

BOOK REVIEWS

Clay Materials Used in Construction. G. M. Reeves, I. Sims and J. C. Cripps (editors). Geological Society, London, 2006, Engineering Geology Special Publication, **21**, 525 pp. ISBN 978-1-86239-184-0, Price GB £100.00.

This unique volume contains a wealth of information on clay minerals, their composition, formation and alteration, properties, world clay deposits, exploration, textural analysis, laboratory testing, earthworks, earth moving, specialized applications, earthen architecture, brick and other ceramic products and cement. Also included are four appendices and a very useful glossary.

The references at the end of each chapter are extensive and very complete. This book should be on the bookshelf of every scientist interested in clays and clay minerals as it contains the definitions, composition and structure of the clay minerals along with an excellent discussion of the non-clay mineralogy of clay materials. In addition, there are discussions of the formation and alteration of clay materials in various geological environments. Chapter 4 covers the properties of clay materials, soils and mudrocks, their composition, geological, engineering, and pedological classifications. Also included is a table which covers the classification of weathering for mudrocks. Included in this chapter is an excellent presentation of geotechnical parameters including strength and stiffness of clay materials and a discussion of potentially troublesome clay materials such as quick clays.

In chapter 8, on compositional and textural analysis of clay material, X-ray diffraction, infrared, thermal, petrographic, X-ray fluorescence, electron microprobe, ion exchange, and organic matter analyses are described. In chapter 9, many tests are described which relate to properties needed for determining engineering applications. Chapter 12 describes many specialized applications including diaphragm walls, landfill liners, radioactive waste storage, and sealing of lagoons, ponds and reservoirs.

This book is very well written and the illustrations are excellent. As a practising clay mineralogist, I found this book is an excellent reference volume covering many important aspects of clay materials. The Geological Society of London is to be congratulated for sponsoring and publishing this important book.

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Medical Mineralogy and Geochemistry. N. Sahai and M. A. A. Schoonen (editors). Reviews in Mineralogy & Geochemistry, **64**, Geochemical Society and Mineralogical Society of America, Washington, D.C. and Chantilly, VA, USA, 332 pp., 2006; ISSN 1529-6466; ISBN 978-0-939950-76-6. Price US \$40.00.

Need some novel research ideas? Although clay minerals are seldom explicitly mentioned in this book, those with knowledge about and interest in clays will find it fascinating, mostly easy to read, and inspiring in terms of new research ideas. It might be best to wrap up some old projects before reading this book, because once you start, you'll be thinking of new things to try....

The volume was published in conjunction with a two-day short course held at the USGS in Menlo Park, California, December 9–10, 2006. The opening chapter tells us that modern studies of interactions between earth materials and human health began with V.M. Goldschmidt and E.J. King in 1945, but only in the past several years have advances in analytical technology and molecular and cellular biology combined with a growing interest in the overlap between geosciences and health to create a blossoming new subdiscipline. The ten chapters review work to date in the budding, cross-disciplinary area of medical geology. Although the biology gets a bit thick in a few places, most chapters are written for geoscientists seeking familiarization with biomedical concepts and literature.

The almost complete absence of clays (or other very specific materials) from the chapters is not so much a shortcoming as a reflection of how young this field is and how much fundamental work remains to be undertaken. Because of their ubiquity and catalytic nature, clays and clay surfaces no doubt play central roles in many of the health issues discussed here, but no research has yet elucidated those roles or identified the exact materials involved. Thus, plenty of opportunity awaits clay experts, among others.

The opening chapter by Sahai *et al.* defines medical mineralogy and geochemistry as “investigations that aim to understand the interactions between geomaterials and humans as well as normal and pathological formation of inorganic solid precipitates *in vivo*”. A brief history of the field is presented, including description of recent advances in spectroscopy, high-resolution imaging, and molecular biology that have made this into a *bona fide* subdiscipline that will probably see rapid growth in coming years.

The next several chapters concern the roles of earth materials in causing or aggravating adverse health effects. In chapter 2, Plumlee *et al.* give a general

discussion of factors governing the toxicity of earth materials associated with disease, including dose, exposure route, solubility and reactivity in body fluids, and adsorption, distribution, metabolism, and elimination of toxins in the body. They stress the importance of physical and chemical characterization of materials associated with disease. There are few specific examples of how these factors correlate with patterns or mechanisms of disease, however, suggesting that much research on this topic has yet to be done. The chapter ends with updated information about two specific materials, asbestos and lead.

The following chapter by Reeder *et al.* discusses the importance of metal speciation, addressing, in particular, several heavy metals known to have deleterious effects in humans if certain species are present in excess. Reeder *et al.* explain how oxidation state and coordination environment of metals can make all the difference, not only in terms of mobility in the environment, but also with respect to bioavailability, transport within the body, and specific reactions within the body. Reeder's readers will also note the importance of processes at the solid-fluid interface, including dissolution, precipitation, and adsorption to charged or uncharged particles in governing how metals interact with the body.

Chapter 4 by Perl and Moalem is about geospatial patterns of neurodegenerative disorders such as Alzheimer's and Parkinson's disease. These are characterized by neurofibrillary tangles in the brain and accumulation of aluminum. The reason for Al accumulation, which is otherwise not seen in biological tissues, is unknown, including whether Al accumulation is a cause or an effect of neurodegenerative disease. The main source of ingested Al is drinking water, so certainly local geology may play a part in geospatial patterns of disease, but the actual observed patterns have not been clearly correlated to regional geology or drinking water composition. Much of the chapter focuses on the fascinating, unsolved mystery of a few dense clusters of neurodegenerative disease in Guam and the Kii Peninsula of Japan. Despite considerable research, mostly by medical doctors and epidemiologists, the genetic and/or environmental factors responsible for the incredible rate of disease in these isolated places have not been identified.

Chapter 5, on prion disease transmission, is also fascinating, and the specific importance of clay minerals is already apparent. Schramm *et al.* explain that prion diseases (known in various species as chronic wasting disease, scrapie, mad cow disease, and Creutzfeldt-Jacob disease), result from an anomalously folded form of a specific protein. The sheep version of this protein, PrP^{Sc}, can be transmitted from one animal host to another by consumption of feed made from the bodies of infected animals, but PrP^{Sc} can also remain viable in soils, without a host, for years! Experiments have shown

that extreme conditions are needed to destroy PrP^{Sc}. Additional experiments have measured the binding capacity of various soil components for PrP^{Sc}. The prion readily adsorbs to montmorillonite and less so to quartz and kaolinite, and clay content is correlated with overall adsorption by soils (Johnson *et al.*, 2006, *PLoS Pathogens* **2**, 296–302).

The following chapter is a discussion of problems associated with inhalation and ingestion of coal dust, an area where considerable research has already been done. Huang *et al.* begin their extensive review of the subject with the pathology and epidemiology of coal workers' pneumoconiosis. They then move on to the importance of iron in coal dust. Iron occurs mainly as pyrite in coals, which is readily oxidized in the body, producing bioavailable ferrous sulfate. This iron can then participate in Fenton reactions, generating harmful reactive oxygen species. Several additional pathways to damage in the body by iron and other transition metals are also explained. Calcium is a significant inhibitor of such damage, as it buffers pH at a high value, thus reducing the tendency of pyrite to oxidize. The authors also discuss other environmental issues, such as fly ash, acid rain, and acid mine drainage. The chapter ends with a review of mechanisms by which coal-induced oxidative stress leads to lung dysfunction.

Chapter 7 by Schoonen *et al.* focuses on mechanisms that generate reactive oxygen species (ROS) when the body interacts with earth materials. Five mechanisms are explained, three of which are mentioned here because of the potential role of clay or other minerals. First, ROS can be produced by surface-bound reactions, in which atoms in a mineral surface or adsorbed to a mineral surface serve as electron donors. Second, ROS are known to be produced more readily in the presence of mineral particles that have been crushed, suggesting that near-surface crystal defects are important. Third, inhaled or ingested mineral particles activate the body's own production of ROS as an immune system response. The chapter gives a particularly accessible introduction to the biology of ROS for geoscientists.

The last three chapters are less obviously relevant for clay or soil scientists, but are nevertheless fascinating. Chapter 8 concerns bone formation, including a review of older and some very new knowledge about how the body controls the site, size, initiation and termination of hydroxyapatite growth in bones. Glimcher includes some beautiful nanoscale images that are helping to reveal the complicated process of bone formation.

Chapter 9 by Cerruti and Sahai includes a history of medical implants. They discuss the physical and chemical characteristics of suitable materials, mostly silicate ceramics, as well as the chemical reactions that occur at the implant-body interface.

The final chapter is about encapsulation of live cells within oxide glasses or gels. Many enzymes and microorganisms have been recognized for their potential

to sequester metals for remediation purposes, synthesize desirable molecules for medical use, or catalyze particular reactions. Scientists and engineers are looking to nature for ideas about how to generate and stabilize populations of such organisms. Diatoms are presented as an example of an organism that naturally protects itself with silica encapsulation, and sol-gel technology is being used to mimic that. Livage and Coradin present a review of recent successes and a comparison of engineered and natural oxide encapsulation systems.

In all, this book provides a highly affordable, fascinating introduction to the new field of medical mineralogy and geochemistry. If anything is missing, it is discussion of beneficial health effects of earth materials and the biology of how those work. It is

difficult to read this book without thinking of ideas for addressing the many fundamental questions that remain unanswered in this new realm of work. Energetic interactions between medical researchers and earth scientists will be inspired and required as this subdiscipline gains ground and expands in coming years. The collection of authors in this book demonstrates that such interdisciplinary collaboration is already underway, and it will not be long before another volume is needed to provide an update.

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