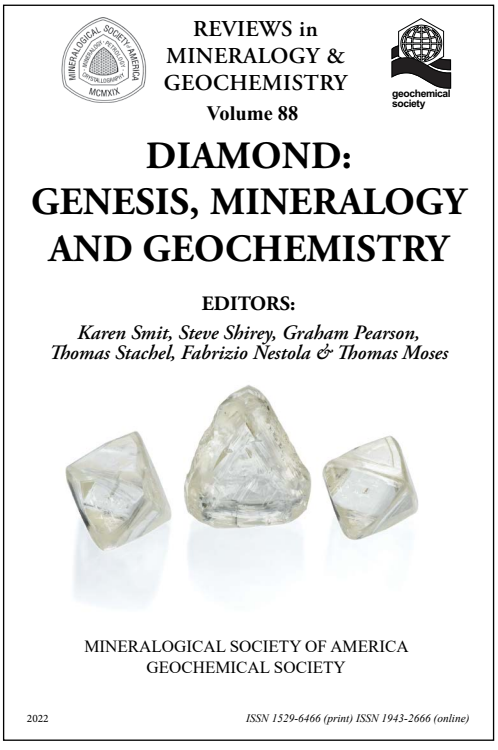
American Mineralogist, Volume 109, pages 1143–1144, 2024

Book Review

Book Review: RIMG Volume 88: Diamond: Genesis, Mineralogy and Geochemistry (2022) By Karen Smit, Steve Shirey, Graham Pearson, Thomas Stachel, Fabrizo Nestola and Thomas Moses, editors. Mineralogical Society of America/ Geochemical Society. ISBN 978-1-946850-10-2, i-xvi + 876 p. (25% discount for MSA, CMS and GS members, except shipping). https://pubs.geoscienceworld.org/rimg/issue/88/1 (Open Access)



I propose that there is no mineral with so much salience to geoscience, technology, society, and bling as diamond. Its combination of superlative properties—hardness 10, resistance to both chemical reactions and abrasion, high thermal conductivity, transparency, high refractive index, high dispersion, great metastability—and principal origin in and peerless sampler of deep Earth make it so important. This combination of properties has made extraordinarily detailed research possible with the help of the diamond marketplace.

As the authors state, it is amazing it has taken 50 years of RIM and RIMG volumes for one to be assembled on Diamond. So, it is about time! To the point though, advancements in research technology and consistent interest in diamonds have made it appropriate for a volume now. As the editors suggest "The delay has been worth the wait." The physical volume weighs in at 2.25 lbs. (1.02 kg), extends to 875 pages, uses condensed font, and has little blank space. There are 15 chapters, all rich in figures, maps, tables, and detail, appropriate for a review volume. The starting and longest chapter on diamond deposits has numerous maps, including fold-out ones (for the first time in my memory). Both primary and secondary deposits of all ages are considered. I was gratified to see the current interpretation of the early-discovered Kalimantan deposits of Borneo, Indonesia. For many years these deposits were under-reported and a mystery. So the new interpretation is good to find here.

Moving on to morphology, the next chapter presents the perfect octahedron, then cubo-octahedron and onto cube, cuboid, macle (spinel twin), and resorbed shapes from trisoctahedron and dodecahedron to rice grains. Next are the so-important internal features like inclusions (and their morphologies) and growth/zoning textures. Chapter three, "Polycrystalline diamonds from kimberlites," presents composites such as diamond intergrowths and "diamondite" (diamond rock). Other diamond oddities like carbonado, fibrous diamond, and ballas are also described in this chapter. Ultrahigh-pressure (UHP) diamonds and their sources (e.g., Kokchetav, N. Qaidam, and Erzgebirge) and the more controversial/challenging ophiolite-and volcanic-hosted diamonds are presented in considerable detail, plus the problem of contamination of samples from processing.

Two chapters address non-destructive examination of inclusions in diamond, first, by X-ray diffraction using both laboratory and synchrotron radiation and, second, by Raman spectroscopy. Single-crystal X-ray diffraction methodologies permit crystallographic information on diamond inclusions, whether single crystals or aggregates, without needing to expose or extract the inclusions. Raman spectroscopy also enables phase identification and thermobarometric assessment. Although Raman is easier to perform, challenges to data collection (e.g., fluorescence of the laser light and fewer established standards) can make interpretation a challenge. Improvements in Raman spectroscopy are likely to make it ever more important for inclusion research.

The chapter on mineral inclusions in lithospheric diamonds, the second longest, reports the progress on identifying and interpreting the significance of mineral inclusions

0003-004X/24/0006–1143$05.00/DOI: https://doi.org/10.2138/am-2024-B109612

in diamonds, which is considered key to understanding the petrologic evolution and processes of the deep lithosphere. Specific minerals and mineral assemblages (e.g., peridotitic and eclogitic, plus "gels" and fluids, which have gained the most attention recently) are presented here in great detail. The discussion considers the role and dynamics of plate tectonics to the structure of the lithosphere.

The chapter "Geochemistry of Silicate and Oxide Inclusions in Sublithospheric Diamonds" goes beyond phase identification and reviews this topic of intense interest, particularly in how the geochemistry of these inclusions reveals concrete evidence about the deep mantle and answers questions about Earth's structure and composition. It is appropriate to quote, "Here we review the mineralogy, major and trace element geochemistry of key silicate and oxide mineral inclusions in sublithospheric diamonds from global data sets assembled from the literature." Although this is the meat and potatoes of current research, it requires the rarest of diamonds containing inclusions.

"Fluid Inclusions in Fibrous Diamonds" focuses on the evidence and data from inclusions interpreted as having been fluid at the time of capture with the most attention given to so-called "high-density fluids (HDFs)." Fibrous growths (overgrowths) on diamonds yield the preponderance of results as is evident from the title. The different types of HDFs are defined from carbonatitic melt types to various C-O-H fluids.

The *P* and *T* conditions where diamonds grow are of fundamental concern, as described in the chapter on the subject. Thermobarometry of inclusions and host rocks (if preserved) is complicated by inconsistencies in the various thermobarometers and the relationship of the inclusion to the diamond—much older or not. These issues are addressed in detail.

Determining the age of a diamond, important both for geoscience and industry, is a challenge because diamond does not incorporate radiogenic elements in its structure. Thus, diamond inclusions or the host rock must be dated. Not all inclusions will yield dates or even self-consistent dates, and the possibility that inclusions crystallized (and closed) prior to diamond crystallization must be considered. The same is true for the host rock, the eruptive host (e.g., kimberlite), or the xenolith in which a diamond is extracted. This chapter explores the complexities of these issues in depth. The chapter goes on to examine how these ages are integrated into the age of continental lithosphere roots, deeper reservoirs in the mantle, and tectonic processes needed to form diamonds. The subject then comes back to closure, focusing on inclusions and their isolation within the diamond. Sulfide and silicate inclusions yield ages, but issues of gas loss (Ar and He) via diffusion or other mechanisms play a role in the conundrum. Constraining the timing of processes involved in diamond formation is of critical importance to understanding Earth's evolution.

The chapter on diamond spectroscopy features an excellent primer on spectroscopy as well as presents a fount of information on the various defects found in diamonds that lead to properties such as color. It also addresses the use of spectroscopy to recognize synthetic diamonds and the treatments used to enhance or minimize color, an important issue to the gem industry.

Diamond synthesis has been of interest since the mineral was determined to be a natural allotrope of carbon. I was a bit surprised that the accomplishment of diamond synthesis by light-bulb manufacturing companies was not pointed out; after all, the tungsten used in incandescent light bulbs is so hard that dies made of diamond are necessary. Nonetheless, the section addresses both the history and technologies employed to synthesize diamond, whether for science, industry, or gems.

A chapter on experimental petrology related to diamond formation naturally follows the synthesis chapter. There are many challenges to constraining or modeling conditions of natural diamond formation, in part because of the diversity of diamond origins. Consequently, the authors have provided extensive tables that summarize research contributions in this area.

A final chapter details natural diamonds from Earth's mantle as hosts and probes of N and C isotopic compositions, nitrogen concentrations, growth signatures, host associations, and mine/geographic source. The analysis represents a database of more than 5000 analyzed diamonds, which is an amazing resource. The discussion embraces the variety of Earth reservoirs and processes recorded by diamonds.

Each chapter concludes with a synopsis of where the topic is and what research is still needed to resolve outstanding issues. This demonstrates that each chapter was written by scientists active in research—the work is never done. Despite the incredible richness of this volume, there is still a lot of work to do and much to learn about this fascinating mineral.

RIMG 88 is open access with electronic versions of each chapter on the MSA website (msaweb.org). Despite this accessible format, I think the paper volume is worth owning. The size of this volume may be daunting to a "digital" audience, but reading the book while curled up with it is rewarding because of the well-written prose. There is no index, so the electronic version is valuable for searching and keeping notes. The density of each chapter means the maps and figures are small. So, the electronic version permits more detailed examination of these resources.

RIMG 88 is an amazing compilation representing a wealth of knowledge and a dedication to making it accessible to all.

George E. Harlow
Department of Earth and Planetary Sciences
American Museum of Natural History
New York, New York, U.S.A.