sequences. Because volcanic ash-falls are short-lived events and often very widespread, K-bentonites have the potential to serve as event markers for interpretation of regional stratigraphy and, since the trace-element chemistry of the parent ash is essentially retained, can also provide information relevant to patterns of tectonism.

This GSA Special Paper provides comprehensive detail on properties and distribution of 60 K-bentonites in the Ordovician succession of eastern North America. Most of these are not widely distributed, but a few can be correlated for hundreds, or even thousands, of km by chemical fingerprinting techniques, tracings on wireline logs, and matching of outcrop descriptions. Two large folded sheets in pockets show correlations of K-bentonites along various traverses, based on wireline-log cross sections. Conclusions are drawn about the composifion of the parental magmas (mainly calc-alkaline) and the tectono-magmatic setting (destructive plate-margin volcanics). Other topics covered include: problems of 'dating' K-bentonites from K-Ar data (what do these signify? – mobilizafion of K at some time subsequent to volcanic ash deposition?; a regional K-flushing event?; what about Ar diffusion and resetting?); layer charges of the illite-smectite component (MacEwan crystallite model *vs* inter-particle diffraction); and the significance of high-resolution TEM of K-bentonites.

Although this evidence for long-distance correlation of K-bentonites 'across the pond' is convincing, the real challenge is to use these clays to help unravel events accompanying closure of that other, older 'pond' – the Iapetus Ocean, as K-bentonites are also widespread in Lower Palaeozoic sequences in north-western Europe. Kolata, Huff and Bergstrom are active among investigators currently aiming at this goal, and the present Publication confirms that the basic approach is sound. D.J. MORGAN

Lichtner, P. C., Steefel,C. I. and Oelkers, E. H. (eds). *Reactive Transport in Porous Media*. Washington, D.C. (Mineralogical Society of America: Reviews in Mineralogy Vol. **34**), 1996, xiv + 438 pp. Price US$28.00 (MSA Members $21.00). ISBN 0-939950-42-1.

Understanding transport of fluids in non-reactive systems is hard enough when the only variables are the physical properties of the fluid and rock matrix. Getting fully to grips reactive transport in porous media where the material properties of the matrix are in flux and even living organisms play an important role is really pushing the boat out. This is a topic that encompasses much of the physical and a fair helping of life sciences. Can it even be properly defined? Imagine taking a degree in 'microstructural bio-geochemical fluid dynamics'! This is truly the stuff of Renaissance man. But the reality is that fluid flow in the crust, from metmorphism and diagenesis to hydro-thermal ore deposition and transport of radiogenic and toxic waste, involves reaction of one kind or other kind with its surroundings. Given this, the 34th volume of the Mineralogical Society of America Reviews of Mineralogy series *Reactive Transport in Porous Media* is to be praised for tackling this complex area of research in a coherent and systematic way. In essence, a book on reactive transport in porous media is only possible because of the computer – more explicitly the exponential growth in computational power that now allows complex numerical calculations to be undertaken in seconds that even a few years ago took weeks to perform. As the technology allows us to include more and more variables in our calculations, so the job of building multidisciplinary models becomes easier.

The book comprises eight chapters. The first by Lichtner provides an excellent overview of the physical principles (conservation of mass and momentum) of fluid flow, along with a discourse on the philosophical aspects of treating rocks as a continuum (do the properties of rocks really change 'smoothly' enough to allow the application of differential calculus to processes taking place within them?), along with a detailed technical description of multicomponent transport reaction equations and how they are applied in modelling. Steefel and MacQuarrie, who further address the technicalities of reactive transport from a modelling perspective, continue this theme in Chapter 2. Chapters 3, 4 and 5 deal with a review of the physical and chemical proprieties of crustal rocks and fluids (Oelkers), multicomponent ion exchange and chromatography (Appelo) and solute transport in the unsaturated near surface (Suarez and Simunek).

Chapter 6 is anothpr excellent overview, this time on reactive transport in heterogeneous systems Thompson and Jackson). The important word here of course is heterogeneous. Even the most sophisticated computer models can produce nothing of real consequence if the effects of rock heterogeneity, both physical and chemical, are not

taken into account. The problem is how can heterogeneity be incorporated realistically into computer models? This is not just a problem of turning the processing power on your massively parallel Cray supercomputer up a notch or two – there are serious conceptual challenges here. The problem of how to deal with heterogeneity, on all scales, is fundamental to this kind of work if reactive transport models are ever to be truly predictive, simply pretending the system is homogeneous and assigning average properties is not good enough.

Chapters 7 and 8 deal with bugs and their role in catalysing and buffering chemical reactions during solute transport in the subsurface (Rittmann and VanBriesen) and the role of organic matter in aquatic sediments (Van Cappellen and Gaillard). In particular, a full understanding of the microbial role in modulating pH, speciation and biodegradation is necessary in modelling fluid movement during sediment burial and diagenesis. The final chapter deals with both inverse and forward geochemical models applied to a real life case study of acidic heavy metal contaminated groundwaters in the Pinal Creek basin, Arizona using computer simulations such as NETPATH and PHREEQC. A USGS internet site and web page address with the latest downloadable hydrogeological modelling codes looks like a useful place to visit for those working in this field, or the simply curious.

In summary, this book will be of interest to anyone working in the general area of groundwater flow in crustal rocks, and for those still modelling flow in nonreactive systems, it highlights nicely the complexities and challenges of incorporating mineral–fluid chemical interactions.

N. PETFORD

Ammen, C. W. *Recovery and Refining of Precious Metals*, London and New York (Chapman & Hall), 1997, xii + 441 pp. Price £37.00. ISBN 0-412-72060-4.

This book records 50 years of experience by the author in extraction of precious metals from natural ores and industrial scrap. It is a wonderful journey through basic chemical phenomena such as oxidation, combustion, ionisation, electrolysis, solution and chromatography and their relevance to recovery of precious metals. Chapters include blow pipe tests, electrochemical principles, fire assay and summary master plans for wet chemical methods to extract platinum-group elements, gold and silver. The writing style is unusual, being determined, convincing, enthusiastic and lively. The text is very readable, oozing wisdom and experience and is never boring. The author sets up and describes problems often over several pages and then produces the answer making for compulsive reading as the need to find and understand the answer to the problem becomes essential and exciting. This book is a must for people interested in precious metals, but who lack a chemical background and for those involved in hands-on processing of the precious metals. There is an emphasis on lengthy but memorable explanations of how and why chemical reactions occur; illustrated with everyday examples familiar to everyone. The author paints vivid images of processes and quite often lapses into anecdotes and hobby horses in between factual data. This makes the book very interesting, with unexpected new pieces of information suddenly appearing and either explaining something that had always puzzled you or introducing a refreshing break in the text. There is much information on all sorts of properties of the precious metals and how these properties can be utilised to recover them. The book is pragmatic and provides many recipes for precious metal recovery with cautions on dangers of the use of different chemicals. It includes much reference material surprisingly difficult-to find elsewhere, and references to other useful texts are placed firmly in their entirety in the text at suitable points. The book is extremely well illustrated with clear, simple diagrams. Although the book is well written, topics are sometimes covered in unexpected chapters. For example, oxidation and rust occurs in the chapter entitled 'the platinum sisters' and chapter headings such as 'chemistry', 'various systems' and 'odds and ends and author's do's and don'ts' are not helpful, but there is a good index. In the first chapter the author plunges into gold extraction under the heading of ores. Many terms are explained carefully whereas others are introduced with no explanation. Often a term is used in earlier chapters and explained in later ones, almost as if the author is whetting the appetite of the reader and getting them used to the term before he produces the definition. The book is a little repetitive in places with subjects covered briefly in one part of the book covered in more detail elsewhere. The subject of recovery is viewed almost exclusively from a chemical point of view. Physical processes of recovery are briefly