BOOK REVIEWS

PHYSICS AND CHEMISTRY OF EARTH MATERIALS. By Alexandra Navrotsky. Cambridge University Press, 1994. xiv + 417 pages. $79.95 (hard cover), $34.95 (paperback).

Physics and Chemistry of Earth Materials, by Alexandra Navrotsky, is a textbook designed for a one-semester course for advanced undergraduates and first-year graduate students. The breadth implied by the title is reflected in the table of contents: Following the introduction, there are chapters on crystal chemistry; modern instrumental analysis for investigating the structure of matter, ranging from diffraction techniques to various types of spectroscopies and microscopies; experimental methods for determining thermodynamic properties; chemical bonding; thermodynamics; solid solutions and ordering; melts, glasses, and amorphous materials; and a short summary that considers how mineral physics and materials science are related. No one-semester course designed to address such a breadth of subject matter would achieve great depth, and, recognizing this, Navrotsky has "chosen to take an approach more phenomenological than rigorous" in the hope that the text will "spur you to specialize further in some subset of the field."

The concept and organization of this book are excellent. The chapters are arranged in an order that makes good sense for an advanced survey course in the subject, and the level of detail is appropriate; moreover, the chapters are self-contained, so that they can be used in any order desired by an instructor or for independent topical study. Each chapter lists both general references and the specific references that are cited in the text. Most illustrations are simple line drawings or graphs, but they are adequate. The book would benefit from a much more complete index than has been provided; with just over one page of index for every 200 pages of text, many important topics Navrotsky discusses are not listed.

This book is not intended to be a tutorial for computational methods in the various subjects covered. For instance, the chapter on chemical bonding provides an excellent summary of various approaches to bonding and gives references to example calculations in the literature, but it is not intended to lead a student through bonding calculations; nevertheless, it is a good starting point for those who wish to delve into such calculations. Similar statements may be made about the chapters on thermodynamics, ordering, and glasses. Although Navrotsky warns the reader of her predisposition to emphasize spinels and perovskites, numerous other minerals and compounds are used in examples.

Like any textbook, this one has its shortcomings, and, unfortunately, some of them are rather serious. Numerous errors, some typographical, begin to appear almost immediately in the chapter on crystal chemistry, where crystal lattice and crystal structure (atomic arrangement) are confused on the first page of the chapter. Before leaving this chapter, the reader has been informed, incorrectly, that a particular Navajo rug design contains two twofold axes, that low and intermediate albite crystallize in space group $C2/c$, and that celsian crystallizes in space group $I\bar{1}/c$. Navrotsky has also included all natural garnet and clinopyroxene solid solutions in a table of "ABX_3 structures," suggesting that the X and Y cations in these minerals play similar crystal-chemical roles. Chlorites such as clinochlore, chamosite, and pennantite are incorrectly listed as 2:1 layer silicates, instead of 2:1 + 1 or 2:2 layer silicates. The impression is given that low albite and maximum microcline are formed only in slowly cooled metamorphic rocks.

The remaining chapters contain fewer errors that are obvious to this reviewer, but still have problems that may confuse readers. For example, an X-ray map for Si, obtained using an SEM equipped with an energy-dispersive analyzer, apparently shows that Si is absent from a natural silicate garnet; the common oxidation states of As are given as +3 and −5, instead of +5 and −3; and the equations given for Slater-type orbitals and Gaussian functions are identical (the equation given for the former is incorrect). The text relating to Figure 5.4 begins with a discussion of band gaps in Cu, but the figure actually illustrates Mg, not Cu; the next paragraph continues with a discussion of Mg and MgO but switches (apparently unintentionally) from MgO to Si in the last sentence, resulting in the unfortunate statement that "pure silicon is an insulator." A discussion of the phase relations in the $CdCO_3$-$MgCO_3$ system and the accompanying figure refer to these as calcites and to $CdMg(CO_3)_2$ as dolomite, instead of phases with calcite-like and dolomite-like ordering schemes. These examples are representative but hardly exhaustive.

Many of the figure captions are self-explanatory, but some would benefit from a significantly more direct connection to the text. Two examples suffice: Figure 3.5 shows the b-c and α^*-γ^* plots for alkali feldspars, and the text affirms that ordering state can be inferred from these plots using bond lengths (which is only indirectly correct); however, neither the text nor the figure caption give a clear explanation of how to do so or why the plots yield Al-Si ordering. Figure 6.20, which displays ABO_3 compounds related by high-pressure phase transitions, is presented with no explanation whatsoever but contains numbers that are not meaningful without some explanation.

My initial reaction to this book, upon seeing the table of contents, was positive and rather enthusiastic. After reading it, my enthusiasm dampened somewhat. I shall keep the book on my shelf as a useful aid when I need to review concepts covered in it. I shall not use it as a textbook for students, however, because it contains too many inaccuracies and typographical errors for such use. A revision of the book that corrected the errors would prompt a welcome reconsideration of that decision.

DANA T. GRIFFEN
Brigham Young University

APPLIED MÖSSBAUER SPECTROSCOPY: THEORY AND PRACTICE FOR GEOCHEMISTS AND ARCHAEOLOGISTS. PHYSICS AND CHEMISTRY OF THE EARTH, volume 18, Parts III–VI. Edited by S. Mitra. Pergamon Press 1992. xiv + 381 pages. $528.00

This monograph is divided into two major parts, A and B, that deal with the theory and practice, respectively, of applied Mössbauer spectroscopy. The first chapter in part A, entitled "Principles of Mössbauer Spectroscopy," is a standard treatise on theoretical considerations, including hyperfine interactions, experimental setup, curve fitting of spectral data using Lorent-

0003–004X/96/0910–1287$05.00

zian line shapes, and measurement of Fe^{3+}/Fe^{2+}; it also provides an introduction to back-scattered and conversion electron Mössbauer spectroscopy. The following chapter discusses the use of Mössbauer spectroscopy to study mineral magnetism but with special emphasis on studies of microcrystalline material. The use of magnetic spectral data to infer site occupancies is discussed elsewhere. The third chapter assesses the use of Mössbauer spectroscopy to analyze electron-delocalization processes in minerals such as magnetite, Ti-rich garnet, vivianite, lazulite, babingtonite, rockbridgeite, clinopyroxenes, and ilvaite, but the reader will need to refer to the cited references for a thorough knowledge of how thermally activated electron-hopping processes affect spectral patterns.

The second part of this monograph is subdivided into sections on geochemistry and environmental studies and archaeology. The geochemistry section comprises 12 chapters mostly devoted to the ^{57}Fe Mössbauer spectral characteristics of the major rock-forming minerals. Chapter 4 is on oxides and oxyhydrites, and Chapter 5 is on the Mössbauer effects of aluminum substitution in hematite and goethite. In Chapters 6, 7, 8, 9, 10, and 11, the ^{57}Fe Mössbauer spectral data are presented for spinels, ortho and ring silicates, chain silicates, phyllosilicates, carbonates, sulphides, sulphosalts, and phosphates. Each of these latter chapters begins with an introduction to the specific crystal structure. There is also an extensive conclusion, the usefulness of which is limited by a writing style that largely consists of brief, unrelated sentences. Chapter 12 is entitled "Site Occupancies: Geothermometry, Geospeedometry and Oxygen Fugacity." Its theme is the petrologic significance of site-occupancy data for orthopyroxenes and calcic amphiboles. A discussion of Fe^{3+} in mantle-derived garnets is included. Chapter 13 has the very broad title "Petrological Studies" and includes selected examples from the literature of the petrologic significance of Fe^{3+} in biotite and chromites. Most of these data, however, were presented previously. It is also not clear why a section on Fe in P-rich silicate melts is included, nor why these data are not presented in a subsequent chapter specifically devoted to silicate melts. The chapter concludes with a discussion of Mössbauer studies of deep-ocean sediments and deep-sea ferromanganese crusts and nodules. Chapter 14 is entitled "Glass, Silicate and Magmatic Melt Studies" and includes data on synthetic and lunar glasses, obsidians, and natural melt compositions. The reader has to refer back to Chapter 8 for data on pyroxene melt compositions! In Chapter 15, the effect of pressure on the hyperfine parameters in a variety of inorganic compounds and minerals is presented. Also discussed is the effect of pressure on Fe^{3+}/Fe^{2+} in silicate glasses and Fe^{3+}/Fe^{2+} in spinels and garnets from mantle-derived xenoliths, but these sections, again, duplicate information from previous chapters. The chapter concludes with a review of alkaline earth and rare earth perovskites. The final chapter in this section is concerned with extraterrestrial materials, and the discussion of lunar samples includes soil and glasses, metallic iron, pyroxenes, and feldspars. The spectral data of carbonaceous meteorites and their constituent mineral phases are also presented. Section B2 includes a chapter entitled "Environmental and CEMS Studies" that focuses on the use of ^{57}Fe Mössbauer spectroscopy to analyze air samples, bacteria, higher plants, and animals. The use of glass and glass ceramics as nuclear waste disposal material is also examined. Finally, the use of conversion electron Mössbauer spectroscopy to analyze surface effects is discussed. The final chapter in this monograph is entitled "Archaeological Studies." and mainly documents the magnetic and paramagnetic components in clay minerals and metals that have been used in ancient ceramics, potteries and their glazes, roofing tiles, and artifacts. A key aim is to evaluate ancient technologies, principally firing temperatures, kiln atmospheres, and sources of clay and soil.

This monograph offers graduate and research students in geochemistry, mineralogy, and archaeology an introduction to the principles of Mössbauer spectroscopy and provides an overview of the research problems that can be tackled with this spectroscopic technique. In this regard, the editor has compiled over 1300 references that are more or less up to date. However, most of the material is presented uncritically, and site-occupancy data and Fe^{3+}/Fe^{2+} ratios, which form important cornerstones for applied problems in the earth sciences, are not compared with the results of other techniques. For this reason, readers may prefer the relevant issues of the Mineralogical Society of America short-course notes that cover the crystal chemistry of the major rock-forming minerals.

Your library probably already has this monograph since it is part of a serial, but this work is also available from the publisher for $528 as a back issue of the serial. I would recommend using your library's copy.

David Virgo
Carnegie Institution of Washington