# BOOK REVIEW

Steefel, C.I., Emmanuel, S., Anovitz, L.M., editors. *Pore-Scale Geochemical Processes.* Reviews in Mineralogy & Geochemistry, Volume 80, Chantilly, Virginia (The Mineralogical Society of America), 2015. i-xiv + 491 pages. ISBN 978-0-939950-96-6.

This volume is concerned primarily with transmission of fluid through porous media, the development, or loss, of porosity, and their consequences. Historically, this would have been of primary interest to the hydrocarbons and hydrogeology communities, but as the authors point out throughout the volume, pore-scale processes are ubiquitous and are also relevant for geothermal energy applications and anyone interested in metamorphism and metasomatism, or the delicate interplay between thermodynamics and kinetics.

The authors reveal the improvements that have emerged in the last 20 or so years in several parallel fields related to pore-scale processes, including imaging, experimental and modelling. What is clear from this volume is that improvements in one of these disciplines often helps to advance the others, but these advances are extremely hard won. The problems encountered by proponents in this field are daunting, especially at the micro-porous (nanometre) scale, where familiar friends such as Darcy's Law and Fick's Law become difficult to use without cumbersome modifiers. The chapter authors do not shy away from these problems and are as open and transparent about the current limitations in modelling, imaging and experimentation as they are enthusiastic about the advances in these techniques that have been made recently.

From the very beginning, while providing a thorough primer/refresher on all things porous, Putnis makes it quite clear that we are not in Kansas any more – emergent processes resulting from non-linear behaviour at the nanometre scale (e.g. Steefel *et al.*) confound the application of experiment-scale observations to the geological scale. While meso-scale modelling (Mehmani and Balhoff) may provide some reconciliation between the micro and macro, what follows are state of the art, warts and all, reviews of a wide range of pore-related fields. The methods of determining pore structures and their scale is reviewed by Anowitch and Cole, and how this develops in real time is provided by Noiriel in a fascinating chapter on X-ray microtomography. Reaction rates in heterogeneous media are considered by Liu *et al.*, while various aspects of modelling pore-scale process are reviewed by Yoon *et al.* and Molins. Other chapters concerning the weathering rates of silicate rocks (Navarre-Sitchler *et al.*) and the development of pore spaces by Emmanuel *et al.* are equally fascinating.

Each of the fields of modelling, experimentation and imaging are disciplines in themselves and advances that unify these fields seem unlikely in the near future. A cynic could picture this as being akin to a group of blind naturalists trying to identify an elephant for the first time – the problem is simply too big for any one individual. But what the authors of the chapters and editors of the volume have brought together here is not only a state of the art appraisal of a very broad field but also changed many of the Rumsfeldian "unknown unknowns" into "known unknowns", which, as we all know, are the best alternative to "known knowns". What is needed to progress the field still further has been identified; the job at hand now is to find ways in which these paths can be followed and the RiMG volume that documents this process will be as riveting as Volume 80.

JASON HARVEY



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