

## BOOK REVIEW

**Soil Mineralogy with Environmental Applications**, edited by J.B. Dixon and D.G. Schulze. Soil Science Society of America, Madison, Wisconsin, 2002; xxix + 866 pages. [ISBN: 0-89118-839-8]. Price \$90

This book is the latest volume in the Soil Science Society of America (SSSA) book series and at 866 pages it is literally a weighty contribution. At first glance the similarity in looks, style and content gives the immediate impression that it is a revised edition of the classic text *Minerals in Soil Environments*, the very first volume in the SSSA book series, the 2<sup>nd</sup> edition of which graced our shelves in 1989. Strangely, there is no formal confirmation of the relationship of this book to the previous one, in the preface or elsewhere. This must be deliberate, perhaps because of the change in focus towards environmental applications of mineralogy as expressed in the title? Nonetheless, it is a surprising omission given that 23 out of the total of 28 chapters appear to cover the same topics. Indeed, the introductory chapter by Schulze is virtually identical word for word to his introductory chapter written for the 1989 book. This in itself is not a criticism, since the material of the introduction is essential background for anyone keen to develop an understanding of soil mineralogy, for any purpose, environmental or otherwise. So-called ‘environmental mineralogy’ is very much in vogue, so it is understandable that this book has been presented in this way at this time. In my view, in one sense or another, most soil mineralogy has always been ‘environmental mineralogy’. The subject matter has changed little; mineralogy is as important as ever to any environmental issue that involves soil, all that has really changed is the emphasis.

To get back to the detail of the book, this is divided essentially into three parts. The first five chapters are described as introductory; the following 17 are devoted to specific mineral groups; and the final six are described as applied. No one person could review a book of this diversity in the detail it deserves, or comment authoritatively on all the subjects covered and I apologize to the authors in advance because my comments are no doubt inadequate in many respects.

Color is used to great effect in several places throughout the book, none more so than in the introductory chapter by Schulze where the various ways to represent mineral structures diagrammatically are greatly enhanced by its use. One aspect that struck me here is that this chapter could have been rewritten with a little more emphasis on the disordered and ‘poorly crystalline’ characteristics of many of the minerals found in soils. Although these aspects are

covered in later chapters, in my opinion this point deserves more emphasis in the introduction. The second chapter by Johnston and Tombácz is a very clearly written account of the surface chemistry of soil minerals and the underlying structural features that dictate most of what can happen at mineral surfaces. Again, the use of color plates to illustrate features such as the distribution of surface charge works very well. From my own perspective, this chapter is insightful, and I greatly enjoyed reading it. Chapter 3, by Deng and Dixon treats soil organic matter and organic-mineral interactions. Interactions of soil organic matter with minerals in soil are the rule, but the complexity of soil organic matter means that this is a difficult subject to study and much of what is known has been gleaned from studying the interaction of minerals with simpler organic molecules. Three short case studies at the end of the chapter illustrate the importance of soil organic matter-mineral interactions for a range of environmental issues, including aggregate stability and soil erosion, engineered barrier systems for organic compounds, and as sorbents for toxins in animal feeds. Clearly, organic-matter-mineral interactions represent an area of research where mineralogists have a lot to contribute. In Chapter 4, Karathanasis describes the approach of using mineral equilibria to understand processes that occur in soils and the considerations and limitations of this approach. Chapter five by Amonette, the last of the introductory chapters, is a very useful and concise summary of the plethora of chemical and instrumental techniques available to modern mineralogists. From a review or teaching point of view, the set of illustrations that summarize the information obtained, the principles, the experimental set up, the typical output, and the advantages and disadvantages are most useful. The chapter concludes with an introduction to the concept of environmental availability.

The next part of the volume deals with various aspects of many of the different mineral groups found in soils. The balance of each is variable, with some providing more in-depth mineralogical information compared to others that place more emphasis on the role of minerals as surfaces, reactants and products in various environmentally important processes that occur in, or are regulated by, soils. Carbonates and evaporites are dealt with by Doner and Grossl, mainly from the point of view of their importance for the management of soil properties and their various roles in relation to the geochemistry of minor nutrients and potentially hazardous trace elements. Fanning *et al.* deal with sulfides and sulfates and focus particularly on the problems associated with acid sulfate soils. Huang *et al.* describe

Al compounds in soils, not just as crystalline hydroxides but as various species in solution, and in association with various organic and inorganic ligands. Summaries of the roles of these compounds, particularly in acid soils, in environmental processes including acidification, soil structure, organic carbon turnover, transformations of nutrients and pollutants, plant growth, microbial activity, human and animal health, and the aquatic systems that are effectively buffered by soils, indicates just how important these compounds are. Harsh *et al.* deal with allophane and imogolite, placing particular emphasis on what is known about these minerals in soils derived from volcanic ash. For this chapter I felt that some more emphasis could have been placed on the occurrence, origin and importance of these minerals in Spodosols. The chapter by Bigham *et al.* on Fe oxides is another well-written chapter and is a good introduction to virtually all aspects of the mineralogy and environmental chemistry of Fe oxides. Although usually minor components of soils, the case for further research into the Mn oxides is well made by Dixon and White, although more attention could have been given to the spectroscopic methods that are currently providing a wealth of information on Mn in soils.

The following seven chapters cover the phyllosilicate minerals found in soils, beginning with chapter 12 by White and Dixon who discuss the kaolin-serpentine group of minerals. This is one of the more mineralogically oriented chapters in the book. Methods for the identification of kaolin and serpentine minerals by various techniques are discussed in some detail but, surprisingly, there is no reference to the extensive literature on the use of intercalation methods for the identification of kaolins. As with its predecessor *Minerals in Soil Environments*, a chapter on talc and pyrophyllite by Zelazny *et al.* is also included. As explained by the authors, these minerals are generally unimportant in soils, although from an environmental viewpoint they are used extensively in industry and may be widely distributed as a result. More emphasis on the latter aspect might have been useful, and one is left with the impression that this chapter is included largely for some notion of completeness, simply because talc and pyrophyllite are phyllosilicates. Chapters on micas, smectites, vermiculites, chlorites and sepiolite and palygorskite follow. Most surprisingly of all, there is no separate chapter on mixed-layer clay minerals, and in my opinion this is a major weakness. Thompson and Ukrainczyk discuss some aspects of mixed-layer minerals in their chapter on micas, but their discussion combines disparate aspects from studies of both soil and sedimentary environments and its organization may confuse the topic for many readers. From a mineralogical point of view, the chapter on smectites by Reid-Soukup and Ulery is also weak. For example, the review of soil smectites by Wilson (1987), a key reference on the topic, is not cited. Malla's chapter on vermiculites is

well written and gives a good overview of the many actual and potential roles of vermiculite in the environment. I would have liked to see more on the nature and importance of hydroxy interlayering, but once again this omission of mineralogical detail more than likely reflects the attempt throughout the book to strike a balance between soil mineralogy and environmental applications of soil minerals. This balancing act is a difficult task, and it is perhaps unfair to look at this book in too polarized a way. Nonetheless, for any detail on hydroxy-interlayered clays the reader must be content to consult the earlier volume *Minerals in Soil Environments*. Chlorites are covered briefly by Kohut and Warren. Most of this chapter concerns chlorites *sensu stricto*, *i.e.* those that are derived from the soil parent materials and are thus of an inherited origin. Mention is also made of so-called pedogenic chlorites, but more emphasis could have been placed on the distinction between these clay minerals and true chlorites. For many issues the former are potentially of far greater environmental significance. These two kinds of 'chlorite' have very different properties and in my opinion the term 'pedogenic chlorite' is a source of confusion for many. The final chapter of the phyllosilicate grouping is on palygorskite and sepiolite and is authored by Singer. These minerals are increasingly being recognized in soils from arid areas of the world where improved agricultural production is often dependent on irrigation. In terms of future research needs, Singer's main message is that the effect of these minerals on the rheological properties of such soils is a gap in understanding that urgently needs to be filled.

Four chapters on zeolites, silica minerals, phosphates and Ti and Zr minerals form the next grouping. Zeolites are not common in soils but there are many potential applications where they may be added to soils and Boettinger and Ming provide a good summary of the work and potential in this area. Silica minerals are adequately reviewed by Monger and Kelly. The importance of biological cycling of silica in soils and its potential links to mineral weathering seems an area for potential further investigation. Harris describes phosphate minerals in soils. This is a well written chapter and some of the problems it highlights, from a mineralogical perspective, are the uncertainties and challenges that remain in determining the forms of P in soils that receive additions from fertilizer. The following chapter by Fitzpatrick and Chittleborough on Ti and Zr minerals emphasizes their use for studies of soil genesis.

The final six chapters of the book concentrate on applied aspects of soil mineralogy. Lynn *et al.* discuss how mineralogical information is used in the USDA system of soil taxonomy and illustrate how this information may be mapped. Many environmental issues and questions relating to policy require spatial data and the integration of soil mineralogical informa-

tion into geographical information systems is likely to see increasing application in the future. Borchardt's chapter on mineralogy and soil tectonics, which follows, illustrates how soil mineralogy, together with other tools, can be used to constrain the history of movements on faults. This is not an application I would have imagined before reading this book and it illustrates how wide ranging the practical applications of soil mineralogy can be. Elless and Lee provide a useful introduction to the contrasting behavior of different radionuclides that are common in radionuclide-contaminated soils and deal with the role of mineralogy in relation to the various options for clean-up and containment. The main message, and one that is well illustrated in the case study of U-contaminated soils at Fernald, Ohio, is that it is the nature of the contamination, not just its extent, that is important. This is a message that applies to all kinds of contaminated land, and one that mineralogists must make sure is heard by the regulatory agencies. Laird and Sawhney's account of reactions of soil minerals with pesticides begins with a lucid description of the properties of mineral surfaces that are important for the sorption of pesticides by soil minerals. This is followed by selected examples of specific pesticide mineral interactions in aqueous systems and to a lesser extent in the vapor phase. This is another well-written chapter that highlights the situations in which soil minerals may play a more important role than soil organic matter in the interactions of pesticides with soils. Shen *et al.* describe the interactions of enzymes with clays and the potential of clay-bound enzymes in bioremediation. This will no doubt be another area of increased future research

activity since it impinges upon the very active sphere of biotechnology. It is also potentially of significance for a greater understanding of the interactions between minerals and microbes, a topic perhaps conspicuous by its absence from this book. The final of the 28 chapters of this book is by Teixeira *et al.* and covers the subject of charcoal in soils. Advances in instrumentation now allow  $^{14}\text{C}$  dating of the minute quantities of charcoal that can be found in many soils, and this chapter attempts to highlight the research potential of this technique for soil genesis.

Even though I have expressed some misgivings about this book, there can be no doubt that overall it is a valuable and welcome source of reference. In conclusion, it seems difficult to find a mineral in a soil that is not of some environmental significance, either intrinsically or as a tool to unravel aspects of a soil's history. However, readers should not pick it up thinking that it replaces *Minerals in Soil Environments*, but do have them open at the same time since you will want to flick between them both.

#### REFERENCES

- Wilson, M.J. (1987) Soil smectites and related interstratified minerals: recent developments. Pp. 167–173 in: *Proceedings of the International Clay Conference, Denver 1985* (L.G. Schultz, H. van Olphen and F.A. Mumpton, editors). The Clay Minerals Society, Bloomington, Indiana.

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