

## BOOK REVIEW

### **Methods for Study of Microbe-Mineral Interactions.**

Patricia A. Maurice and Lesley A. Warren. CMS Workshop Lectures Series No. 14, The Clay Minerals Society, Chantilly, Virginia. ISBN 978-1-881208-15-0. Price: USD \$30.

Microorganisms interact not only with minerals, but also respond to thermodynamic controls, as well as modifying their surroundings to influence mineral dissolution, formation, and reactivity. The Clay Minerals Society has produced another excellent resource in its line of Workshop Lecture Series, which (thanks to the editors Patricia A. Maurice and Lesley A. Warren) brings together leaders in the application of conventional and novel techniques to the study of these microbial–mineral interactions. The book focuses on useful methods and provides a large amount of useful information aimed at laying the groundwork for future studies in biogeochemistry.

This volume consists of four chapters: (1) ‘Introduction to microbial mineral interactions’ (P.A. Maurice and L.A. Warren); (2) ‘Counting and imaging bacteria on mineral surfaces’ (P.D. Bennett, A.S. Engel, and J.A. Roberts); (3) ‘Analysis of (bio)geochemical kinetics of Fe(III) oxides’ (S.L. Bantley, S. Ruebush, J.-H. Jang, and M. Tien); and (4) ‘Anaerobic microbial-mineral processes with Fe(III) oxides: experimental considerations and approaches’ (J.M. Zachara, J.K. Fredrickson, R.K. Kukkadapu, and Y.A. Gorby). All chapters convey well not just the works of the different active research groups represented, but also provide a brief summary of international biogeochemical research.

Chapter 1 reviews microbial-mineral interactions, including a discussion of the still-changing world of microbial phylogenetics, specifically bacteria and archaea, important in many geochemical reactions. Also considered are general aspects of microbiology relative to geochemistry: attachment to surfaces, role of biofilms, and role of exudates such as siderophores. Further consideration is given to the critical relationship of experimental scale and microbial activity to gaining useful information from field studies of microbial-mineral interactions. A case study is used to illustrate these concepts.

Chapter 2 is an excellent resource for planning research on microbial–mineral interactions where the need is to relate geochemical activity to microbial activity and/or population dynamics. This chapter provides useful information on recipes and techniques that work, based in large measure on the authors’ own experiences. The application of *in situ* ‘microcosms’, useful for assessing microbial affinity for various

mineral surfaces, is discussed, and recipes for useful microbial preservatives are provided. A large section is devoted to methods of biomass detection by scanning electron microscopy, including sample preparation, serial dilution, the use of various staining techniques (e.g. fluorescent *in situ* hybridization (FISH) and other hybridization methods), and imaging. A section on the application of environmental SEM includes an interesting discussion on the hazards of experimental artifacts. The chapter wraps up with a case study on the role of microbes in acid sulfate speleogenesis in the Lower Kane Cave, Wyoming, where all the techniques discussed were applied to discern how the acid sulfate, as well as neutrophilic microbial communities, enhanced karst development.

Chapter 3 reviews and discusses abiotic and biotic dissolution kinetics of (bio)geochemical processes. Aspects of experimental systems (e.g. reactor types) are thoroughly considered, as are the thermodynamic equations necessary for quantification. While the mechanistic equations are based on rather simple systems, the authors do provide references to more detailed and specific methods to assess more complex systems. This chapter is closed with a discussion of the stimulation of reductive dissolution of goethite by chelates (EDTA in this case), suggestive of the role siderophores may play in the transformation of Fe-bearing minerals.

Finally, chapter 4 reviews and discusses the role of anaerobic dissimilatory Fe-reducing bacteria (DRMB) in biogeochemical transformation of the Fe oxides, and provides a good close to the book. This chapter includes a brief discussion of the mechanisms of reduction by *Geobacter* and *Shewanella*, two of the most widely studied DMRB microorganisms, including outer membrane-bound multi-heme *c*-type cytochromes, and extracellular electron shuttles, such as quinones. Also covered are DMRB culture methods, including the description of a microscopic slide flow-through reactor, a discussion on the transformation products of the Fe oxides, and experimental considerations. A large section is devoted to microbial molecular tools, including mutagenesis, gene activity reporters, and molecular profiling; all the methods are useful (indeed important) in characterizing who is doing what and why. The chapter ends with a good discussion of mineralogical tools to study biomineralization, including traditional methods such as X-ray diffraction, electron microscopy, and, specific to Fe, Mössbauer spectroscopy, as well as newer techniques such as scanning probe microscopy, scanning transmission X-ray microscopy, and X-ray absorption spectroscopy.

Overall I found the book to be thought provoking and that it contained gems of information and sound, tried-and-tested advice useful for performing research in this exciting field. If I can fault the book, it would be in the concentration on biogeochemical reactions of the Fe oxides. While the last chapter does discuss Mn oxides, I felt that minerals containing Mn and U, and metalloids such as Hg or *REE*, could have received more coverage

throughout the book. However, this is still a worthy addition to the growing literature on biomineralization and geomicrobiology.

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