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BOOK REVIEW

Nanoparticles and the Environment, edited by J.F. Banfield and A. Navrotsky. *Reviews in Mineralogy and Geochemistry* **44**, 2001; 349 pp., 118 figures, 16 tables. [ISBN 0-939950-56-1]. Price $28

Nanoparticles and the Environment is volume 44 in the highly successful review series entitled *Reviews in Mineralogy and Geochemistry* (RIMG) co-produced by the Mineralogical Society of America and the Geochemical Society. Books in the series are typically accompanied by a 1–2 day short course given by the contributing authors, which in this case occurred on December 8–9, 2001 at the University of California at Davis. Since the inception of the book series in 1974, nearly 50 volumes have been produced. The majority of previous volumes either cover specific mineral groups or constituents (~55%), reaction processes (~19%), methodologies (~17%), or minerals under specific thermodynamic conditions (~6%). Only one volume has considered issues related to dimensionality as a central focus area (*Mineral-Water Interfacial Geochemistry*, volume **23**). While several of the volumes have focused on minerals that are inherently small-sized, *Nanoparticles and the Environment* is the first book in the series centered primarily on the effects of particle size on particle properties and reactivity. Also, in contrast to most previous volumes, which are usually inspired by the need to distill a large quantity of scientific findings in a mature field, this volume comes on the leading edge of an emerging or perhaps redefined field in mineralogy and geochemistry. Indeed, the timeliness of this book cannot be overstated as the appearance of the book itself has helped to establish a more collective awareness of the importance of size-dependent mineral behavior in the geosciences.

This book provides an excellent starting point for anyone interested in the current state of knowledge of how properties of crystalline particles change as their size decreases into the 1–100 nm range. As the chapters are contributed by different authors, it seems appropriate to describe each of their highlights individually. The book begins with an excellent introduction in didactic prose overviewing the likely materials, possible formation pathways (inorganic and biotic) and adsorption processes with implications for lifetimes of nanoparticle phases in the environment. Detailed coverage is given to recent nanoparticle systems of interest such as TiO_2, ZnS, and also to some of the mineralogical players in acid mine drainage. It also skilfully accomplishes the sometimes difficult task of defining exactly how and why nanoparticles are different from bulk materials, and why they are important. The introduction is followed by more narrowly focused chapters beginning with a nice look at the kinetics of phase transitions in nanoparticle systems, where conditions are particularly optimal for transformation to occur as a single structural domain. In this chapter, the authors borrow from the materials science literature to present a sufficiently studied example system (CdSe) and successfully use it as a compelling case for similar behavior in naturally occurring nanoparticles. The third chapter articulates the central thermodynamic values of importance, discusses their measurement and then focuses on reviewing what is known regarding thermodynamic phase stabilities of specific nanoparticle systems of geochemical relevance (various oxides of Al, Fe, Mn, Ti, Zn, and $MgAl_2O_4$, and silica).

Among other more standard mineral growth concepts, aggregation phenomena are nicely presented in chapter four, providing a good introduction to what is now recognized as one of the principal modes of mineral growth from smaller particles. It also gives a very useful overview of our current analytical capabilities applied to nanoparticles. Chapter five gives an in-depth review of the structures and ligand-exchange reactivities of aluminum polynuclear clusters, and nicely builds a picture of structure-dependent reactivity of small oxide particles with molecular-scale detail. The challenges and future directions of applying computational approaches to nanoscale systems are discussed in chapter six. This chapter has an emphasis on multiscale modeling and summons, if not conjures up, several completely novel methods to make solid, solid surface, and fluid nanoscale systems tractable by simulation. Chapter seven is a thorough, landmark review of the magnetic properties of nanoscale phases of iron and their physical origins. This chapter is a complete tour with sections on magnetic nanoparticle distribution, measurement methods, physical underpinnings of types of magnetism and their size-dependencies, recent developments, and examples from natural systems. The final chapter gives a comprehensive review of the origins, distribution, nucleation, properties, reactivity, growth and characterization of nanoparticles in the atmosphere.

Each chapter has been contributed by well-recognized authorities in the geochemical and mineralogical communities and each is well written and illustrated. As a whole, the book gives excellent coverage to the majority of current and important topics pertaining to nanoscale particles, and provides up-to-date references. Finding areas for improvement in the book is difficult. If anything is to be mentioned in this regard, one would be that several references are made in various chapters to

the importance of size-dependent electronic effects in semiconducting nanoparticle systems (*i.e.* modification of the band gap due to quantum confinement), but there is no corresponding chapter detailing this phenomenon. Also, although all of the chapters are successful at bringing a unique aspect of nanoparticle research to the book, several different definitions of a nanoparticle have been used. This has the effect of adding a slight blur at times to the distinction of nanoparticles from other more quickly recognized small particle systems such as colloids. But the benefits of reading this book clearly outweigh any such shortcomings. It would be a disservice to the community not to also mention that the RIMG book volumes are highly affordable. As the book stands alone in the field of geosciences as the only book available on nanoparticles to my knowledge, it is hard to imagine why any geoscientist working with small particles in general would not have this book in his/her collection.

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