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BOOK REVIEWS

Spectroscopic Methods in Mineralogy and Materials Sciences. Grant S. Henderson, Daniel R. Neuville, and Robert T. Downs, editors. Reviews in Mineralogy and Geochemistry v. **78**, Mineralogical Society of America and the Geochemical Society, Chantilly, VA, ISBN 978-0-939950-84-3. Price: $50.

Spectroscopic analysis is a powerful tool for analyzing the composition and structure of materials. Some spectroscopic methods, such as powder X-ray diffractometry, are widely used in the earth sciences, whereas others are more specialized and their use is confined to a smaller number of laboratories. An understanding of spectroscopic methods is critical to 21st century researchers in mineralogy, petrology, geochemistry, and related fields, as they produce most of the data underpinning the current understanding of geomaterials.

The application of various spectroscopic methods to geologic materials was previously covered in volume 18 of 'Reviews in Mineralogy and Geochemistry' (RiMG), published in 1988. The underlying theory has not changed in the 26 intervening years, and the older volume can still be consulted profitably for that information; however, the practical use of many techniques has changed dramatically since that time. Technological advances in instrumentation have improved the reliability, reproducibility, resolution, and detection limits of many techniques, while improvements in computer equipment and control software have increased ease of use and of data collection, storage, analysis, and sharing. The increased availability of very bright synchrotron radiation sources has expanded the sensitivity of established techniques such as infrared spectroscopy and X-ray diffractometry, and has permitted *in situ* monitoring of experiments in real time. Newer analytical methods have also been adopted profitably for application to earth materials. The intention of this new RiMG volume is to present both updated information on techniques covered in the previous volume, and descriptions of newer techniques that are not currently as well known. This is a massive undertaking, and the editors are to be commended for producing such a valuable work for earth scientists.

The 19 chapters in this book cover X-ray diffractometry, X-ray absorption fine structure and near-edge spectroscopy, X-ray photoelectron spectroscopy, Fourier transform infrared spectroscopy, nuclear magnetic resonance spectroscopy, electron paramagnetic resonance spectroscopy, optical spectroscopy, Brillouin scattering, Raman and X-ray Raman, and luminescence spectroscopy. Additional chapters discuss remote sensing spectroscopic techniques, transmission electron and atomic force microscopy, sampling errors, theoretical modeling, and *in situ* spectroscopy of high-pressure and high-temperature experiments. Many of the chapters discuss techniques that were also covered in the previous volume, and these focus mostly on developments since that time, but all chapters provide at least some theoretical background.

One particular factor that has changed dramatically since 1988 is the wide availability of powerful computing resources and of specialized software for data processing, theoretical modeling, and the management of very large datasets (*i.e.* datacubes). This has expanded tremendously the capability to make full use of modern analytical instruments and the torrents of data they often produce. It has also allowed the development of advanced computational modeling techniques such as those discussed in depth by Jahn and Kowalski in chapter 17 of this volume, and more briefly in other chapters.

Researchers familiar with the techniques described in various chapters will find them to be excellent resources for training students. The great usefulness of most of the chapters in this book is that they include not only good descriptions of the theoretical principles underlying the techniques and their specific usefulness, with examples of recent applications to geologically interesting problems, but also valuable practical tips from experienced users on how to obtain the best results. The chapters on techniques with which this reviewer is familiar with are clearly written and very readable, particularly the chapter by Newville on Fundamentals of XAFS and that by Henderson, de Groot, and Moulton on XANES. Among the many other well written and informative chapters in this book, chapter 12 by Hofmeister may be of the greatest general value in training students to use laboratory analytical techniques. It discusses the various sources of error in infrared and ultraviolet spectroscopic measurements and how they must be considered in different applications, with several specific examples of past issues and how they have been or might be resolved. Even when IR or UV spectroscopy are not specifically being used, this chapter should be tremendously useful reading for those students who tend to think of a laboratory instrument as a magical box that tells only perfect truth.

The book is generally well edited, and although certain chapters suffer from more typographical errors than others, there are few for such a large volume. As of this writing, one erratum is posted on the Mineralogical Society of America website, a correction to Figure 14 in chapter 13 (Advances in Raman Spectroscopy).

This book will be very valuable to the student who needs to learn new techniques, to the researcher who

may wish to understand more about unfamiliar methods, and to anyone training new users of these techniques. It will be an excellent companion volume to RiMG v. 18, and deserves a place in the row of white volumes on the shelf of every geochemist, petrologist, and mineralogist.

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The Geochemistry of Geologic CO_2 Sequestration. Reviews in Mineralogy and Geochemistry v. **77**, Mineralogical Society of America and the Geochemical Society, Chantilly, VA, ISBN 978-0-939950-92-8. Price: $40.

If we continue our business-as-usual greenhouse emissions, our species will need to sequester (*i.e.* prevent from reaching the atmosphere) trillions of tons of carbon dioxide over the next 100 years if we are to avoid dangerous climate change. *The Geochemistry of Geologic CO_2 Sequestration* collects together the underpinning science of CO_2 storage in underground rock formations in 15 chapters. As you might expect from the RiMG series, this volume focuses on the molecular and pore-scale processes occurring in a CO_2 reservoir. One hundred pages were dedicated to a comprehensive review of the kinetic and thermodynamic properties of CO_2–H_2O–mineral interaction in high-pressure systems (chapters 3, 4, and 5). Chapter 3 is a formidable review of carbonate mineral thermodynamics in which citations from the 1970s (*e.g.* the classic work of Robie and Hemingway) are interspersed with recent work on more exotic carbonate minerals. Chapter 3 is an excellent summary of brine–CO_2 interaction, which is a critical factor in evaluating the storage capacity of a reservoir, but which lacks fundamental experimental data.

This leads neatly to the state-of-the-art geochemical modeling currently employed to describe these environments, and attempts to connect the pore-scale processes (chapter 8), with the larger-scale rheology of a CO_2 storage formation (chapter 12). A contribution by Bickel *et al*. (chapter 2) presents some of the natural analogs of underground CO_2 storage, including methods of monitoring and quantifying leakage from these systems. Power *et al*. (chapter 9) present a summary of carbon mineralization, an alternative pathway to sequestration involving the chemical transformation of CO_2 into carbonate minerals.

The widespread acceptance of underground carbon sequestration for climate change mitigation is presently held back by uncertainties in the capacity and longevity of the storage reservoirs. While this book discusses contemporary investigations of these, including a section on cap-rock fracture (chapter 13), the natural examples of leaking CO_2-rich aquifers (chapter 2), and the relative and time-dependent contribution of physical and chemical trapping (throughout), there are no overarching conclusions or normative statements that might decrease this uncertainty. These uncertainties, of course, can only be resolved by reservoir-specific studies, and it is probably too much to ask of this volume. I would encourage anyone with interests in CO_2 sequestration to acquire a copy of this book as it is likely that CO_2 reservoir engineers of the future will call heavily upon it as a standard reference text.

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