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BOOK REVIEWS

Mineral Science: An Introductory Survey by Keith Frye. Macmillan, 1993, vi + 360 p., US $58.50 (ISBN 0-02-339945-7).

A SOLID BACKGROUND in mineralogy is necessary for all earth scientists. Most textbooks for undergraduate students emphasize crystal structures, the physical and optical properties of minerals, and the occurrence of minerals. Few undergraduate texts adequately cover crystal chemistry and the stability relations of minerals. *Mineral Science*, by Keith Frye, attempts to cover all of these subjects. The author combines various topics from mineralogy, petrology, and geochemistry into a single text, in order to show how they are interrelated. The book is aimed at upper-division undergraduates and first-year graduates. The objective is to provide a broad background in mineral science that can be used as a foundation for more advanced study.

The book can be divided into four sections. The first consists of one chapter in which the basic principles of crystal architecture are reviewed. The topics covered in this review include atomic models, chemical bonds, properties of ions, ionic configurations, noncrystalline and crystalline matter, and thermochemistry. It would have been useful to show charge-density or electrostatic potential maps for minerals, because in most texts, the size of oxygen relative to other species in silicates and oxides is exaggerated (depending, of course, on how "ionic" size is defined). The next section of two chapters deals with the crystal structures and symmetries of minerals important in the earth sciences. I found the coverage of crystal chemistry to be inadequate, though this is true of most undergraduate mineralogy texts. The third section also consists of two chapters, one on the physical properties of minerals (density, specific gravity, elastic properties, thermal properties, electrical properties, magnetic properties, radioactivity, surface properties, hardness, and tenacity), and the other on radiant energy and crystalline matter. A chapter covering chemical properties and emphasizing the compositional variations shown by minerals would have been useful here. The final section includes a chapter on the phase rule and phase diagrams and a chapter on mineral genesis. I was surprised to see hypothetical phase diagrams used to illustrate phase equilibria. Phase diagrams of experimentally determined systems relevant to geology would better illustrate how mineralogy and petrology are interrelated. Another criticism of this section is the exclusive use of the RICHARDSON et al. (1969) triple point for the Al_2SiO_5 polymorphs in Chapter 7 (Mineral genesis).

All of this material is crammed into 360 pages of text and is illustrated by 180 figures. The text is necessarily concise, but is generally well-written and free of factual and typesetting errors. However, I do not agree that "ideal pressure and concentration" provide a good "operational notion of fugacity and activity" as stated on p. 48. A glossary at the back of the book provides definitions of many of the terms used in the text.

In my opinion, *Mineral Science* attempts to cover too many topics, and ends up covering none in sufficient depth for an undergraduate course in mineralogy or petrology. I cannot see this book being widely used in teaching, and I believe that the book falls short of the stated goal to provide a background in mineral science that can be used as a foundation for more advanced study. For some time, there has been a need for a comprehensive undergraduate textbook in mineralogy that includes recent developments based upon spectroscopy and transmission electron microscopy. Unfortunately, those who teach undergraduate mineralogy, petrology, and geochemistry are still waiting for that book to be written.

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An Introduction to Organic Geochemistry by S. D. Killops and V. J. Killops. Wiley, 1993, 265 p., US $39.95 (ISBN 0-582-08040-1).

THE STUDY of organic geochemistry is truly multidisciplinary. It brings together different elements of chemistry, biology, and earth sciences in its exploration of the sources, transformations, and cycles of organic matter in the geosphere. During the past decade, in particular, organic geochemical studies have expanded their focus beyond their historical strengths in petroleum geochemistry to include new interests, such as records of climate change and environmental consequences of anthropogenic organic matter. This change has attracted new people to organic geochemistry, some as practitioners and some as users of its results. *An Introduction to Organic Geochemistry* was written for these people.

The book is intended to be an integrated introduction to this multidisciplinary field, and it is the first book to succeed at doing this in a comprehensive fashion. A particular strength of the book is that it is written in a consistent and unified style, unlike books which consist of collected contributions from different authors. The eight chapters—Production and fate of organic matter, Chemical composition of biogenic matter, Conditions for the accumulation of organic-rich sediments, Formation of humic material, coal, and kerogen, Generation and composition of petroleum, Molecular evaluation of Recent sediments, Molecular assessment of ancient sediments and petroleum formation, and Environmental behaviour of anthropogenic organic compounds—are nicely illustrated. Of special importance to beginners, a large number of chemical structures and reaction pathways are shown. Suggestions for additional reading are provided for each of the eight chapters, and specific citations to sources of research results are given in the text. A subject index at the end of the book is done well and is quite useful.

This book is meant to be used as a textbook for upper level undergraduate and beginning graduate students. It will do very nicely as an introduction to the various aspects of organic geochemistry. The book does not, however, have the space to go very deeply into any one topic. Students are likely to find the superficiality of most sections unsatisfying, and so it will be the job of their instructor to flesh out the various topics. The brevity of these sections does not mean that their material is unsophisticated. On the contrary, the level of the discussions is on a rather high plane. In a sense, the book serves as a outline from which excursions into some of the details of selected topics can be made. This means that the book should work very well as a textbook for an instructor knowledgeable in organic geochemistry, but it would be less useful to someone who wishes to learn independently about the subject.

I did much of my reading of this book while on my way to and from the International Meeting on Organic Geochemistry in Norway, and it was at this meeting that I discovered an example of the type of readers who will find the book especially useful. I noticed three graduate students paging through a copy in the lobby of my hotel. When I asked them what they thought of the book, they enthusiastically shared with me that it was just what they needed for brief explanations of some of the organic geochemical principles and concepts that they had encountered for the first time at the meeting. They clearly liked the book.

My attitude about *An Introduction to Organic Geochemistry* changed dramatically as I read through it. When I first picked up the book, I was skeptical that its length—about 250 pages—could satisfactorily reflect the breadth and fascination of organic geochemistry. My skepticism was compounded by the fact that the authors are not mainstream organic geochemists. I expected to find much to criticize, and so I began looking for important topics that had not been included, poorly interpreted material, and outright mistakes. I actually found a few flaws, but they are minor and not worth mentioning. As I continued my critical reading of the book, I became progressively more impressed by its coverage, the clarity of its explanations, and its accuracy. As an example of the latter, the book correctly shows the double-bond configuration of the C_{37} methyl ketones as *trans* and not as the often commonly assumed *cis*, which is typical of most biolipids. As another example, the discussion of pristane/phytane ratios includes both the classic and often too literally taken anoxic-oxic interpretation and the more complicated interpretations involving multiple origins and diagenetic effects that have subsequently become recognized. I had no choice but to be converted from a skeptic to a fan of this book!

There exists a number of excellent books which deal with the petroleum applications of organic geochemistry, and this book has neither the technical detail nor the relatively narrow focus of those more specialized books. Instead, it has a much broader coverage which reflects the continuing growth of organic geochemistry from its strong roots in the oil patch to areas such as paleoclimate reconstructions, environmental issues, and even molecular archeology. As a consequence, the book contains brief discussions of the current state of knowledge about topics that don't show up in petroleum geochemistry books. Some examples are amino acid geochemistry, porphyrin geochemistry, humic substances, and anthropogenic organic compounds. These discussions help convey to students some idea of the important contributions that organic geochemistry can make to a wide range of fundamental and practical earth science problems and particularly to the study of past and present environments.

The Killops have created an important book that is indeed an integrated and comprehensive summary of the subject. I have personally found it useful in refreshing my grasp of subjects distant from my research areas, and I intend to use this book as a text for my students.

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Thermodynamics in Geochemistry: The Equilibrium Model by Greg M. Anderson and David A. Crerar. Oxford University Press, 1993, xx + 588 p., US $75.00 (ISBN 0-19-506464-X).

AS A STUDENT, I found chemical thermodynamics to be a totally opaque subject. As a geochemist, I find that chemical thermodynamics is a beautiful theoretical structure and an indispensable practical tool. How can such a dichotomy exist? I believe that it is because chemical thermodynamics is too elegant. The concept of temperature and three simple laws are parlayed into a mathematical structure that applies to a boundless set of natural phenomena. This is made possible by subtle formulations of the laws that create extraordinarily general results. This combination of subtlety and generality frustrates the novice and dazzles the veteran. *Thermodynamics in Geochemistry* offers insight for both. The book develops the mathematical basis for nearly all the important thermodynamic relationships used by geochemists. The primary objective of the book is to derive thermodynamic expressions in their ideal model form. Then the authors show how various conventions, nonthermodynamic models, and other tricks are used to make this theory congruent with observations and measurements.

The book has three general sections. The mathematical fundamentals and their application to the three laws are treated in the first six chapters: Thermodynamics—a model subject, Mathematical background, Thermodynamic terms, The first law of thermodynamics, The second law of thermodynamics, and Statistical interpretation of entropy. These chapters include careful definitions of terms such as equation of state, adiabatic equilibrium, virtual process, local equilibrium, and degrees of freedom. The mathematical background chapter is a handy supplement in case this book is used as a textbook. The next seven chapters—Thermodynamic properties of simple systems, Application to simple systems, Partial and apparent molar properties, Ideal solutions, Fugacity and activity, Standard states, and The equilibrium constant—set up the concept of chemical equilibrium and examine it from numerous theoretical standpoints. The detailed discussion of standard states in chapter 12 is an exceptional contribution to this often confusing, but essential topic. The final six chapters—Heterogeneous and open systems, Solid solutions, Gaseous solutions, Aqueous electrolyte solutions, Redox systems, and Speciation calculations—connect the mathematical models from the previous chapters to the computational techniques commonly used by geochemists.

This is a book that every geochemist will want to own. It is well written and provides a nearly complete coverage of geochemical thermodynamics. Its rigorous mathematical development, careful attention to definitions (especially of standard states), extensive analysis of various cases (for example, appendix B treats the extrapolation of ΔG_r°, ΔS°, ΔH_r°, and ln K assuming $\Delta C_p = 0$, ΔC_p = constant, and $\Delta C_p = f(T)$), and explanation of the common conventions used by geochemists (e.g., for free energy, the Benson-Helgeson convention, the Berman-Brown convention, and the formation from the oxides convention) make it an indispensable reference book for the professional. These same features make it equally desirable as a textbook.

Thermodynamics is one of the sharpest instruments in the geochemist's tool kit. Many geochemical processes can be explained using models built with thermodynamic tools. Because of this, geochemistry students are subjected to an endless series of courses that teach thermodynamic theory and techniques. Many of these courses are taught using textbooks designed for chemists and/or from an amalgamation of papers drawn from the literature. This book, and the book by NORDSTROM and MUNOZ (1986) offer an effective alternative to this approach. The book by Nordstrom and Munoz contains less mathematical development and more emphasis on geochemical application. I would prefer to use it in a first course on geochemical thermodynamics. The book by Anderson and Crerar develops the mathematical basis of thermodynamics in a rigorous way; it is an excellent textbook for a subsequent graduate-level course. Not only do these books document the importance of thermodynamics as a tool of geochemists, but they celebrate the important practical and theoretical contributions that geochemists have made to the field of chemical thermodynamics.

REFERENCE

NORDSTROM D. K. and MUNOZ J. L. (1986) *Geochemical Thermodynamics.* Blackwell Scientific Publications.

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