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AND GEOCHEMISTRY

Volume 88 2022

Diamond: Genesis, Mineralogy and Geochemistry

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COVER ILLUSTRATION

Rough diamond crystals from unspecified African mines. Left: 15.96 ct octahedron, Center: 22.32 ct macle, Right: 10.50 ct octahedron containing a visible orange-red garnet inclusion.

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Diamond: Genesis, Mineralogy and Geochemistry

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PREFACE

After more than 80 volumes of Reviews in Mineralogy and Geochemistry (RiMG), we now have a volume on diamond—*Diamond: Genesis, Mineralogy and Geochemistry*. Diamond is the record-setter in many mineralogical properties such as hardness, diffusivity, thermal conductivity, purity, and covalency of bonding. Similarly, diamond, as the premier gemstone of the mantle holds primacy for geological features such as age and depth of origin. Diamond was among the first crystalline structures to be solved by X-ray diffraction and the first materials measured for their Raman spectrum. The second issue of the multi-society journal Elements was devoted to diamonds. At more than 80 billion USD in yearly commercial value, diamond sets the record for the most traded, valuable mineral on the planet. Despite its chemical simplicity, diamond has been the object of more research effort, and had more scientific and popular press pages written about it, than any other mineral. How odd it is then that a RiMG volume on diamond took fifty years to be published! Here we address that shortcoming.

The late emergence of Volume 88 is perhaps like the emergence of a now-famous understudy in a Broadway show who used her time well to prepare for the real performance. After more than half a century, geologists now thoroughly understand many aspects of the mantle-convection-driven process of plate tectonics. This understanding is an essential backdrop to understanding how diamond forms because diamond is the only mantle gem to be directly created by plate tectonics, wherever its carbon has been derived. Over the same half century, many analytical techniques such as mass spectrometry (SIMS, TIMS, LA-ICP-MS), spectroscopy (Raman, IR), microanalysis and sampling (EPMA, STXM, TEM, FIB, XRD) have developed such improved sensitivity and spatial resolution that they now can handle the purity and minute lattice imperfections in diamond and allow the study of its very tiny mineral and fluid inclusions. Similarly, advances in the size, depth, and pressure attainable by experimental apparatus such as piston cylinder, multi-anvil and diamond anvil presses have reproduced and mapped the stability of the mineral inclusions trapped in the diamond structure to reveal the P,T conditions of diamond formation and to allow stringent constraints to be placed on the mineralogy of the mantle host rocks.

The delay has been worth the wait. Through diamond study, we now have a way to see directly and to great depths, the plate tectonic-driven recycling processes, now and in the past, of the most dynamic and active rocky planet in the solar system, our own Earth. We now can evaluate the physical and chemical effects of Earth's geodynamics with the deepest samples available: diamond and its mineral and fluid cargo. Diamond played a central role in the recent decade-long exploration of the deep carbon geochemical cycle by the Deep Carbon Observatory (cf. Hazen et al. Carbon in Earth and Orcutt et al. Deep Carbon). The minerals contained in these rarest, deepest diamonds are among the most special samples we have on Earth. Like lunar rocks and soils, like unique meteorites, like samples returned from comet flybys, or asteroid landers — they are messengers from another time and place that we are not going to get by any other means. Science simply demands that we study them to understand the inner workings of our planet.

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Over time, the interior of a planet controls everything: its exterior, its surface features, its geochemical cycles, its atmosphere, its hydrosphere, and its habitability. Earth is the only template we have for direct study of the relationship between the solid mantle/crust and the hydrosphere/atmosphere of a rocky exoplanet. If we want to understand how the atmosphere evolved or life began we have to understand Earth's interior better. Earth is the only place where, now and in the near future, we will be able to obtain enough samples and enough measurements to understand how interior dynamics couple with surface properties. If, for example, we can find unique connections between plate tectonics and certain characteristics of the atmosphere, then we might be able to use exoplanet atmospheric observations to infer something about the solid exoplanet. But this will be impossible to do the other way around.

The purpose and goal of this new volume is to assemble all the chief current knowledge about natural diamond in one body for the use of the Earth Science community. The contents of this volume are wide-ranging with the goal to leave little out so that any scientist could reach for this volume to obtain as much basic diamond knowledge as necessary. RiMG volumes have always served this role. An important feature of *Diamond: Genesis, Mineralogy and Geochemistry* is that the authors of several chapters used new and up-to-date databases that were expressly compiled for the purposes of accuracy in writing their chapters. These databases are available for community use at: https://dataverse.scholarsportal.info/dataverse/diamond.

The authors of this volume have had to work in times of unprecedented difficulties in collaboration due to the COVID-19 pandemic and yet they have managed, in all cases, to produce monumental works that are not only state-of-the-art reviews, but that set the scene for diamond research in the coming decades. We thank every contributor for overcoming these difficulties and collaborating to produce a truly comprehensive volume. Should anyone take on the task up up-dating this volume, in perhaps another 50 years, we truly hope that they will be able to do so in a pandemic-free world that more resembles the environment so conducive to research that we all desire.

Reviewers, beyond the editorial team, worked hard to improve the quality of these long chapters. Our thanks go to Mike Ashfold, Gerhard Brey, Ingrid Chinn, Phil Diggle, Wali Faryad, Yana Fedortchouk, Boris Feygelson, Andrea Giuliani, Jon Goss, Herman Grutter, Ben Harte, Peter Heaney, Juske Horita, Janne Koornneef, Konstantin Litasov, Volker Lorenz, Martin Kunz, Tania Marshall, Sami Mikhail, Tom McCandless, Oded Navon, Lutz Nasdala, George Read, Steve Richardson, Roberta Rudnick, Hans-Peter Schertl, Zachary Sharp, Evan Smith, Andrew Steele, Tatsuki Tsujimori, Daniel Twitchen, Fanus Viljoen, Michelle Wenz, and Dmitry Zedgenizov.

We are grateful to Ian Swainson and Rachel Russell for their patience and dedication to ensuring that the RiMG series remains a product of the highest quality. We thank the Deep Carbon Observatory for bringing the diamond community together at so many meetings, all facilitated by the Sloan Foundation, who part-financed the Open Access for this volume. Thank you also to the Geological Survey of Canada and the Gemological Institute of America who provided further Open Access funds for this volume.

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