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BOOK REVIEWS

The Fundamentals of Mineralogy. By Andrei G. Bulakh. St. Petersburg University Press, St. Petersburg, Russia, 1999, 356 p. US$30 (shipping and handling extra), softbound (ISBN 5–288–01757–3) (in Russian). Available from: A.G. Bulakh, bulakh@ab5062.spb.edu.

The Fundamentals of Mineralogy is a rightful successor of the textbook *Mineralogy with Essentials of Crystallography*, the first edition of which was published in 1989. The first and subsequent editions have "survived" through many generations of students, evolving into what can be considered one of the most comprehensive, yet concise mineralogy texts for undergraduates. Although the book retains the structure adopted in the previous editions, many important amendments have been made in the sections exploring the practical aspects of our science, *i.e.* applied, environmental, technological and biological mineralogy. The number of drawings and diagrams has been increased from 138 to 253 (!), with the number of tables now totaling 78 (including the Appendices).

In a short prefatory note, the author explains to students the challenges they will be facing during this course, and encourages them not to lose enthusiasm in their quest for mineralogical erudition. In a spirit of many "classical" texts, including *Manual of Mineralogy*, *The Fundamentals of Mineralogy* begins with a twelve-page introductory chapter defining a mineral and giving a retrospective on the evolution of human knowledge about minerals. Using simple, yet illustrative examples, the author demonstrates the intimate linkage between mineralogy and other disciplines, and shows how broad our contemporary perception of minerals is, emphasizing that the scope of mineralogy is not merely the study of minerals. Also in Chapter 1, the practical significance of mineralogy is neatly demonstrated with examples from everyday life, this section culminating with an impressive estimate that an average *Homo sapiens* consumes twenty-five railway cars of mineral resources throughout his or her lifetime.

Chapter 2, entitled *Crystal Structure and Chemical Composition of Minerals*, introduces students to the basics of crystallography and crystal chemistry, from the types of chemical bonds to the principles of close-packing of atoms, their coordination numbers, ionic radii and polymorphism. In the final section, the variation of the chemical composition of minerals is discussed with relation to the concept of isomorphism. I found particularly interesting the discussion of various genetic factors affecting the extent of solid solution in minerals in diverse geological environments.

Crystallographic topics are further explored in the next Chapter (*Symmetry and Crystal Forms*) concerned with structural defects, growth of crystals and their external symmetry. Interestingly, a tribute to Steno's Law comes only a few pages later, as a prelude to the discussion of real crystals in Chapter 4… and from a student's standpoint it does make perfect sense! This Chapter gives an excellent overview of diverse aggregates of crystals, including those that are often left out of the mineralogy course: oolites, concretions, geodes, framboids, *etc*. Chapter 4 is well illustrated with more than twenty line-drawings and several photographs of "split" crystals and druses.

Chapter 5 (*Physical Properties of Minerals*) begins with an introduction to the concepts of anisotropism, polarity, additivity, and then gives a comprehensive review of optical, cohesive, magnetic and major electric properties of minerals. This Chapter introduces students to several notions essential for the discussion of physical properties, but commonly omitted from the contemporary textbooks for the sake of brevity. These include reflectivity, microhardness and magnetic susceptibility, among others. Throughout Chapter 5, the author stresses the variability of physical characteristics across solid solutions, and those properties that would ease identification of minerals in hand specimen.

In Chapter 6, entitled *The Genesis of Minerals*, the author describes various types of mineral deposits. He groups them into five major series and 17 smaller subdivisions. Bulakh's classification is reasonably complete and easy to memorize. Many of the less-common types of deposit are characterized in sufficient detail further in the book, in relation to a particular mineral or mineral paragenesis (*e.g.*, kimberlites), or as an illustration to the discussion of practical applications of mineralogy in Chapter 22 (*e.g.*, metamorphic phosphate deposits). *The Genesis of Minerals* concludes with a discussion of typomorphism, *i.e.*, those paragenetic, morphological, textural and compositional features of minerals that may serve as indicators of the conditions of their crystallization. Appendix 1 (*Mineral Parageneses*), designed to assist students in their laboratory classes, contains 23 Tables listing characteristic rock-forming and accessory minerals for each of the mineral-deposit types from

Chapter 6. In most instances, these Tables also describe conspicuous textural features observed in hand specimen.

In Chapter 7, the author returns to the definition of a mineral, now stressing the significance of solid solutions, end-members and polymorphism for the purposes of mineral classification. In the following sections, the distribution of mineral species over different symmetry systems and chemical categories, and the principles of contemporary nomenclature of minerals, are discussed. This Chapter essentially serves as a prelude to the mineral descriptions given in Chapters 8 to 19. Most of these chapters begin with an introductory section describing relationships among minerals of that particular class, then provide a brief summary of their structural characteristics, morphology, physical properties and conditions of formation, and conclude with a description of individual mineral groups and species. In some Chapters, this order is slightly modified to discuss the crystal chemistry of each mineral group individually. The mineral descriptions are very concise; only the properties of diagnostic or practical value are normally listed. With the exception of native elements, most of crystal structures in this part of the book are presented in a mixed style incorporating both coordination polyhedra and spheres. I have found the majority of these drawings easy to understand and helpful for mnemonic reconstruction.

Chapter 20 (*Minerals in the Universe*) represents a seven-page collection of data on the occurrence and relative abundance of minerals and ices among the planets, their moons and in various types of meteorites (including some of the author's own estimates of the "modal" composition of the earth's crust). Chapter 20 further introduces students to the concept of metallogeny, and concludes with a journey into the Earth's mantle and core. Chapter 21, in contrast, explores the microcosm of minerals. The topics here extend from dimensional boundaries of "microminerals" to their peculiar physical properties, and to the principles of polysomatism. The last Chapter, entitled *Elements of Applied Mineralogy*, explores some traditional areas (indicator minerals and their significance for economic geology, mineral-processing technologies, mineralogy and materials science), as well as those areas that have been increasingly attracting researchers during the recent years, *i.e.*, environmental and biological mineralogy. *The Fundamentals of Mineralogy* concludes with a brief account of methods and instrumental techniques currently used.

As with any book, this one also has its flaws. Some readers will probably find (as I first did) that the selection of minerals chosen for the descriptive part not totally appropriate. For instance, there are descriptions of hemimorphite and lamprophyllite among the sorosilicates in Chapter 13, whereas the melilite-group minerals, although being relatively more common and of greater petrological significance, are not included even in comparative Table 34. Neither is ferrihydrite mentioned anywhere in the book, although it is a key component of many soils and an important Fe reservoir in biological systems. On the other hand, who among us can honestly confess to thinking about the petrological or environmental significance of minerals during that memorable second year at the university?.. The author clearly aimed at showing the Mineral Kingdom in all its diversity and marvel, the goal that he successfully achieved. There are very few actual errors in the book; for example, the name of naturally occurring $Al_2[C_6(COO)_6]\cdot 16H_2O$ on page 87 should be mellite. Then there are the incorrectly placed boundaries within the ternary pyrochlore diagram on page 188 [the field of betafite should start at approximately 33 at.% Ti: Hogarth, D.D. (1977), *Am. Mineral.* **62**, 403-410]. It is also unfortunate that the mediocre quality of printing had a serious negative impact on some of the half-tone illustrations.

In summary, *The Fundamentals of Mineralogy* clearly serves its purpose. Miraculously, the author managed to avoid overwhelmingly complicated definitions, classifications and mesmerizing multidimensional depictions of framework structures. The text is written briskly, using the language of humans, not scientists. Many of the line drawings combine artistic vision with an outstanding knowledge of mineralogy. The Tables are concise and informative (I do, however, miss Appendix 4 from the old edition listing Mineralogical and Geological Museums throughout the former Soviet Union).

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Fracture and Fracture Networks. Theory and Applications of Transport in Porous Media. By Pierre M. Adler and Jean-François Thovert. Kluwer Academic Publishers, Dordrecht, The Netherlands, 1999, 429 pages. US$213 (hardcover). (ISBN 0–7923 5647–0).

As the authors indicate in their introduction, the aim of this text is to show how it is possible to determine the macroscopic properties of individual fractures and fracture networks in rock systems. All rocks are fractured to some degree, at least in the upper 10-15 km of the crust, so this is pretty fundamental stuff! The topic has wide-ranging implications for fluid flow, with applications in hydrology (and the all-important domestic water supply), the petroleum industry, the mining industry and underground nuclear waste storage, to name but a few. Interestingly, neither of the authors is a geologist,

so they present a somewhat different approach to the subject. One of the authors (Pierre Adler) is in the Department of a Physics, the other (Jean-François Thovert) is in the Laboratoire de Combustion et de Détonique. Both are with divisions of the CNRS government agency in France.

The book consists of eight chapters. Aside from chapter 1, all require a solid understanding of mathematics; the text is not for the innumerate. As the authors indicate in connection with Chapter 3, "Familiarity with basic vector and tensor calculus is assumed...., as well as a basic knowledge of continuum mechanics." No consideration is given to the chemistry of fluids passing along fractures, nor how chemical reactions between fluids and fracture walls, and potential mineral precipitation, may influence fracture roughness and width through time. The work is essentially a theoretical text, with the emphasis on physical parameters.

The first chapter is an introduction, with definitions of the basic terms used (fractures, faults, fracture networks, porosity, permeability, percolation, scale analysis, *etc.*). The second deals with the generation and analysis of fracture networks, including a consideration of fractals, Fourier transforms, random variables and probability distribution. Chapter 3, titled Transport and Mechanical Properties, concerns conduction, convection, dispersion and mechanical deformation in fracture systems. Chapter 4 deals with the generation and characterization of a single fracture, as a precursor for fracture network appraisal in the subsequent chapters. Chapter 5 concerns the geometry of fracture networks, with the aim of describing the parameters necessary for predicting transport properties. The notion of "continuum percolation" is raised here, the spanning connected cluster of fractures that facilitate permeability. Chapter 6 addresses transport in single fractures, complemented by the consideration of transport in fracture networks in Chapter 7. The last chapter deals with coupled processes in a single fracture: essentially how geometrical changes (generally due to deformation) in the fracture system affects transport properties.

The writing style and use of words are not always appropriate. Given that the authors' first language is not English, this is forgivable, if not entirely satisfactory. This is something the publishers should have corrected at the proof-reading stage. For example, the plural of "transport" is often deployed, when it should be used in the singular. I cannot find the word "fracturation" in any dictionary; I think "fracturing" is what is meant. Overall, however, these relatively minor language problems do not detract from the essential science. Perhaps there could have been more consideration of host-rock properties, especially bulk permeability and how this relates to the fracture system. One would expect considerable variation between, for example, a highly permeable sandstone and a more massive granite with respect to fluid interactions with the fracture system. Fracture-network permeability can be tested by direct sampling and measurement (*via* coring, *etc.*), although there are the obvious scale-dependent difficulties that may be encountered (*e.g.*, serial slicing a cubic meter block of rock to determine its three-dimensional array of fractures is not an easy task!). However, there could have been more appreciation and use of real data on fractures, obtained from rocks, and tips on how to go about measuring and characterizing real fracture-networks in the field. This would have nicely complemented the authors' more theoretical approach.

This book is not for general consumption by geologists. It is a specialized text for researchers and practitioners concerned with fluid flow through rock. I suspect that the text will not be useful for undergraduates, except for those taking certain rock mechanics options, or hydrogeology–hydrology electives. However, it would be a useful book to have for an Environmental Geoscience or Geo-engineering degree program, as a supplement to a more general course text. At the graduate level, and beyond, it would be valuable to have in the library for those involved in fracture and fluid-flow studies. For the mineralogist, the text could provide some insight into how compounds and ionic species are transported through rock to precipitate as mineral vein systems. The quality of printing is generally good, though some of the diagrams are somewhat faint (*e.g.*, Fig. 2.14) or too dark (*e.g.*, Fig. 1.5). Although certainly a useful addition to an engineering or science library, the text is very expensive at US$213! If your institution's budget can take it, and there are researchers present who are interested in fluid flow in rock systems, I would recommend the purchase.

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