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BOOK REVIEWS

ULTRAHIGH-PRESSURE MINERALOGY: PHYSICS AND CHEMISTRY OF THE EARTH'S DEEP INTERIOR. Russell Hemley, Editor. Mineralogical Society of America Reviews in Mineralogy, 1998, Volume 37, 671 pages. Washington, D.C., $32 ($24 for MSA members).

Ultrahigh-Pressure Mineralogy: Physics and Chemistry of the Earth's Deep Interior is a wonderful book that Russell Hemley, as editor, and the contributing authors should look to with satisfaction. This book results from a three-day seminar course organized by Ho-kwang Mao and Hemley (both at the Geophysical Laboratory) and held at the University of California at Davis in December 1998. *Ultrahigh-Pressure Mineralogy* is broad in scope, drawing on expertise from an impressive and diverse group of 37 specialists, many of whom have institutional affiliations with the Center for High Pressure Research (CHiPR; representing the Mineral Physics Institute at Stony Brook, the Geophysical Laboratory, and the Thermochemistry Laboratory at the Univ. of California Davis). At least one author from the CHiPR group is included in 11 of the 19 chapters.

Ultrahigh-Pressure Mineralogy accomplishes its purpose—to summarize, in tutorial fashion, the current knowledge in three broad areas: (1) high-pressure experimental methods; (2) the effect of minerals in shaping properties of the Earth; and (3) fundamental material properties at high pressure. These three areas are described in the Preface and grouped as Sections I-III in the abridged Table of Contents on the back cover.

"Section I. Overview" is synonymous with *Chapter 1: New Windows on the Earth's Deep Interior* and authored by the seminar organizers. It contains interesting historical notes on high-pressure mineralogy (such as the often overlooked role of quartz in spurring high-pressure mineralogy studies) and provides a useful, readable, and almost complete overview of high-pressure techniques and applications.

"Section II. Minerals in Context: The Earth's Deep Interior" (Chapters 2–8) alone is worth the price of the book. The first two chapters of this section provide petrologic details for the top of the upper mantle. In the remaining chapters of Section II, the upper mantle, transition zone, lower mantle, core-mantle boundary, and core are examined in sequence. Highlights in these chapters include (1) analyses of the 410, 520, and 660 km discontinuities (Chapter 5); (2) seismic heterogeneity in the lower mantle (Chapter 6), (3) reasons for topography in the core-mantle boundary region (Chapter 7); and (4) seismic anisotropy in Earth's inner core and discrepant information obtained from theory and experiments (Chapter 8).

"Section III. Mineral Fundamentals: Physics and Chemistry" (Chapters 9–19) describes basic mineral properties at high pressure, discusses how these properties are determined, and points out their relevance to Earth's interior. Ten of the eleven chapters in Section III are based on experiments. *Chapter 19: Theory of Minerals at High Pressure* is the only theory chapter in the book, although *Chapter 8: The Earth's Core* includes an overview of theoretical methods. Topics included in Section III are crystal chemistry, thermodynamics, elemental partitioning, melting, equation of state, elasticity, rheology, Raman and infrared spectroscopy, and magnetic and electronic properties. Several chapters in this section include experimental details that complement the Chapter 1 discussion on experimental techniques.

Ultrahigh-Pressure Mineralogy is especially useful on two accounts. First, it applies a wealth of mineralogical information to large-scale questions about Earth's interior. This volume is, therefore, an excellent resource covering high-pressure experiments, physics of Earth's interior, and physical properties of minerals at high pressure (and in some cases high temperature). This book does not, however, contain detailed listings of physical properties for specific materials. Other volumes cited in the Preface are more appropriate for those details.

Second, *Ultrahigh-Pressure Mineralogy* is accessible. The informed non-specialist can readily become acquainted with current knowledge on a variety of topics. Each chapter begins with an Introduction that provides background information for the non-specialist and points out the importance of the chapter topic. In some cases, the Introductions are too general and repetitive, but overall, they are informative. At times, the Introduction spurs the reader on. In *Chapter 8: The Core-Mantle Boundary Region*, we see that the primary surface of the Earth is actually the core-mantle boundary; only the remoteness of this region has deflected our attention from it. Moving beyond the Introduction, the authors attempt to adhere to the tutorial philosophy of the volume, even as they discuss current research. Many chapters conclude with a section outlining future research directions.

There are a few organizational shortcomings with *Ultrahigh-Pressure Mineralogy*. The full Table of Contents omits the explicit grouping of chapters into three sections. The abridged contents on the back cover incorrectly place *Chapter 9: High-Pressure Crystal Chemistry* in Section II rather than Section III. There is no index for this volume, but the collections of references at the end of each chapter are useful.

The overview in Section I falls short in its treatment of shock-wave experiments. There is passing reference to shock studies on page 5 with a couple of citations and a brief mention of shock waves in setting primary standards on pages 13 and 14 with no citations. The value of shock studies for high-pressure calibration and very high pressure (terapascal) experiments is not reflected by the space allocated in Section I. An expanded discussion on shock waves does finally appear, however, in *Chapter 14: Pressure-Volume-Temperature Equations of State*.

Why was this volume named *Ultrahigh-Pressure Mineralogy* rather than "High-Pressure Mineralogy"? Ultra in the title implies specificity, but it refers to nothing in particular and is, therefore, confusing. Furthermore, any implicit boundary between ultrahigh- and high-pressure mineralogy is certainly crossed by the scope (100 km depth to Earth's inner core) of this book. We see in *Chapter 2: High Pressure Minerals from Deeply Subducted Metamorphic Rocks* that high pressure, ultrahigh pressure, and very high pressure all have specific meaning in petrology and metamorphic studies. In fact, Chapter 2 redefines the meanings of ultrahigh pressure and very high pressure as understood in petrology to avoid confusion with the rest of the book. Given the broad scope of this book, a more general title, one without ultra, would better fit the volume. This point is apparently endorsed by the authors since the term "high pressure," and not "ultrahigh pressure," appears throughout the chapter titles and subtitles.

Ultrahigh-Pressure Mineralogy presents an excellent summary of the physics and chemistry of Earth's interior and the role of mineralogy in understanding this hidden realm. A wealth of material is brought together in one place in a way that makes this volume a valuable resource for specialists and nonspecialists alike.

DONALD G. ISAAK
Institute for Geophysics and Planetary Physics,
University of California Los Angeles
Los Angeles, CA 90095-1567, U.S.A.
(also at Department of Mathematics and Physics,
Azusa Pacific University, Azusa, CA 91702, U.S.A.)

THE NATURE OF DIAMONDS Edited by George E. Harlow, Cambridge University Press in association with American Museum of Natural History (1998) Hard cover $74.95, soft cover $29.95, 278 p.

From "old four legs," the *coelacanth* once thought to be extinct, to sub-Saharan dioramas of early man on the Savannah, we saw them all in museums that were a must on our adventurous holidays while growing up in Africa. And there were displays of the epic discovery of diamonds, the history of consolidation, and chronicles of events that later fueled the mining of gold and altered the continent forever. Spectacular, and they left indelible impressions. But everything was always dusty, red, and oxidized, and so were the custodians on occasion. Moving to London and college in the 1960s, museums were our extended laboratories, but the dust persisted, only there it was darker and more reduced.

Happily, all that has changed and George Harlow's book is a fine example of the new direction that museums have taken in their outreach programs of education. His creation of "The Nature of Diamonds," held at the American Museum of Natural History in New York City in 1997–1998, was a *tour de force* in quality, diversity, and harder than hard currency. What is diamond? The science was presented at just the right level and with innovation: not an easy task when it comes to covalent bonding; electrical resistance is somewhat easier; and it would be impossible not to have understood the interactive exhibit demonstrating that diamond has a high thermal conductivity, so large that it is six times greater than copper. Refraction and reflection raised appreciative "oohs" and "aahs" but with a seemingly genuine understanding among the onlookers. This flowed smoothly into exhibits of kimberlites and mantle xenoliths, and models for the origin of diamond; and there were diamonds everywhere but only to whet the palate for what was to come. The canary-yellow cushion-cut Tiffany (128.5 ct) was stunning; the 407.8 ct Incomparable is just that, and to boot is the third largest cut stone in the world; the exquisite D-flawless emerald-cut Armstrong weighed in at a modest 14.1 ct but with incredible brilliance; and on it went. A history of the adornment of diamond was tastefully done in a selection of classic oil paintings, and no exhibit for the sake of completeness could possibly omit a rendering of "Diamonds are a (scientist's) best friend," or the star of admiration that Richard Burton held for Liz Taylor.

One was drawn into a dome that took the observation of a mantra to appreciate the walk-in safe; and there it was, the *piece de resistance,* the sable-skirted crown of Peter the Great, studded in diamonds, rubies, emeralds, and topped by a magnificent uncut red spinel (most pleasing); and permissible dust from the Kremlin museum.

George Harlow's book follows the exhibit as outlined, and without being there is a wonderful record of its spectacular displays. But in many ways the volume is richer because it can be quietly savored and revisited. It has lavishly colored diagrams, paintings, and photographs on good quality paper, with sidebars, bibliographies, and cross-references. There is something for everyone: basic and not so basic mineralogy, touches of optical and high pressure physics, chemistry and geology, lapidary, mining, and the many applications of diamond in industry, as windows for research instruments, and in supercomputers. It is these components as well as the history of diamond, the regal fascination, intrigue, myth, and the many references to diamond in classical literature that sets this book apart from others that cover some but not all of these topics.

Harlow wrote or co-authored five of the thirteen chapters and has provided an interesting introduction of gathering material as well as profiles of the other thirteen authors. It is a smooth read and well edited and with most enjoyable analogies: The compactness of carbon atoms in diamond is equated to distances from New York City to Niagara Falls (519 km) which on elastic rebound would form an octahedron about 5 cm wide (p. 6); and the pressure required to synthesize diamond is "the weight of the Eiffel Tower standing on a one-cent piece" (p. 259). Beautiful, but beware, graphite is softer not harder than talc (p. 10).

This is not a museum guide but a volume of distinction: suitable as a reference source; an ideal text for a semester-long seminar series that would have great appeal to science and nonscience majors alike; a prize to deserving students; a millennium gift (in lieu of the real stone); and it would not be out of place on a coffee-free coffee table. Diamond has the allure, Harlow has provided the instrument, and the American Museum of Natural History has produced an absolute bargain by any standard. In summary, this is a superb and highly recommended volume.

STEPHEN E. HAGGERTY
Department of Geosciences
University of Massachusetts
Amherst, Massachusetts 01002
E-mail haggerty@geo.umass.edu