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Book Review

FRONTIERS IN GEOCHEMISTRY: CONTRIBUTIONS OF GEOCHEMISTRY TO THE STUDY OF THE EARTH by Russell S. Harmon and Andrew Parker, Editors. (2011) Wiley-Blackwell, paperback 280 pages. ISBN: 978-1-4051-9338-2

Over the last few decades, geochemistry has increasingly played a leading role in quantitative Earth sciences across an ever-broadening range of topics. Despite its immense impact, there are surprisingly few textbooks on the subject and their depth and scope varies widely. This book is an interesting addition arising from a symposium held in Norway in 2008 as a contribution to the International Year of Planet Earth. As the title suggests, the book is divided into two halves. The first is a set of brief reviews of a number of topics that have been of long-standing interest and research; the second half is a composite of introductions to newly emerging topics. This makes the book stand out from others on the topic, but the nature of the coverage may also mean that many readers will only be interested in certain chapters.

The book opens with a brilliant, witty, and sometimes castigating introduction by Ross Taylor that may, by itself justify purchase, to many! The next chapter by Kamber provides a necessarily, non-exhaustive review of the contribution of Pb isotopes, in particular, to our present understanding of the secular evolution of the Earth's mantle and lower crust. Although ocean island basalts are not discussed in great detail, the chapter demonstrates the need for a multistage Pb evolution model and how the lower crust rearranges itself to transfer heat-producing elements to the upper crust. The roles of oxidation, recycling, and possibly lamproites in trying to explain the first and second Pb paradoxes are also described in an accessible manner while acknowledging that a number of complications remain.

Hawkesworth, Kemp, Dhuime, and Storey provide an articulate update of how the isotope signatures preserved in zircon have been informing models for evolution of the upper crust, mainly in Australia. They argue that the crust has grown in a punctuated way over Earth history although the scope of the chapter means that exciting and controversial evidence from recent studies of ^{142}Nd is not discussed. Interestingly, they conclude that the lower crust has not been modified by removal of heat-producing elements and so the contrast between this and the inferences in the previous chapter highlight just one area of ongoing discussion in geochemistry.

Holland provides a largely historical review of the history of atmospheric oxygen. However, such reflections provide important and interesting insights into the progression of research areas in science and should be viewed as didactic by young researchers. The pivotal role of redox is emphasized along with the questionable role of the rise of plants in oxygenation of the atmosphere.

Hasse provides an overview of some aspects of the geochemistry of the oceanic crust but the amount of available information is really too vast for the breadth and depth of this topic to be satisfactorily addressed. However, it provides a good introduction as long as readers make the additional step of delving into the well-compiled and extensive list of references for details on specific aspects of oceanic crust genesis.

Gislason and Oelkers review the field of silicate weathering and the global carbon cycle stressing that the increase in weathering rates with temperature leads to negative feedback. They discuss two-stage CO_2 drawdown and equilibrium dissolution in rivers. Usefully, they outline the needs of future research to constrain clay mineral precipitation and basin-scale weathering and erosion rates (e.g., from cosmogenic and U-series isotopes) if we want to constrain the extent of global climate change due to anthropogenic effects.

Paces reviews the secular geochemical evolution of groundwater. He presents interesting summary diagrams that may be useful to highlight the complexities of groundwater systems although discussion of the constraints on transfer times available from ^{14}C measurements and U-series disequilibria are absent. Nevertheless, the discussion of dissolution rates provides a nice link to the previous chapter.

This half of the book ends with some perspectives from Hoefs on the contributions stable isotopes have made to geochemistry. Application to waters is highlighted forming a logical progression from the preceding three chapters. The distinction between mass-dependent and mass-independent fractionation is discussed for oxygen and sulfur. Interaction with the crust is shown to be critical for ore generation but some of the assumed knowledge may be beyond undergraduates. The chapter finishes with ideas about future directions and the potential of non-traditional stable isotopes and isotopologs.

The second half of the book "Frontiers" commences with a detailed discussion by Kharaka and Cole on the geological sequestration of CO_2. Most readers will be aware this is a potentially critical issue, but many may be unaware of the key phase equilibria involved and the various possible trapping mechanisms and their relative merits. Real industrial experiments are described with emphasis on detection of breakouts and leakage.

Bennett and Omelon outline the interdisciplinary aspects of the rapidly growing field of microbial geochemistry. After the alarming revelation that 1 mL of water can contain up to 10^9 microbes, they show that primary respiration pathways have the greatest impact on rock reaction allowing microbes to dig caves! From precipitation of calcite to form stromatolites, to biofilms and poisoning of the Bengal Fan, it is made clear that microbes are more highly involved in geochemistry than most readers would have realized.

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Nanogeochemistry is discussed by Wang, Gao, and Xu who describe the range of possible and current technical applications (e.g., for osmosis). They show that stability is size dependent and emphasize the importance of colloids. Thus, synthetic materials can be designed to effect the removal of toxins, like Hg and Pb, from H_2O and to undertake nuclear waster management.

Jartun and Ottesen outline the geochemical aspects of urban geochemistry concentrating on the poorly monitored way in which landfill moves environmental hazards (e.g., Pb) around our cities. Interestingly, soil pollution in city centers can be largely independent of industrial history. This chapter is a little overly emotive but provides an example of geochemical application that, while in its infancy, may become increasingly focused in the public eye.

The book ends with a chapter by Schwarcz on archaeological and anthropological applications. Although commonly concerned with age dating, this chapter also highlights the application of trace elements and hand-held spectrometers to the determination of the provenance of artifacts and the dietary niche of animals and humans. There is a pleasingly thorough coverage of available analytical techniques, and the use of C and N isotopes to constrain palaeoclimate is also briefly discussed.

Overall this book is an interesting, if somewhat eclectic, collection of chapters that will be of interest to anyone wanting to broaden their knowledge of the field of geochemistry. The book is nicely put together, although the order of chapters and their inter-linkage could have benefited from more consideration, and there is really no need for the color plates. Some chapters do not always make clear what we have learned and what we still need to be solved, and the depth and coverage is quite variable. Nevertheless, overall the book is very readable, and the reference list and the nice addition of "additional reading" lists at the end of the chapters will be very welcome to those that buy it.

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ERRATUM

Tobelite and NH_4^+-rich muscovite single crystals from Ordovician Armorican sandstones (Brittany, France): Structure and crystal chemistry by Ernesto Mesto, Fernando Scordari, Maria Lacalamita, and Emanuela Schingaro (vol. 97, p. 1460–1468, 2012: DOI: http://dx.doi.org/10.2138/am.2012.4023).

The authors provide corrected formulas for tobelite:

$[K_{0.18}Na_{0.01}(NH_4^+)_{0.62}]_{\Sigma=0.81}(Al_{1.98}Fe^{2+}_{0.02})_{\Sigma=2.00}(Si_{3.19}Al_{0.81})_{\Sigma=4.00}O_{10.00}(OH)_{2.00}$

and for NH_4^+-rich muscovite

$[K_{0.46}Na_{0.03}Ba_{0.01}(NH_4^+)_{0.36}]_{\Sigma=0.86}(Al_{1.98}Mg_{0.01}Fe^{2+}_{0.01}V^{3+}_{0.01})_{\Sigma=2.01}(Si_{3.13}Al_{0.87})_{\Sigma=4.00}O_{10.00}F_{0.08}(OH)_{1.92}$.