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BOOK REVIEWS

Review of Natural Zeolites: Occurrence, Properties, Applications. Editors: D.L. Bish and D.W. Ming. Reviews in Mineralogy and Geochemistry, Volume 45, Mineralogical Society of America, 1015 Eighteenth Street NW, Suite 601, Washington, D.C. 20036-5274, U.S.A. 2001, 654 p. US$24 for MSA and GS members; US$32 for others. ISBN0–939950–57–X.

Natural zeolites have long held the interest of earth scientists because of their structural and chemical variability, which makes them useful as recorders of their geological environment. In addition, because of their ion exchange and hydration–rehydration properties, natural zeolites have untapped potential to address many of our current environment and energy issues. This new review, which supersedes Volume 4 in the series (1977), is greatly expanded and updated, with the addition of nearly 30 years of new work. The book has more than twice the content of Volume 4 and includes a number of new topics, as well as expanded coverage of previous topics.

The book is divided into 18 chapters that cover crystal structure, crystal chemistry, thermodynamic stability, isotope geochemistry, and zeolite occurrences in various environments, including closed and open hydrologic systems, burial diagenesis and low-grade metamorphism, hydrothermal, soil, and petroleum-reservoir environments. Two chapters deal with thermal stability and cation-exchange properties. Finally, there are chapters on application of natural zeolites to water treatment, building material, energy conservation, and soil enhancement and remediation. Although much was known about crystal structures, crystal chemistry and occurrences in the 1970s, some of the topics such as thermodynamic and isotopic properties and application of zeolites to environmental problems are much expanded owing to extensive research in recent years.

An interesting new chapter on zeolite occurrences in hydrocarbon reservoirs demonstrates that zeolites in many cases play an important part of hydrocarbon systems. Oil exploration into volcanogenic provinces has shown that zeolites such as analcime, clinoptilolite and laumontite can form major cementing phases in hydrocarbon reservoirs.

The chapter on thermodynamic stability brings together the current literature and thermodynamic values for the zeolites and then applies this to various geological environments using activity–activity diagrams. Although some might question the utility of this approach to metastable phases such as zeolites, it nevertheless shows general stability-relations among the species as a function of fluid chemistry and pressure–temperature conditions.

Several chapters dealing with physicochemical properties of zeolites demonstrate the unique character of this group of minerals. The chapter on thermal stability offers an extensive treatment of zeolite dehydration–rehydration in which the type of exchangeable cations and framework structure have a complicated effect on the process. In this chapter are presented new data on zeolite dehydration as well as a thermodynamic treatment of reversible hydration–rehydration reactions. Thermogravimetric curves are modeled for a number of zeolite systems. The chapter dealing with cation exchange presents a thermodynamic treatment of reversible cation-exchange followed by a review of exchange experiments for various zeolites. Of geological interest in this chapter is a calculation of cation ratios in pore fluid from the ratios of exchangeable cations in a zeolite determined by analysis.

The new chapter on isotopic studies offers an excellent review of applications of both stable and radiogenic isotope systems to the zeolites. The author points out the problems of extracting components for isotopic measurements from zeolites and discusses techniques required to obtain reliable analyses. He also reviews isotopic studies in deep sea, hydrothermal and lacustrine environments. I found it to be an objective and useful treatment of the topic.

The zeolite application chapters are very interesting, as they bring together some novel and creative uses for natural zeolites. For example, natural zeolites have been used in heat-exchange systems for heating and cooling homes and for making ice. The authors of the chapter on use of natural zeolites in soil beneficiation and environmental remediation summarize a number of recent soil-chemistry and plant-growth experiments that employ zeolite-bearing mixtures. This chapter also provides some interesting insights into why commercial application of natural zeolites to soil problems has been limited.

References in all the chapters are largely taken from recent literature (post-1977), thus making this book an important replacement of the previous MSA Review and a “must have” for those interested in the topic. Its

greatest value may be the compilation of these recent references on natural zeolites. Each chapter concludes with a section on future studies, which is a nice addition for students. The clarity of the writing is generally good, and except for a small errata sheet that came with the volume, the publication appears to be relatively free of typos. Editors Dave Bish and Doug Ming are to be congratulated for this timely volume. Overall, I highly recommend this Review as it brings the topic up to date and provides a comprehensive treatment of the subject.

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Review of Water–Rock Interactions, Ore Deposits, and Environmental Geochemistry – A Tribute to David A. Crerar. Roland Hellmann and Scott A. Wood, editors. Geochemical Society, Special Publication No. 7, $US 80, or $US 55 for members of the Geochemical Society, hardbound, ISBN 0–941809–06–4.

This is the most recent of the Special Publication Series from the Geochemical Society. The aim of this series is to publish original articles that honor renowned geochemists. This publication, like its predecessors, has achieved its aim and is a fine tribute to Canadian geochemist David Crerar. Some vignettes at the beginning of the book that give us some insights on David Crerar as a person as well as his scientific contributions; they are contributed by Greg Anderson, Hugh Barnes, Roland Hellmann and Susan Brantley. The reviewed articles in this book consist of 23 contributions on three major themes of geochemistry from international authors, many of whom are David Crerar's former students or colleagues. The three major themes reflect the breadth of research that David undertook during his career, which included geochemical problems at the Earth's surface, sedimentary and ore deposit environments, as well as mineral surface – fluid interactions. The book is well put together, is printed on high-quality paper, and also contains a subject index. The manuscripts are well edited, and the figures are generally of high quality, although a few of the photomicrographs are a bit fuzzy. The table of contents can be found at the Geochemical Society website, http://gs.wustl.edu/publications/.

The first theme is "Water–Rock Interactions and Fluid–Mineral Interfaces". Most of the articles in this section concern weathering and mineral–water interfacial reactions that occur at room temperature. Studies include the effect of organic acids on feldspar weathering, fluid flux in regolith formation, modeling of granite weathering, and experiments on the effects of pH jumps on goethite dissolution and on the dissolution of twinned and untwinned zeolite. Authors of two papers used atomic force microscopy; one examined the dissolution of albite and glass of albite composition, and the other examined mechanisms of barite growth. Hydrothermal atomic force microscopy and optical second harmonic generation techniques were also applied to the investigation of interfacial processes. The last two papers in this theme are experiments on the effect of pressure on chalk deformation and the characterization of porosity reduction in chalk during pressure-solution creep by porosimetry, SEM image analysis and X-ray computerized tomography.

The second theme focuses on "Thermodynamics, Hydrothermal Geochemistry, and Ore Deposits". This section starts with a discussion of stable *versus* metastable equilibrium. Next, several papers are presented on experiments of *REE* and Y solubility and speciation, as chloride, acetate or hydroxide complexes, at temperatures up to 300°C. These works have implications for understanding the speciation of the *REE* in seafloor fluids, and *REE* mobility in sedimentary and waste-disposal environments. Another experimental study examines metastable plagioclase – epidote – fluid equilibria at 400–425°C, with implications to the formation of volcanogenic massive sulfides and the composition of vent fluids. Two papers deal with the vapor transport of metals. The first reviews metal concentrations observed in natural fumaroles and sublimates, and presents experimental data on the transport of Ag, Au, Cu and Sn in aqueous vapor at temperatures up to 400°C. The second paper uses open-system equilibrium calculations to model the trace elements observed in high-temperature (160–920°C) gases and silica-tube experiments at the Kudriavy volcano, Russia. The last paper presents a fluid-inclusion study of drusy quartz from the Potosi dolostone, Missouri, which has implications for flow of basinal fluid and the formation of Mississippi-Valley-type mineralization.

The third theme is "Environmental Geochemistry". This section covers a variety of topics, but primarily deals with the sequestering of metals in surficial environments. The first paper is on microbial acquisition of nutrients from mineral surfaces, specifically the bioavailability of phosphorus adsorbed on goethite. Next is an article on ternary surface complexation, which is the co-adsorption of metal cations and organic acids onto mineral surfaces. Mineral – metal – ligand and mineral – ligand – metal ternary surface complexation are reviewed, and the stability of the goethite – citrate – Co^{2+} ternary surface complex is examined. The next paper concerns a simulation of the behavior of arsenic in groundwater, lacustrine sediments and wetland sediments. A key variable examined is the presence of roots and their effects on the redox state of the waters and sediments. This is followed by an article on NAPL dispersion by modeling the time dependence of interface dilation and compression as a fluid–fluid interface

advances through a porous medium. The last two articles deal with the fate of metals in surficial environments. One is a laser-induced time-resolved fluorescence spectroscopy study on the sorption of uranyl ions to amorphous silica, and the other utilises XANES, and Fourier-transform EXAFS to constrain the partitioning of Zn and Mn between the mineral fraction and plant roots at a mine-waste-impacted wetland.

The quality of the articles in this publication is first class, but it is collection of papers that pay tribute to David Crerar, not a textbook. Any geochemist would benefit by owning a copy, as they will likely want to refer to many of the articles for years to come. The price is reasonable at $US 80, and for members of the Geochemical Society, at $US 55, it is a bargain.

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Minerals of the World. By Ole Johnsen. Princeton University Press, 41 William Street, Princeton, New Jersey 08540, U.S.A., 2002. 439 pages, US $24.95 (ISBN 0–691–0937–X).

Books about minerals span a broad range: from the least rigorous picture books designed for children or the peripherally curious, and coffee-table books that stress the remarkable beauty of the mineral kingdom, to demanding and thorough no-nonsense textbooks that challenge university students in comprehensive (not watered-down) mineralogy courses. [In the coming months, I shall review two such resilient texts on these pages]. Between these extremes lies the fertile field of books designed for the serious amateur, the collector, and the intellectually motivated layman. Such books are a fastidious challenge to prepare: the author must pick and choose subjects and minerals carefully and present the ensemble within a limited number of pages and in a fashion attractive enough to hold the attention of readers who, in general, have other interests. I have picked from my shelves eight such books, published between 1906 and 1977. Probably the best-known is Fred Pough's "*Field Guide to Rocks and Minerals*" (1953). The book here under review is the ninth, and in my view, by far the best of the lot.

Minerals of the World is one of the Princeton Field Guides, an eclectic series of ten volumes that cover subjects from the vast ("Stars and Planets") to the restricted ("Birds of the Seychelles"). The copy of *Minerals of the World* in my hands is a paperback ($20 \times 13 \times 2$ cm), though it is also available in hard cover. It is printed on excellent, truly opaque, semigloss stock. The book is generously illustrated with 616 figures, of which more than 500 are mineral photos in color, all taken by the author. These merit special note, for most of them are superb. To see pyrite, in the first figure (p. 10), reproduced so realistically that one feels that the specimen could be plucked from the page, is a tour-de-force. This is but a precursor of the beauty that follows, page after page. Many specimens are portrayed in conventional framed settings, but most are displayed against the white background of the page, surrounded by a subtle grey halo that lightens gradually outward. This clever digital technique is highly effective. Emphasis on color is strong (p. 67–71), but not surprising, as the focus of the book is on "minerals and their properties as they can be seen with the naked eye or with a hand lens" (p. 7).

Minerals of the World is divided into two unequal parts. The first (62 pages) deals broadly with the principles of crystallography and physical mineralogy. The second (320 pages) offers mineral descriptions. The book concludes with two tables of minerals arranged according to hardness and density (a weak correlation!); the first (4 pages) covers minerals with metallic or submetallic luster, the second (19 pages), covers those with a nonmetallic luster. These are followed by two pages on the chemical elements, a five-page glossary, and an 11-page general index.

Part I, after a highly introductory discussion of what a mineral is, dives directly into fundamental crystallography: symmetry, notation, and the seven crystal systems. It concludes with an overview of physical mineralogy, including chemical bonding and the basic properties of minerals used in their identification.

Part II is arranged chemically, along the lines of Dana's classical system, though in a condensed fashion. Short and useful introductions (10 to 20 lines) are given to each of the groups (native elements, sulfides...). The silicates are arranged structurally. The choice of the "about 500 minerals described" (p. 7) and the number of lines allotted to each one "is governed by its significance for the keen amateur mineral collector rather than the professional mineralogist. For example, the very rare mineral boleite is included because of its attractive crystal form and beautiful color, which are highly appreciated by collectors [unfortunately, the color photograph of boleite, on p. 142, conveys these attributes rather unsuccessfully]. The scientifically very important clay minerals are, on the other hand, mentioned only briefly, since they are in general unattractive to the private collector..." (p. 75). Even so, I found that of the 204 minerals required in the introductory course that I took as an undergraduate, 203 are treated in *Minerals of the World*, although a handful have undergone a name change in the intervening 50 years.

Most of the minerals included by Dr. Johnsen (who, by the way, is one of the current Associate Editors of

The Canadian Mineralogist) are afforded only a few lines of descriptive text. Minerals of relatively more substantial importance are accompanied by more detailed information: crystallography, physical and chemical properties, names and varieties, occurrence, use, and diagnostic features. Chemical formulae are given for all minerals, and delicately executed crystal drawings or structure diagrams (in color) are shown for some. The choice of obscure minerals is slightly skewed toward Greenland and Scandinavia, apparently a reflection of the author's background and experience. In addition, all but five of the specimen figures are from the collections of the Geological Museum at the University of Copenhagen. The text, written originally in Danish, and published in 1994 as "Mineralernes verden", is smooth and clear. The translation into English was careful and well edited with two exceptions: the extensive abuse of adverbs of time, and the consistent misuse of the abbreviation "*e.g.*".

Although I shall give a list of minor errors and shortcomings below, I have two major criticisms of *Minerals of the World*. The first is the absence of references. A list of works to encourage the reader to consult additional, perhaps more thorough works, is a serious failing. The intellectually motivated layman that I referred to in the opening paragraph of this review might benefit from a list of texts and reference works such as "*Dana's New Mineralogy*", "*The Handbook of Mineralogy*", Fleischer's "*Glossary of Mineral Species*", or the Mineralogical Association of Canada's own "*Encyclopedia of Mineral Names*". My second major criticism is the absence of a discussion on the topic of asbestos. We, as mineralogists, have a responsibility to speak out and to put science into what has become a wholly irrational and downright hysterical issue. For instance, we must mention the vast dissimilarity in the toxicity of the multiple varieties of commercial asbestos (chrysotile *versus* "crocidolite", for example, and isn't it unfortunate that the two have such similar names?), or raise the possibility that had the asbestos ban in the U.S. not come about at the onset of construction, and had the steel structure been insulated properly with asbestos following earlier norms, perhaps the World Trade Center towers would be standing today.

Minor deviations are numerous, though in general not serious. In approximate order of appearance, here are a few of those that caught my eye: The opening discussion of "What is a mineral" (p. 11-12) is too sketchy and, surprisingly, fails to deal with the role of chemical composition. The (+) and (–) ends of crystallographic axes are mentioned (p. 25), but defined only for hexagonal and trigonal crystals (Fig. 40). On page 26, *m*3 should be 2/*m*. The symmetry elements depicted in color (Figs. 25, 34, 41...) are nearly undecipherable; shaded line drawings would have been more effective. The discussion of pseudomorphism is inadequate and confuses pseudo- with paramorphism (p. 52). The numbers have been omitted from the Mohs scale (p. 60), and the definition of parting (p. 64) is wrong. Canada has been shortchanged: unmentioned are the world's largest known deposits of sylvite and carnallite (in Saskatchewan), and ilmenite (in Quebec). The important property of scheelite – to fluoresce in ultraviolet light – is passed over (p. 224). The U.S. State is Maine (not Main, p. 238). Fibrolite is not an obsolete name for sillimanite (p. 264); it is a fine-grained nematoblastic variety of the mineral commonly referred to by petrographers. The characteristic color of andalusite is pink, not "usually grey or dirty green, brown or red" (p. 264). The diaspore in Figure 252 is indistinguishable from the margarite in Figure 524. Clay is not a sedimentary rock (p. 423) and, on the same page, a concretion is not necessarily "a rounded nodule of a mineral". Omphasite should be omphacite (p. 424), and not all limestone is pale in color (p. 425).

In summary, among intermediate-level mineralogy books, *Minerals of the World* is the current king of the mountain. The exposition and presentation are lucid, and the mineral photographs mostly breathtaking. The reasonable price of this book makes it a particular bargain.

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