

BOOK REVIEW

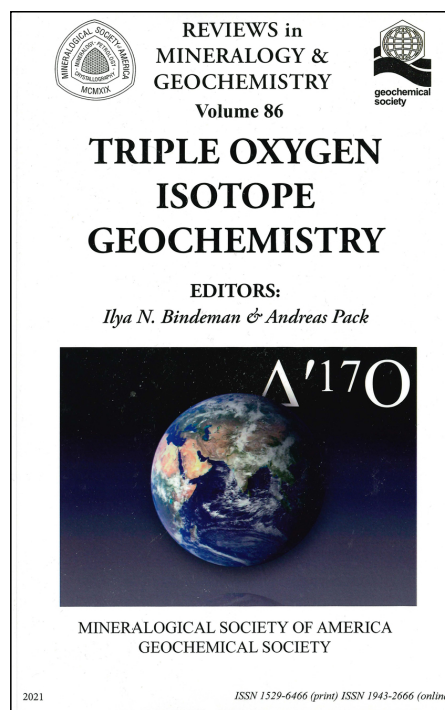
Book Review: Triple Oxygen Isotope Geochemistry. (2021)

Edited by Ilya N. Bindeman and Andreas Pack. Reviews in Mineralogy and Geochemistry, Volume 86. Mineralogical Society of America. ISBN 978-1-946850-06-5, i-xv1 + 496 pages. \$50.00.

Very often the volumes of the MSA Reviews In Mineralogy and Geochemistry series summarize knowledge of well-established geoscience research fields. RIMG 86 *Triple oxygen isotope geochemistry* is somewhat different in that it reports findings of a new and rapidly evolving area of stable isotope geochemistry: that is, the isotope geochemistry of the rare isotope ^{17}O . Readers interested in isotope geochemistry will be aware of the importance of the $^{18}\text{O}/^{16}\text{O}$ ratio across the breadth of the geosciences that includes its application to thermometric and hydrologic problems. But what about $^{17}\text{O}/^{16}\text{O}$ ratios? This is the theme of the book. For many years it was assumed that measurements of the $^{17}\text{O}/^{16}\text{O}$ ratio were not necessary, because its variations should track $^{18}\text{O}/^{16}\text{O}$ variations at about half the magnitude. Although this is generally correct, recent progress in mass spectrometry now permits the determination of very small variations of ^{17}O with high precision.

The editors, Ilya Bindeman and Andreas Pack, have been successful in bringing the leading experts in this exciting area of isotope geochemistry together in a most timely volume. The book is divided into 14 chapters written typically by two authors; three manuscripts are single authored, one is written by three, and another by four authors. The book excludes cosmochemical topics, but otherwise covers a large spectrum of topics in geochemistry concentrating on ^{17}O variations in the different domains of the Earth sciences. Examples range from calculations of theoretical $^{17}\text{O}/^{16}\text{O}$ fractionations using first principles density functional theory to the formation of Precambrian cherts, from continental climate reconstruction to interactions of atmospheric oxygen with rocks and minerals. Every chapter ends with an outlook for future research directions that together suggest that ^{17}O isotope geochemistry potentially has even more applications than investigated to date.

Triple oxygen isotope geochemistry can be divided into two broad themes: (1) the relatively large mass-independent ^{17}O variations (MIF) observed in the atmosphere and in meteorites, and (2) the small mass-dependent fractionations observed in all geological reservoirs. Maybe the greatest potential of ^{17}O analysis is the possibility it offers to distinguish between equilibrium and disequilibrium (kinetic) isotope effects in chemical sediments and metasomatic alteration products. Furthermore, ^{17}O geochemistry allows the reconstruction of conditions of primary formation of different geological materials, whether samples have preserved



their primary composition or have been diagenetically overprinted. This distinction may be used to constrain the long-standing problem of the O-isotope composition of paleo-ocean water, in particular that of the Precambrian ocean.

In Chapter 1, Miller and Pack present a historical perspective of the development of oxygen isotope measurements with the focus on ^{17}O . They introduce triple oxygen definitions and notations and give some Earth science applications of triple oxygen measurements.

Chapter 2 by Thiemens and Lin reviews the discovery of Mass-Independent Fractionation (MIF) effects and their relevance for the solar system. Mark Thiemens as one of the explorers of mass-independent fractionation effects is especially suited for writing this chapter. After discussing the basic theories of MIF, a new “Chemical Mechanism Model” is proposed to explain triple oxygen isotope fractionations in meteorites and the solar system.

Chapter 3 with the title “Climbing to the top of Mount Fuji: uniting theory and observations of oxygen triple systematics” by Yeung and Hayles discusses chemical models for triple oxygen isotope effects. The somewhat grandiloquent title suggests a successful voyage to complex theories in isotope chemistry

and summarizes what theory predicts for triple oxygen isotope variability in chemical processes.

Using first principles density functional theory, Schauble and Young in Chapter 4 calculate isotope equilibrium factors for a suite of common minerals and molecules. They show that the models used for the calculation of $^{18}\text{O}/^{16}\text{O}$ fractionation factors predict $^{17}\text{O}/^{16}\text{O}$ fractionations with similar accuracy.

In Chapter 5, Sharp and Wostbrock report internationally agreed standardization and correction factors of measured isotope ratios. Although not always regarded as being very exciting, standardization and correction factors are very important issues for ^{17}O determinations, since the errors induced by correction factors may be far larger than the measured differences themselves.

Brinjkji and Lyons review in Chapter 6 models for mass-independent isotope fractionations of oxygen in the lower atmosphere. They discuss O isotopes in the atmosphere below 100 km with a focus on ozone formation and its interaction with other oxygen-containing species. In the second part of their article, they present a model for the Earth's atmosphere above 100 km, where diffusive separation leads to strong depletions of ^{17}O and ^{18}O in atomic oxygen, the main oxygen component in the upper atmosphere.

The article by Pack in Chapter 7 describes the interactions of atmospheric elemental oxygen with rocks, minerals, and melts. The ^{17}O composition of the Earth's atmosphere is rather unique and can be used as a characteristic geochemical fingerprint. Pack summarizes evidence for interactions of atmospheric oxygen with small meteoritic fragments, the only samples older than one million years in which the composition of atmospheric oxygen can be reconstructed.

Bindeman considers in Chapter 8 the triple oxygen isotope evolution of clastic sediments and granites over the 4 Gyr evolution of the Earth and describes how ^{17}O analyses provide new insight into weathering conditions of the recent and ancient hydrosphere. A new ^{18}O time curve is presented for shales, which like those for carbonates and cherts exhibit a decrease in ^{18}O with age.

In Chapter 9, Herwartz describes ^{17}O variations in high-temperature rocks, which compared to their low-temperature counterparts are more difficult to resolve. He discusses the basic systematics of triple oxygen isotopes during water/rock interactions, giving particular attention to assimilation, dehydration, and decarbonation processes.

Zakharov, Marin-Carbone, Alleon, and Bindeman focus on the oxygen isotope composition of cherts in Chapter 10. They present unpublished data for selected Precambrian cherts that

combine bulk rock and in-situ ion microprobe measurements to determine exactly which chemical signals have been preserved in ancient cherts. The combination of high-resolution small-scale data and bulk rock data enabled the disentanglement of the signals from early and late generations of quartz.

Wostbrock and Sharp in Chapter 11 review low-temperature triple oxygen isotope fractionations in the silica-water and carbonate-water systems. Adding ^{17}O to the traditional ^{18}O determination allows the recognition and distinction of equilibrium and disequilibrium fractionation. Furthermore, ^{17}O analysis clearly indicates whether fossil carbonate organisms have preserved their primary depositional information. All samples investigated by the authors clearly indicate a diagenetic overprint.

Chapters 12 and 13 consider the triple oxygen isotope composition of water. In Chapter 12, Surma, Assonov, and Staubwasser summarize ^{17}O excess values of water worldwide and show that the temperature-independent ^{17}O parameter is a powerful tracer for estimating paleohumidity during evaporation of water bodies. Passey and Levin in Chapter 13 apply triple oxygen isotope to the study of water cycles in lakes, plants, and animals. Since leaf and body water have been affected by evaporation, ^{17}O compositions in plants and animals have a characteristic signature, that may be even traced in continental carbonates and biological apatites.

In the final chapter, Cao and Bao discuss the origin of small ^{17}O variations in low-temperature sulfate. The oxygen isotope composition of sulfate originates from multiple oxygen sources. Large mass-independent ^{17}O fractionations in sulfates may originate from interactions with stratospheric ozone. By examining the small, mass-dependent ^{17}O fractionations in rivers and lakes, the different pathways of sulfur cycling at present and in the geological past may be revealed.

Summarizing, this volume presents a well-balanced overview of the present state of the art of ^{17}O isotope geochemistry across the geosciences. The editors have to be congratulated providing a multi-authored book with articles that are cohesive and have little overlap. As ^{17}O geochemistry will continue to expand and evolve, more applications and new insight into long-standing geological problems can be expected. For students interested in and researchers investigating stable isotopes, the book is an absolute must.

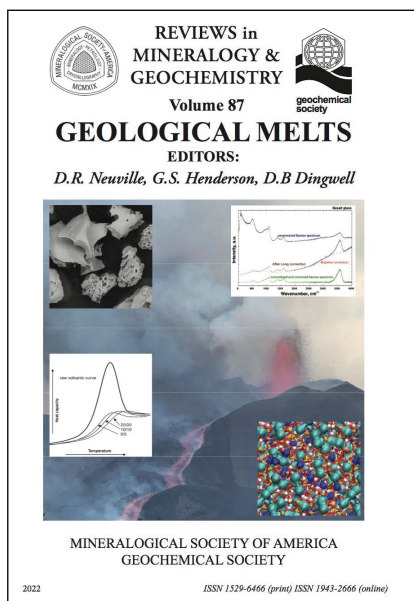
JOCHEN HOEFS
Geowissenschaftliches Zentrum
Universität Göttingen
D-37077 Göttingen
Germany

Announcement: Two *New* Reviews in Mineralogy & Geochemistry Volumes

The Mineralogical Society of America is delighted to announce the availability of two exciting new volumes in the *Reviews in Mineralogy & Geochemistry* series.

Volume 87: *Geological Melts*

Daniel R. Neuville, Grant S. Henderson, and Donald B. Dingwell, editors



From the preface to the volume:

Collected in this volume are a compact set of chapters covering fundamental aspects of the nature of silicate melts and the implications for the systems in which they participate, both technological and natural. The contents of this volume may perhaps best be summarized as structure–properties–dynamics. The volume contains syntheses of short and medium range order, structure-property relationships, and computation-based simulations of melt structure. It continues with analyses of the properties (mechanical, diffusive, thermochemical, redox, nucleation, rheological) of melts. The dynamic behavior of melts in magmatic and volcanic systems, is then treated in the context of their behavior in magma mixing, strain localization, frictional melting, magmatic fragmentation, and hot sintering. Finally, the non-magmatic, extraterrestrial and prehistoric roles of melt and glass are presented in their respective contexts.

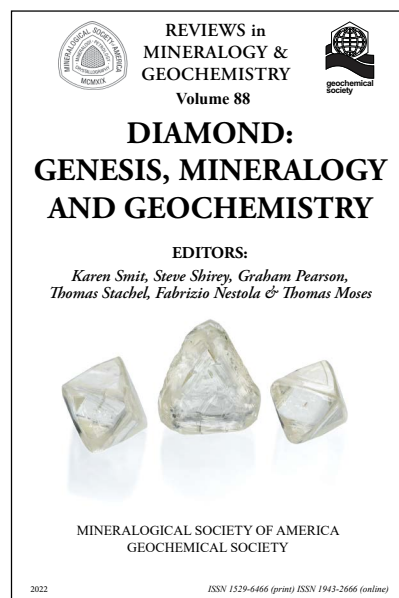
Volume 88: *Diamond: Genesis, Mineralogy and Geochemistry*

Karen Smit, Steven Shirey, Graham Pearson, Thomas Stachel, Fabrizio Nestola, and Thomas Moses, editors

This is an open access volume sponsored by the Gemological Institute of America, the Deep Carbon Observatory, and the Geological Survey of Canada.

From the preface to the volume:

*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>.*



MSA wishes to extend its thanks to the volumes' editors, authors, and sponsors, as well as Ian Swainson, Series Editor, and Rachel Russell, Managing Editor of *American Mineralogist*. Both volumes are available to purchase in hard copy from the MSA Bookstore: <https://msa.minsocam.org/publications.html>. For any questions, please contact the MSA Business office at business@minsocam.org.