.

For all who like to read about Clay Mineralogy in Polish, this book will be a mine of information. It brings up to date the information to be found in *X-Ray Identification and Crystal Structures of Clay Minerals* (G. Brown, Editor, 1961), *Clay Mineralogy* (R. E. Grim, 2nd ed., 1968), and other standard sources of information on clays. Each chapter is divided into sections, each with a comprehensive list of references, with titles of articles. There is a final, comprehensive subject index, but (perhaps understandably) no author index. The main subdivisions deal with physical and chemical methods of analysis, the structures of clay minerals, the genesis of clays, and physico-chemical and technological properties of clays. Structures are discussed in relation to diffraction patterns and identification, chemical compositions, and thermal behavior. Less attention is given to polytypic forms and interstratified minerals than one might have expected, particularly as a large section deals with geological aspects. For those who do not read Polish, perhaps the main interest of the book will be the comprehensive lists of references which are reasonably complete up to about 1969, with a few post-1970 references. The book is well produced, with good binding, good paper, clear printing and many figures (many of which, like old friends, we readily recognize).

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ZEOLITE MOLECULAR SIEVES: STRUCTURE, CHEMISTRY, AND USE. By Donald W. Breck. John Wiley and Sons, New York, 1974. 771 pages. \$32.50.

This book is the first comprehensive compilation in this special field and is an essential reference volume to any researcher interested in these relatively new industrial minerals. The subjects covered in this volume, with a second volume promised on catalysis, are crystal structure, mineral zeolites, synthetic reactions, adsorption by dehydrated crystals, and the manufacture and properties of commercial molecular sieve adsorbents. The author, who is one of the pioneer industrial scientists who established synthetic and natural zeolites as important industrial minerals, has listed key references at the end of the book: 8 general, 11 on catalysis, 4 on crystal structure, 2 on occurrences in sedimentary rocks, 3 on synthesis, and 3 on ion exchange. Acquisition of these references along with this book would provide the initial library to one entering the field. In addition the book lists over 1000 other references. Summary tables (313) and figures (242) contain a wealth of very useful information; the geoscientist will especially appreciate the crystallographic, X-ray powder diffraction, and synthesis data. There is a glossary (p. 207–208) of geologic terms for the non-geoscientist but no glossary of other technical terms which might be unfamiliar to the geoscientist. For example, the kinetic diameter, σ , is not listed in the index and one must search the text

for the definition. For such an important reference volume, the index is minimal. An author index and a listing of tables and figures would be helpful. Surprising is the lack of many diagnostic adsorption isotherms, considering that the basic interest in these materials is due to the property of selective adsorption of molecules into the intracrystalline pore system.

Breck's proposed classification of zeolites is based on extensive data, much of which has been supplied from his laboratories on synthetic zeolites. Mineralogists concerned with nomenclature will find this section in the introduction of particular interest, as emphasis is placed on nomenclature based on differences in properties. Letter designations are sometimes given instead of the mineral name. In addition, the author advocates the use, for example, of "mordenite-type" to that of "synthetic mordenite" where other authors have used the latter nomenclature. The nomenclature problem that has developed is unprecedented for a mineral group and is being studied by an international nomenclature committee headed by Professor R. M. Barrer of the Imperial College of London. The following quote from the book typifies the problem: "Zeolites X and Y and faujasite have topologically similar aluminosilicate structures, although they are distinct zeolite species with characteristic differences."

The points mentioned do not detract from the fact that this volume is an indispensable contribution. It will be of value to the crystallographer, the geochemist, and the economic geologist. It is a classic case history of the rapid development of a family of new industrial minerals, natural and synthetic, with a concurrent rapid development of basic scientific data.

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SELECTED POWDER DIFFRACTION DATA FOR MINERALS—DATA BOOK and SEARCH MANUAL. By the Joint Committee on Powder Diffraction Standards, Swarthmore, Pennsylvania, 1974. Data Book xlvi + 833 pages, Search Manual xiii + 262 pages. \$250.00.

This publication provides a search-index for the mineralogical sub-group of the inorganic section of the Powder Diffraction File and consists of two volumes, the *Data Book* and the *Search Manual*. The *Data Book* contains reproductions of the Powder Diffraction Data cards for the nearly 1900 mineral species in sets 1 to 23, and an index by mineral names and groups. The Search Manual provides for rapid access to the Data Book and comprises sections organized by mineral name, chemical name, and the three most intense d values and intensities (Hanawalt method). An additional search manual organized according to the Fink method may be purchased for \$25.00. The principles of organization employed in this publication are those successfully used in the *Inorganic Index*, and this publication lacks only in that the Hanawalt and Fink numerical sections of the search manuals do not list the chemical compositions of the mineral entries. This proves a bothersome omission for those unfamiliar with obscure mineral names, since it is necessary to refer to the mineral name section to determine an entry's chemical formula. Despite this shortcoming, mineralogists and geologists will find these books highly useful and a very inexpensive alternative to the *Inorganic Index*, which tips the scales at a hefty \$1750.00.

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ENCYCLOPEDIA OF MINERALS. By Willard Lincoln Roberts, George Robert Rapp, Jr., and Julius Weber. Van Nostrand Reinhold Company, New York, 1974. xxv + 693 pages, 128 plates. \$69.50.

This highly attractive compendium lists 2200 mineral species in alphabetical order. For each is stated: its chemical formula; its crystal class, system, and space group; its unit cell constants and cell content Z ; its three strongest powder diffraction lines; its refractive indices and, if biaxial, $2V$; its hardness, density, cleavage, habit, color, and luster; its mode of occurrence; and the best reference in English for further information on this mineral. The 693 pages of mineral data are accompanied by 128 pages of handsome photographs of minerals in color, each such page containing 7 or 8 individual photographs.

In any future edition the authors should reconsider their treatment of the members of solid solution series. At present they cite hortonolite $(\text{Fe,Mg})_2\text{SiO}_4$ as a member of the olivine group with a composition ranging from 50–70 atomic percent Fe^{2+} . Yet, rather than giving a range of lattice constants or of optical constants for hortonolite, they state the values as $a = 4.799$, $b = 10.393$, $c = 6.063$, and $\alpha = 1.752$, $\beta = 1.781$, $\gamma = 1.795$, $2V(-) = 65^\circ$.

The book is intended for service "on the encyclopedia shelf of the small town library" and "on the desk of the established mineral collector." Its breadth of minerals covered should certainly make it esteemed in both areas. Professional mineralogists will also be impressed by this book. It even contains "proidonite (= a natural gas) SiF_4 ."

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MÖSSBAUER SPECTROSCOPY. AN INTRODUCTION FOR INORGANIC CHEMISTS AND GEOCHEMISTS. By G. M. Bancroft. Halsted Press, John Wiley & Sons, Inc., New York; McGraw-Hill Book Co., Ltd., London, 1973. xii + 251 pages. \$21.50, £6.95.

This text is divided into three parts: Part 1 (Chapters 1, 2, 3), the Introduction; Part 2 (Chapters 4, 5, 6), Applications in Inorganic Chemistry; and Part 3 (Chapters 7, 8, 9), Applications in Mineralogy and Geochemistry. A number of problems are listed at the end of each chapter (except Chapter 9), and answers or references to research papers are given at the end of the book. These do extend the interested reader's understanding, but this avenue is also occasionally used by the author to vent personal grievances regarding a specific research paper.

Chapter 1 lucidly approaches the question "What is the Mössbauer effect?" in terms of basic concepts such as radioactivity, nuclear properties, the Doppler effect, and nuclear resonant absorption. Chapter 2 discusses the origin of the hyperfine parameters, isomer shift, quadrupole splitting, and magnetic Zeeman splitting, although the last effect, unfortunately, is not explored elsewhere in the book. Chapter 3 outlines the basic equipment and experimental expertise that pertain to a Mössbauer effect experiment. The least-squares fitting of experimental data and the criteria for a "good fit" are discussed despite an example of a 10-peak fit to the spectrum of the mineral omphacite. Chapter 4 illustrates the fingerprint application of the Mössbauer effect in inorganic chemistry. Examples have been chosen to demonstrate applications such as determining the purity of a compound and the oxidation state of the Mössbauer atom, proving whether one com-

pound has a structure different from another of the same composition, determining whether two or more Mössbauer nuclei in a polynuclear compound are in equivalent environments, and identifying the compound or species in a complex mixture. Chapter 5 interprets trends in the isomer shifts of series of related compounds of a large variety of Mössbauer ions using simplified M. O. theory (discussed are I, Xe, Fe^{II}, Ru^{II}, Au^I, Sn^{IV}, Sb^{III}, and Fe^{II} high-spin compounds). With this approach to chemical bonding, trends of the isomer shift values can be correlated with parameters such as electronegativity, the spectrochemical series or the nephelauxtic series. Trends in the quadrupole splitting for I, Xe, Fe^{II}, and Ru^{II} compounds are similarly explained in Chapter 6 in terms of the nature and distribution of ligand bonds. The concept of partial quadrupole splitting for specific ligands and for Mössbauer ions in a given coordination is introduced, and this approach is used in discussions of the stereochemistry of Fe^{II}, Sn^{IV}, Ru^{II}, Ir^{III}, and Co^{III} compounds. Finally, in this chapter an evaluation of a crystal field model to explain the quadrupole splittings for Fe^{II} (high spin), Fe⁰, Au^{III}, compounds is considered. Chapter 7 is concerned with fingerprint applications of ⁵⁷Fe Mössbauer spectroscopy in many iron-containing, rock-forming minerals. The important principles discussed are determination of the oxidation state of iron (divalent or trivalent state) and the electronic configuration (high or low spin) of iron, specific coordination symmetries (tetrahedral or octahedral) and departures from regular symmetry about the iron atom, assignment of absorption peaks to crystallographically distinct cation positions, and the correlation of quadrupole splitting values with crystal structure variations. In Chapter 8, the method and some applications of quantitative site populations in silicate minerals, mainly pyroxenes and amphiboles, are discussed. In Chapter 9, Mössbauer analyses of multimineral mixtures, e.g.,

meteorites and lunar rocks and soils, are discussed as a method of mineral identification, to determine mineral abundances, and to estimate bulk ferric to ferrous ratios in a rock sample.

This book provides an adequate introductory account of the Mössbauer effect in the fields of inorganic chemistry and geochemistry. It is recommended for the potential Mössbauer spectroscopist.

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GEMS AND MINERALS IN COLOR. By Rudolf Metz.

Translated from the German by G. A. Wells. Illustrated with 150 color photographs by A. E. Fanck. Hippocrene Books, Inc., New York, 1974. 255 pages. \$6.95.

This pocket-sized hardback contains 150 remarkable color photographs whose clarity usually permits the mineral to be recognized. The photograph showing labradorescence (plate 2) is striking, but so are many others of the 150. The plates' legends often detail the origin of the mineral's name—for example, anorthite from the Greek *anorthos* (= askew); or amethyst from the Greek *amethystos* (= counteracting intoxication) because the ancients valued it as an amulet against drunkenness. The text describing processes of mineral formation is relatively professional in language and content. An alphabetical list of the more important minerals cites the formula, crystal system, density, hardness, color, and occurrence for each. A useful index follows. Amateurs and collectors should welcome this handbook.

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LIST OF BOOKS RECEIVED

THE THIRD PLANET: AN INVITATION TO GEOLOGY. By Konrad B. Krauskopf. Freeman, Cooper & Company, San Francisco, 1974. 523 pages. \$13.50 hardbound; \$8.95 paper (for orders of 4 or more).

THE WAKABAYASHI MINERAL COLLECTION at the University Museum of the University of Tokyo. By Ryoichi Sadanaga and Michiaki Bunno. University of Tokyo Press, 1974. International Scholarly Book Services, Inc., Portland, Oregon. 177 pages. \$28.00.