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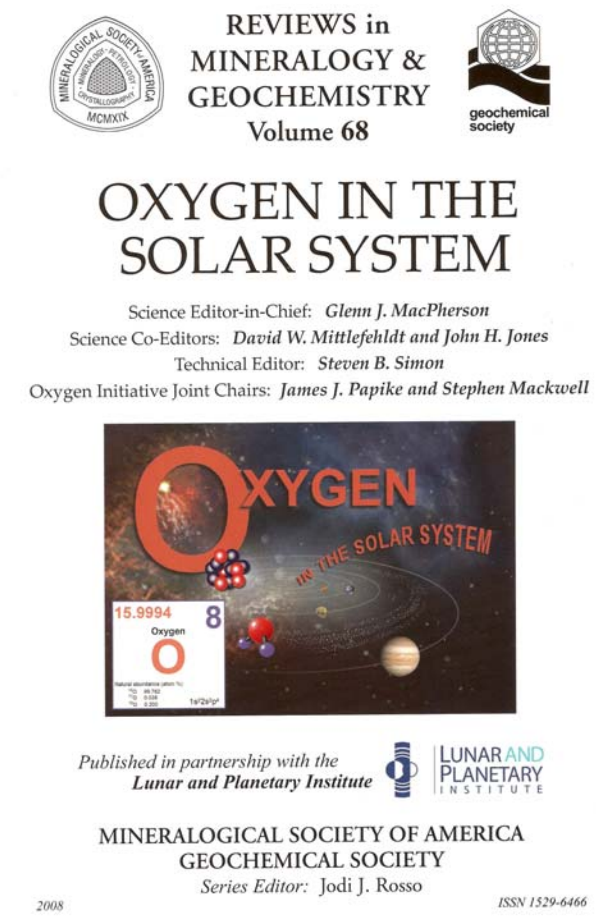
Book Review

Oxygen in the solar system, scientific editor in chief Glenn MacPherson. Reviews in Mineralogy and Geochemistry, vol. 68. Washington, D.C.: Mineralogical Society of America. 2008, 598 p., $40.00, paperback (ISBN 978-0-939950-80-5).

To cosmochemists, oxygen is arguably the most important element of the periodic table, and the person who first established this was Robert Clayton. Oxygen is the lightest element that has 3 stable isotopes, each produced by different nucleosynthetic processes. Oxygen also partitions into solids, liquids, and gases that coexist over a large range of temperatures, opening rich possibilities for isotopic fractionation during all the stages of the formation and evolution of solar system bodies. Clayton's breakthrough in the early 1970s (Clayton et al. 1973) was that he audaciously did not assume that the fractionation of $^{17}O/^{16}O$ would be half of the measured $^{18}O/^{16}O$ fractionation in meteoritic materials, as most previous researchers had done, but he decided to measure it. In doing so, Clayton, along with L. Grossman and T. Mayeda found that the graph of $^{17}O/^{16}O$ against $^{18}O/^{16}O$ becomes a map showing how the materials are related to each other and what processes might have occurred in the early solar system. Famously, high-temperature minerals from calcium-aluminum-rich inclusions (CAIs) in carbonaceous chondrites plot on a slope of almost unity, not a line of slope 0.5 as was expected. How this occurs and why the different solar system materials and bodies plot where they do on the oxygen isotope map is the subject of this book. Clayton himself is known here deservedly as "Mr. Oxygen" and this volume is dedicated to him.

Interpreting the oxygen isotope graph has always been a little contentious, but the field has been overturned in the last decade by the realization that the interpretation of the slope ~1 carbonaceous chondrite anhydrous mineral (CCAM) line as resulting from the injection of ^{16}O into the early solar system could not be correct. Two competing processes that can also give a slope 1 line, ultra-violet dissociation of carbon monoxide (Young et al. 2008) and isotopic symmetry-selective chemical effects (Thiemens and Heidenreich 1983) certainly both occur, but to what degree and which was responsible for the CCAM line? This book contains the distilled knowledge of three workshops that took place in 2004 and 2005, and now forms **the** textbook for oxygen, its role in planetary bodies, and the interpretation of its isotopic variations in solar system materials. No matter which is your area of solar system studies, you need this book.



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OXYGEN IN THE
SOLAR SYSTEM

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The book is comprised of 20 chapters written by most of the experts in the field. The historical review is written appropriately by Robert Clayton and is followed by clear introductions to oxygen isotope systematics; what all the funny jargon means—essential if as a graduate student you are just embarking on this scientific journey—then an excellent introduction to where and why oxygen is produced by nucleosynthesis. Then, perhaps a little unusually in meteoritical works, astronomical observations of oxygen in the universe are discussed and what we can learn from them. The real meat of where oxygen isotope variations are found in different meteoritical materials is covered extensively by Yurimoto et al. (2008) in the chapter Oxygen Isotopes of Chondritic Components. The remaining chapters move up in size scale to comets, asteroids, and planetary bodies and what oxygen can tell us about their formation, evolution, and inter-relationships, so there is something here for everyone.

I have purposely so far not mentioned one early chapter, Oxygen in the Sun (Davis et al. 2008), because this chapter in a sense demonstrates that this volume is not the last word, and might even be said to be premature. What is not known on the oxygen isotope map of the solar system is the "start here" point, i.e., where does the Sun plot on this diagram? Davis and co-authors discuss the state of knowledge that was current in about 2005 in which there was much ambiguity. They looked forward to the acquisition of oxygen isotope measurements of the solar wind returned by the Genesis spacecraft. But in this fast moving area, these measurements are appearing and very recent research (McKeegan et al. 2008) indicates that good numbers for the oxygen isotopic composition of the solar wind will be forthcoming very soon. Until now, it has usually been assumed that the Earth represents a reasonable zero point for what is "normal" for the oxygen isotope abundances in the solar system, but preliminary data from McKeegan's lab show that it is probably not the rare CAIs that are isotopically weird, but they in fact may be representative of the "bulk" stuff, the same as the Sun, and it is the Earth and other planets that are isotopically out of line with the Sun, although indeed this was anticipated by Clayton six years ago (Clayton 2002). How much of the "oxygen in the solar system" story will therefore need to be rewritten remains to be seen. When the Genesis results are established, accepted, and digested, another volume will probably be needed, but nevertheless another such comprehensive text book on such an important part of cosmochemistry is not likely to come about for at least several years, and this present volume is the best that there is going to be for the foreseeable future.

This volume is for everyone. It is an advanced reference text book, but it is also very accessible for graduate students and even has a summary tutorial on the categorization of meteorites at the end (Mittlefehldt 2008). So if you are an established researcher you need to buy it for your grad students and post-docs, or be prepared to lend it to them because you will need your own copy, too.

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