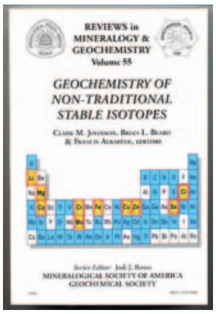
Geochemistry of Non-traditional Stable Isotopes[1]



The latest RIMG volume on the geochemistry of non-traditional stable isotopes is extremely timely, as was the related MSA short course at Spring AGU 2004 in Montréal. The editors, who were also the organizers of the short course, did an excellent job at choosing the structure of the volume; the order of the chapters is logical and there is a good mix of theory and discussion. This volume is an absolute must for anyone interested in these new isotope systematics as well as in geochemistry in general. The geochemistry of the non-traditional stable isotopes represents an important, but very new analytical and scientific field, and the book emphasizes the potential pitfalls. Clearly, as a community, we must be careful in how far we push the interpretation of the results produced to date.

Except for Chapter 2, which presents a necessary overview of isotopic anomalies in extraterrestrial material and their nucleosynthetic heritage, and part of Chapter 8, the volume focuses on mass-dependent fractionation of the isotopes of elements such as Mg, Fe, Cu, and Mo. As elegantly indicated in the foreword by O'Neil, no one until the last decade would have expected mass-dependent isotopic fractionation to occur in natural or laboratory systems for elements that are either heavy or engaged in bonds with a dominant ionic character. It took the development of new instrumentation like the MC–ICPMS, where the ICP allows the ionization of just about any element of the periodic table and the multi-collector allows the simultaneous measurement of the various isotopes, to precision in the per mil–100 ppm range and the resolution of some of the isotopic variations in elements including Fe, Mo, Cu or Si. This has opened up a series of new fields in geochemistry and applications in the study of environmental problems, as well as in some cases providing a new perspective on mantle processes.

The first four chapters review the basics, present essential theoretical and analytical background information, and provide an overall view of the field. The remaining chapters deal with element-specific studies. To broaden the volume's perspective, it might have been useful to include more non-North American authors and/or research groups. One could also question why there are two lengthy chapters on Fe isotope variations, albeit numbered Chapters 10A and 10B, both describing results from the same lab. Clearly, there is more interest and more data for Fe isotopes than for most of the elements considered in this volume. This could justify two chapters, but it would have been more interesting for the reader to be exposed to a different approach on Fe isotopes. Most of the nine chapters dealing with elements are actually not reviews and are somewhat descriptive. This reflects the fact that most of the work discussed in this volume was published within the last 3 or 4 years and also probably explains why the volume is lacking a general conclusion/perspective chapter – it is still too early to reflect.

Understanding mass-dependent fractionation for non-traditional stable isotopes also requires understanding of theoretical calculations; in this respect, the considerations presented in this volume are very useful and accessible. Chapter 3 is clear and absolutely fundamental. The major issues faced in this new field of geochemistry can be summarized as follows:

- Most of the measured isotopic fractionations are significantly smaller, but usually going into the right direction, than predicted from theoretical considerations; there is a need for more rigorous and well-defined experiments to establish the mechanisms responsible for fractionation;
- Analyzing samples, while having the merit of documenting natural variations, is unlikely to provide significant breakthroughs in understanding processes responsible for fractionation;
- Researchers in this field have to think in terms of processes and repeat them in the lab;
- More refined experimental data are needed to allow better modeling and theoretical calculations;
- Analytical precision, in the per mil or fraction of a per mil range, does not yet allow for the resolution of the fine structure of natural variations.

To significantly improve analytical precision with MC–ICPMS instruments, more development needs to be undertaken on the engineering side, especially to increase sensitivity and extraction capabilities. One of the biggest challenges in making high-precision isotope ratio measurements is to resolve mass-dependent isotopic fractionation produced in the laboratory (improved chemistry and close to 100% yield) and mass spectrometer from naturally occurring mass-dependent isotopic fractionation. The chapter devoted to analytical methods provides a good description and mathematical treatment of mass-dependent isotopic variations, while each individual chapter deals with more 'element specific' analytical issues.

In conclusion, if someone needed to start from scratch and work on a non-traditional stable isotope system, this volume fulfills all the needs because it provides a good perspective on the potential analytical pitfalls and shows that, even if quite a few tools are already available, more development work is still needed. This volume is a major contribution to the field and the editors should be congratulated for their excellent job in presenting us most of the facets of these new, exciting developments in geochemistry.

Dominique Weis and Jane Barling

Pacific Centre for Isotopic and Geochemical Research
University of British Columbia
6339 Stores Road, Vancouver, BC
V6T 1Z4, Canada

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