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BOOK REVIEW

Nuclear Methods in Mineralogy and Geology, Techniques and Applications, edited by A. Vértes, S. Nagy, and K. Süvegh. Plenum Press, New York, 1998, 555 pages. [ISBN 0–306–45832-2, Price: $135.00 (US and Canada)/$162.00 (elsewhere)]

Since Faul's *Nuclear Geology* was published in 1954, books having both "nuclear" and "geology" in the title have been few. This book is apparently the first having both "nuclear" and "mineralogy" in the title. Its contents are testimony to remarkable advances in nuclear analytical technology since the mid-century, including techniques that are particularly important in mineralogy today but were new or were still unknown in 1954. This book encompasses *nuclear geophysics*, particularly as the field was represented for a time by a journal of that name, but its title emphasizes that nuclear analytical methods are applicable in geology much more broadly than the term "nuclear geophysics" might imply.

The nuclear methods addressed in this book are largely of two kinds. Several chapters are about analytical methods that depend on direct interactions with atomic nuclei—neutron activation analysis, prompt gamma-ray analysis, nuclear magnetic resonance (NMR) spectroscopy, and Mössbauer spectroscopy. Most of the other articles cover analytical methods that are nuclear methods in the sense that they involve instruments developed for and largely used in nuclear science—nuclear-radiation detectors and particle accelerators in particular (but there is virtually nothing on neutron detection and no mention of neutron diffraction). Ordinary mass spectrometry is not discussed, presumably because it has long since outgrown its origin in nuclear science, but two of the chapters deal with accelerator mass spectrometry. The editors expressed no explicit rationale for the choice of topics, but it is clear that they did not intend to provide broad coverage of *isotope geology*—those aspects of nuclear geology that depend primarily on mass spectrometric methods.

The first chapter, written by the editors and entitled "Basics of Nuclear Science," serves as an introduction to nuclear science, primarily for "students of earth sciences." It deals with nuclear structure and nuclear reactions in greater depth than has any other book on nuclear geology, and the authors have presupposed of the reader considerable knowledge of the mathematical methods of physics. This depth of treatment is appropriate to set the stage for those who would understand the physical basis for the nuclear analytical methods, particularly for NMR and Mössbauer spectroscopy. Sections on radioactivity, interactions of radiation with matter, and radiation detectors have information that is essential to understand most nuclear analytical methods and to understand natural nuclear processes. Given the level of sophistication of this introduction generally, I wonder why some important relationships were overlooked—the Bateman solutions of the decay-series equations, equations for energy of recoil from emission of relativistic particles and photons, the non-reactive interactions of neutrons with matter, and the interactions of fission fragments and recoil atoms with matter and the detection methods based on such interactions.

The final section of Chapter 1, "Variations of stable isotope ratios in nature," seems out of place and fails to deal adequately with those variations. Radiogenic stable isotopes are mentioned only in passing and the methods by which isotope ratios are determined are not mentioned all. Chapter 1 would have been better concluded with a brief overview of *all* aspects of nuclear geology that are not covered in this volume. Such an overview could have provided some perspective on the great importance of mass spectrometry in isotope geology and on the historical importance of such techniques as nuclear radiometry, neutron-neutron well logging, and nuclear track-detection methods.

Chapter 2, by M. Balla, G. Keömley, and Zs. Molnár, is about the techniques and geologic applications of neutron activation analysis (NAA). The chapter includes an introduction to trace-element geochemistry, which may be justified by the historical importance of NAA in trace-element geochemistry. However, to introduce such an important and complex subject in a relatively few pages would be a great challenge to the most careful of writers. In this case, the writing has not been done with enough care to inspire high confidence. Complementary to the chapter on NAA is "Nuclear Reaction Prompt Gamma-Ray Analysis," by G. L. Molnár and R. M. Lindstrom, a generally well-written chapter that concludes with a concise summary of geological applications of the technique. This shows clearly how advanced instrumentation makes it possible to overcome some of the limitations of ordinary NAA.

Chapter 4 by J. Bascó, Á. Pázsit, and A. Somogyi, "Energy Dispersive X-Ray Fluorescence Analysis," covers in considerable detail an analytical technique (EDXRFA) that is important but is arguably not a *nuclear* technique. Its presence in this volume can be justified by the great similarity of EDXRFA to nuclear techniques, with respect to signal detection and analysis, and by the occasional use of radionuclides for X-ray excitation. (The chapter is strictly about X-ray *fluorescence*; there is no discussion here or elsewhere in the book of X-rays generated by electron-beam instruments such as electron microprobes and scanning electron microscopes.) This chapter has no separate section on geological applications, but some are mentioned within the descriptions of various aspects of the technique. A complementary chapter by Sz. B. Török, K. W. Jones, and C. Tuniz includes well-written descriptions of analytical techniques based on high-energy photons (synchrotron radiation) and ion beams, including accelerator mass spectrometry (but not ion-probe mass spectrometry). This contribution is well-balanced between descriptions of important new techniques and their applications in geology. (We should perhaps forgive these nuclear scientists for labeling some Polish clay samples as "Fermian" rather than Permian.)

Chapter 6, by K. Tompa, is a rather brief (and thus quite challenging) introduction to NMR spectroscopy in the geosciences. After a description of experimental techniques, well-chosen examples illustrate the geoscience applications of NMR. I think Tompa did a good job of selecting the aspects of NMR to include in this volume. The chapter is short

enough not to be overwhelming; it serves as a good introduction to the subject, but it leaves no doubt that a person who wants to specialize in this area will need to find more thorough descriptions of NMR theory and techniques elsewhere.

Because I had long ago done some Mössbauer work on clays, I enjoyed reading "Geological and Mineralogical Applications of Mössbauer Spectroscopy" by E. Kuzmann, S. Nagy, A. Vértes, T. G. Weizburg, and V. K. Garg. Much has changed in thirty years. The chapter has fairly detailed descriptions of the Mössbauer effect and its special role in spectroscopy, but more than two-thirds of the chapter is devoted to applications of Mössbauer spectroscopy in mineralogy and geology. This part of the chapter is rather overwhelming because of its length, and the style *suggests* that the writers were attempting a thorough review of the applications. For example, there are a number of one-sentence paragraphs like, "Mössbauer investigations have also been performed on Mn-Fe nodules [87-90]." The review, however, is not thorough; for example, none of the many Mössbauer articles published in *Clays and Clay Minerals* are cited. For this volume, a smaller, critically selected set of application examples would be better.

Good, detailed, and well-illustrated descriptions of various techniques for measuring radiocarbon and tritium in groundwater, and a briefer description of ^{85}Kr measurement, are in Chapter 9, "Radiometric Methods for Dating Groundwater," by E. Hertelendi. There is no discussion of how tritium measurements are used, but there are several different models for interpretation of the abundance of radiocarbon in the dissolved inorganic-carbon component of groundwater. It is regrettable that these models are described without critical evaluation; there is no indication of how well such models actually work for dating groundwater.

There are two chapters by R. Bowen, "Radioactive Dating Methods" and "Isotopic Paleoclimatology." These topics are peripheral to the main theme of the book, so no harm would have been done if they had been omitted. The book would be a much better one without Bowen's contributions. There are many typographical errors in these chapters, there are numerous mistakes in equations, and there is a kind of malapropism in which an inappropriate technical word appears in place of an appropriate one of similar sound or appearance ("precision" for "precession," "volcanisation" for "volatilisation"). Much worse, these chapters are characterized by many errors of fact and misstatements of well-established scientific concepts, by mutually contradictory statements in some places, by abrupt changes in the train of thought, and by cases where reference citations are missing or are erroneous.

In "Radioactive Dating Methods," Bowen appears to have relied heavily on Faure's 1986 book, *Principles of Isotope Geology,* although he has not cited Faure's work. In contrast to Faure's book, however, mistakes in Bowen's chapter are so numerous that much of it is virtually worthless.

The chapters of this book vary widely in quality, both in respect to the expression of scientific concepts and in respect to other matters. There are misspelled words and other departures from standard English in every chapter. Graphs are sometimes mislabeled, are often of poor visual quality, and, in a few cases, do not show what they are purported to show. There is no excuse today for misspellings that a word processor could identify. Other misspellings and a host of additional problems should have been eliminated by a competent technical editor. In the better-written chapters, these shortcomings are no more than minor annoyances, but some chapters have substantial errors that make understanding difficult. Such difficulty would be greatest for the very readers for whom the book is primarily intended—students of the earth sciences who are not already knowledgeable of the matters addressed.

The editors intended this book to mark the centennial of the discovery of radioactivity. In my opinion, they have made a major contribution by bringing together a number of articles illustrating how recent advances in nuclear techniques have greatly expanded the range of applications of such techniques in geology and mineralogy. There are too many flaws for me to recommend this work as a textbook. If the currently flawed work were to be re-published without the articles by Bowen and by a publisher willing to see to a pre-publication review by a well-qualified technical editor, I should be able to recommend the work as an important complement to the available good books on isotope geology.

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