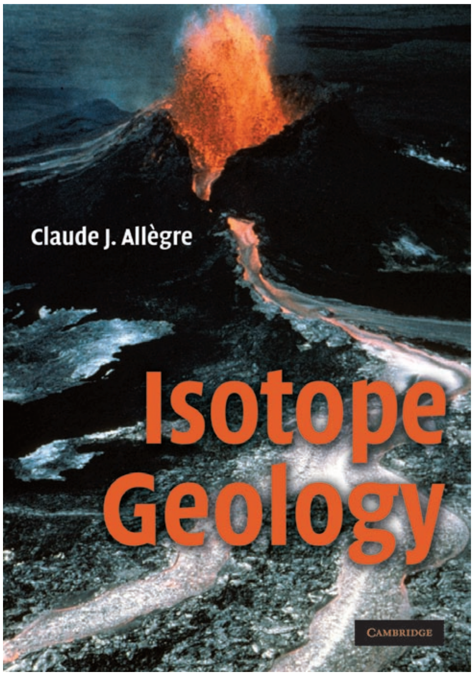
ISOTOPE GEOLOGY[1]

Unlike physics or chemistry, teaching isotope geochemistry is difficult because it is such an interdisciplinary and experiential field. Learning isotope geochemistry is also difficult, not because it is technically difficult, but because geochemistry requires the synthesis of many concepts and applications. Writing an effective book on geochemistry is thus even more difficult. Claude Allègre's *Isotope Geology* is a welcome addition to the collection of Earth science textbooks, joining the two classic isotope geochemistry books by Gunter Faure and Alan Dickin.

You might ask whether there's a need for a new isotope geochemistry book, given how effective the texts by Faure and Dickin are. However, Allègre's *Isotope Geology* is presented using a fundamentally different approach. While Faure's and Dickin's texts are presented in encyclopedic format, that is, each chapter is dedicated to a given isotope system and its applications, *Isotope Geology* has distinctly avoided this format. Instead, each of Allègre's chapters deals with an over-arching concept, wherein case studies of isotope systems illustrate the meaning or importance of the concept. For example, chapters 2 and 3 are titled "The Principles of Radioactive Dating" and "Radioactive Dating Methods," respectively. In these two chapters, Allègre lays out all the radioactive decay equations that one will ever need, providing simple examples from different isotope systems to illustrate their application. He even explains the concept of "fossil" isochrons (not explicitly treated in Faure and Dickin); while the fossil isochron concept is almost mathematically trivial, I have noticed that it is a difficult concept for students to grasp. In any case, if a student can master chapters 2 and 3, he/she should be poised to examine any radioactive system. Allègre is clearly of the philosophy that one's fundamentals must be sound.

I can rave about many other aspects of this book. The most striking is Allègre's amazing ability to articulate concepts through simple and elegant figures and prose. All figures have been redrafted and distilled down to their bare essentials. The text is succinct and to the point, and the layout avoids unnecessary clutter and confusion. Whether this was intentional or not, the end product is like a clear whistle in a thick fog. A testament to the elegant simplicity of the book is that I can even make sense of my copy of the original French version, even though my French reading abilities are horrible. Another highlight is that we get



to see a little bit of Allègre's own perspective. The text is punctuated by anecdotes that liven up the discussion and provide a personal connection with the reader. In some cases, Allègre relates the history of certain ideas or controversies, thus implying that science is a human endeavor marked by fits of brilliance as well as mistakes. Allègre lays out what is now known and what still has not been resolved, inspiring the inquisitive student to explore further.

A few other highlights are worth mentioning. Chapter 7 provides an up-to-date overview of the principles of stable isotope geochemistry, focusing first on fundamentals and then touching on specific examples in low- and high-temperature geochemistry. I was pleased to see discussions on the use of mass-independent fractionation as paleoenvironment records and of "clumped" isotopes in estimating temperature. Chapter 6, "Radiogenic Isotope Geochemistry," summarizes the application of radiogenic isotope tracers in understanding planetary differentiation, clearly one of Allègre's favorite topics. In the last chapter, "Isotope Geology and Dynamic Systems," Allègre provides a much-needed overview of box modeling and mass transport modeling. A student will come away with a sound understanding of residence and response times in geochemical systems. While such concepts are also considered in Albarède's *Introduction to Geochemical Modeling* and *Introduction to Geochemistry*, this is the first time that such a treatment is explicitly presented in an isotope geochemistry book. This is just another example of Allègre's process-based approach.

Since this is supposed to be a critical review, I should mention how *Isotope Geology* can be improved. Given the importance of concepts and fundamentals in this book, it would have been better to delve even deeper into certain themes. For example, there is only limited discussion about nuclear chemistry and physics. What controls the mass of nuclei? What are mass defects? Why are some nuclei unstable? How would one calculate the amount of energy released by radioactive decay? One homework problem asks for the total heat released by decay of a certain amount of a radioactive element. The reader is given the heat-production rate, but it would be nice to know how this number is determined. Another example concerns the chapter on stable isotope geochemistry. Although the equations for equilibrium and kinetic isotope fractionation are presented, Allègre could have elaborated on the physics of equilibrium isotope fractionation as they relate to bond strengths and energy wells, perhaps including some key concept figures. Finally, given the recent rush to study stable isotope fractionation of the heavy metals, I would have enjoyed more than just two pages of discussion on this topic.

I can't help pointing out one egregious error. This involves the story of Lord Kelvin and why he was wrong about the age of the Earth. The almost universally accepted story, the one presented by Allègre, is that Lord Kelvin did not take radioactivity into account in his heat-conduction equations. In fact, a simple calculation shows that accounting for radioactivity doesn't improve Kelvin's situation much. The real reason why Kelvin's estimate was wrong was because of a fundamental flaw in his model, that is, the Earth loses interior heat to the surface by convection, not by conduction. For a review of the correct version of the story, see a piece by England, Molnar, and Richter in *GSA Today* (2007).

In conclusion, Allègre's book represents a long-awaited contribution, which complements those by Faure and Dickin. Read Allègre's book first, then turn to Faure or Dickin for detailed examples of applications for a specific isotope system. Not only is this trio of books on my bookshelf, but I recommend the entire set to my students. This book is accessible to all, not just geochemists, but also geophysicists. Last, I much prefer the purple-laced Kandinsky cover of the original French edition, as it looks much prettier on my bookshelf.

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1 Allègre CJ (2008) *Isotope Geology*; translated by Christopher Sutcliffe. Cambridge University Press, Cambridge, ISBN 978-52186-228-8, 512 pages, $80

Isotope geology. Article Â· January 2008 with 66 Reads. How we measure 'reads'.Â Whole-rock geochemical and Srâ€"Ndâ€"Hf isotopic data and in situ zircon Uâ€"Pb and Hfâ€"O isotopes have been determined for mafic (gabbro and diorite) and felsic (I- and A-type granites) rocks from the Zhangzhou batholith in southeastern (SE) China, in order to constrain their source and petrogenesis. Isotope geochemistry Isotope geochemistry is an aspect of geology based upon study of the relative and absolute concentrations of the elements and their.Â Samarium-neodymium is an isotope system which can be utilised to provide a date as well as isotopic fingerprints of geological materials, and various other materials including archaeological finds (pots, ceramics). 147Sm decays to produce 143Nd with a half life of 1.06x1011 years.