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Book Review

OXYGEN IN THE SOLAR SYSTEM, Glenn J. MacPherson, David W. Mittlefehldt, John H. Jones, Steven B. Simon, James J. Papike, and Stephen Mackwell, Editors. (2008) Reviews in Mineralogy and Geochemistry, vol. 68, 598 p. $40 (paper) $50 (hardcover) ISBN 978-0-939950-80-5. (http://www.minsocam.org/MSA/Rim/Rim68.html)

Oxygen is the third most abundant element in the universe, it occurs as an important component of all states of matter (gas, liquid, and solid), and it can bond with a multitude of elements across the periodic table. Because of its ubiquity and extraordinary chemical versatility, oxygen is one of the most fundamentally significant elements: it has a substantial control on the geochemical evolution of the entire Solar System. In addition, its three stable isotopes act as powerful tracers of a host of cosmochemical and geochemical processes. *Oxygen in the Solar System* is an exploration of the birth of the Solar System, as well as the geological evolution of rocky bodies within it, written from what may be described as an "oxygen-centric" perspective. Topics covered in this book include the origin of the Solar System from its parent molecular cloud; the earliest history of formation of the Sun and its protoplanetary disk; differences in isotopic reservoirs among the terrestrial planets, asteroids, and comets; the diversity of oxidation states in the interiors of the terrestrial planets; and cycling of materials through planetary interiors. Because oxygen is a central and significant player in this story, the emphasis on a single element does not by any means limit the perspective of the subjects discussed.

Oxygen in the Solar System is the culmination of the Oxygen Initiative, originally proposed by James Papike and Stephen Mackwell. The initiative consisted of a series of workshops: "Oxygen in the Terrestrial Planets" (2004), "Oxygen in Asteroids and Meteorites" (2005), and "Oxygen in the Earliest Solar System" (2005). The individual workshop themes necessarily overlap, and the resulting single-volume publication is a successful blend of these different topics. However, the book is not split like the workshops. Instead, it presents two significant overarching themes: oxygen isotopes and the redox states of planets.

Oxygen isotopes play a prominent role in our understanding of the origin and early evolution of the Solar System. *Oxygen in the Solar System* is appropriately dedicated to Robert Clayton, who has played a pivotal role in revealing the non-mass-dependent oxygen isotopic heterogeneities in solar system materials. Clayton's introductory chapter provides a historical perspective on the discovery and various interpretations of this effect. A sequence of chapters covering "Nucleosynthesis and the Chemical Evolution of Oxygen," "Oxygen in the Interstellar Medium," and "Oxygen in the Sun" sets the stage for interpreting oxygen isotopic measurements in extraterrestrial materials. Although oxygen is the focus of these chapters, each provides a broad context, sufficient to make each chapter an excellent general introduction to the individual subjects discussed. Several subsequent chapters provide valuable reviews of the extensive recent literature on oxygen isotope measurements of extraterrestrial materials, including "Oxygen Isotopes of Chondritic Components," "Oxygen in Comets and Interplanetary Dust Particles," and "Oxygen Isotopes in Asteroidal Materials." An in-depth discussion of how the primary diversity of oxygen isotopic compositions is currently interpreted is provided in "Mass-Independent Oxygen Isotope Variation in the Solar Nebula," and secondary processing is discussed in "Record of Low-Temperature Alteration in Asteroids." Authors of several chapters are clearly eager to learn the oxygen isotopic composition of the Sun that will be discovered from analysis of materials returned by the Genesis mission.

The redox states of the different meteorite groups and the terrestrial planets are a separate and equally fascinating subject. "Redox Conditions in the Solar Nebula" explores observational, experimental, and theoretical constraints that can be used to propose a model by which materials of different oxidation states can both form, and then accrete, to give different bodies in the inner solar system unique geochemical characteristics. The ways that these fundamental processes have subsequently controlled the geological evolution of asteroids and the terrestrial planets is discussed in the chapters, "Redox Conditions on Small Bodies, the Moon and Mars," "Basalts as Probes of Planetary Interior Redox State," and "Rheological Consequences of Redox State." One chapter bravely attempts to integrate the two separate themes of the book: "Oxygen Isotopic Composition and Chemical Correlations in Meteorites and the Terrestrial Planets" examines possible relationships between oxidation state and oxygen isotope heterogeneities in the early solar system.

The Earth is the planet we know most about! Chapters on "Terrestrial Oxygen Isotope Variations" and "The Oxygen Cycles of the Terrestrial Planets" discuss isotopic features that result from interactions between Earth's lithosphere, hydrosphere, and atmosphere, and the chemical and biogenic evolution of Earth's surface environment. These discussions prompt broader questions: how can we use our understanding of these processes on Earth to make inferences about other planets?

An additional strength of the book is its tutorial aspect. "Abundance, Notation and Fractionation of Light Stable Isotopes" is a most useful basic reference, as is the Appendix, "Meteorites—A Brief Tutorial," which serves as a succinct introduction to meteorites for the non-specialist. Also, "Oxygen and Asteroids" includes a fine overview of reflectance spectroscopy of asteroids. Inclusion of a chapter on "Oxygen and Other Volatiles in the Giant Planets and their Satellites" is a valuable contribution, broadening the perspective from that of (mainly) inner solar system, rocky materials.

Oxygen in the Solar System, with its emphasis on the behavior of a single element, provides a refreshingly unique perspective on the Solar System. It is not only valuable as a review volume describing current data and ideas, but also as an insightful discussion of the significant questions that we do not currently understand. The authors of every chapter have worked hard to address a unifying theme and the separate chapters are nicely integrated. Every chapter is well written, and the authors, the scientific editing team (led by Glenn MacPherson), and the technical editor, Steven Simon, have much to be proud of. The book will appeal to researchers and graduate students in the planetary sciences, who will find it an excellent resource and the source of much food for thought. It will also be a valuable reference for the terrestrial geochemist who is looking for an introduction to a broad range of topics in planetary sciences. *Oxygen in the Solar System* celebrates both oxygen and the Solar System in all their wonderful complexities.

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