BOOK REVIEWS

Bethke, C. M. *Geochemical Reaction Modeling*. New York, Oxford (Oxford University Press). 1996, xvii + 397 pp. Price £37.95. ISBN 0-19-509475-1.

Craig Bethke's book *Geochemical Reaction Modeling* is about how natural waters and their dissolved masses behave when they react with the minerals, fluids and gases of the earth's crust and hydrosphere. Natural hydrous systems are dynamic hence any description of their behaviour will show a change in composition with time. They are also normally multicomponent solutions. Thus any attempt to describe their behaviour in a realistic way presents a mathematical problem of some complexity. Whilst early workers sought to solve problems of this type 'by hand' it is only with the advent of computer modelling that quantitative solutions can be tested in systems of any complexity. Hence this book is an exposition of a particular approach to geochemical reaction modelling built around a specific suite of computer programs known as 'The Geochemist's Workbench®' produced by the author and co-workers in the hydrogeology group at the University of Illinois.

The author seeks to illustrate the principles of geochemical reaction modelling by describing the concepts that underpin modelling studies and by showing how geochemical modelling studies can be applied to quantitative geochemistry. Throughout the book theory is illuminated by reference to a large number of examples chosen to reflect the practical needs of workers in petroleum geology and environmental geochemistry. These case studies not only show the results but also the limitations and uncertainties that are encountered in geochemical reaction modelling.

The book is divided into three main sections. In the first part 'Equilibrium in Natural Waters' the author describes how the equilibrium equations for hydrothermal systems are derived, and then modified for their application to reaction pathways. This leads into a discussion of the mathematics necessary to solve for the equilibrium state and a discussion of the vagaries of activity coefficients, surface complexation and automatic reaction balancing. In the following section 'Reaction Processes' the reader is shown how geochemical reaction modelling can be applied to problems involving mass transfer, polythermal reaction paths, geochemical buffers geochemical kinetics and how changes in stable isotope ratios can be integrated into the modelling approach. The final section shows how reaction modelling is applied to problems in low-temperature geochemistry. The range of applications is impressive, illustrating the huge power in the methods described. Examples are drawn from the study of low-temperature mineral deposits, the geothermometry of natural waters, the evaporation of natural waters, sediment diagenesis, kinetic reaction paths, the prediction of scaling in geothermal wells, the outcome of steam flooding of oil reservoirs, the management of injection wells and the study of acid drainage.

This volume is an excellent introduction to the power of geochemical modelling. The reader is given a thorough grounding in the appropriate theory, is made aware of the complexities involved and given a wide choice of practical applications. However, it is my guess that for many readers this is not enough and they will want to become users of the methods outlined. For such readers this book is inadequate for they must then follow-up the information presented in one of the appendices and select an appropriate software package for their use. This book is not a 'user manual' although with each case study the author has chosen to outline the appropriate commands necessary to execute the software. For me this was somewhat obtrusive in an otherwise very well written text, and I would have preferred to have taken the results presented 'on trust' and seen the computer commands relegated to an addendum to each chapter. Such a presentation style has the effect of making the reader wish that he/she was sitting at a terminal running the software. Maybe that is what the author intended.

In many ways this is a highly technical and very specialised volume but for organisations working in any area of low-temperature geochemistry this is an essential addition to the library. For those working either in industry or academia in the areas of petroleum geology, environmental geochemistry and the geology of low-temperature hydrothermal mineral deposits this book is invaluable and full of stimulating ideas. It is also a book for graduate

students and final year undergraduates specializing in low-temperature chemistry.

Oxford University Press have produced this book to a very high standard and for a volume in hardback, the price is fair. For some, however, the purchase of this book is but the beginning and the price of a license for the software is in a different league.

H. ROLLINSON

The Manson Impact Structure, Iowa: Anatomy of an Impact Crater. Geological Society of America Special Paper 302. Paperback, vi + 468 pp. Price US$99.50, ISBN 0-8137-2302-7. Edited by Christian Koeberl and Raymond R. Anderson.

The Manson impact structure (north-central Iowa, USA), at ~38 km in diameter is one of the largest impact structures in the United States. The crater is filled with a thick layer of sediments and breccias, and for many years following its recognition as an impact structure, its age was put at between 60 and 90 Myr., (i.e., spanning the Cretaceous-Tertiary (K-T) boundary), on the basis of sediment stratigraphy, fission track- and argon age-dating. After the proposal by Alvarez *et al.* (*Science*, 1980) that the extinction at the end of the Cretaceous was a consequence of a giant impact, the search commenced for the site of the impact. The apparent age of the Manson structure indicated that it was a possible candidate for the K-T impact site. On this basis, in 1991 the Iowa Geological Survey Bureau, with the US Geological Survey, conducted an intensive drilling programme across the structure, resulting in the production of over 1000 m of well-characterized drill core from a dozen locations across the feature. The cores were made available for study, and it is the results from these materials that are collected in this Geological Society of America Special Paper.

The book consists of a series of 22 papers, covering all aspects of the Manson impact structure, including historical, stratigraphic, structural, geochemical, isotopic, mineralogical and petrographic descriptions and interpretations. The occurrence and distribution of shock-produced mineral polymorphs and impact melt breccias receive due recognition. There is discussion of the dynamics of crater formation, and comparisons with craters on the moon and Venus. An introductory chapter contains an overview of other impact craters in the US, for comparison, along with a valuable discussion of the characteristics by which a crater and associated shock features might be recognized, on both macro and micro levels. A major irony of the study has been the precise dating of the Manson structure, at 74 Myr., too old to be implicated as the site of the K-T event. Notwithstanding this disappointment, the comprehensive nature of the investigation has ensured that the Manson structure is now one of the best understood features in the US. The publication is riddled with maps of the Manson structure: geological, geophysical, cross-sections, location, diagrammatic, schematic etc., etc. However (and this is a very minor carp on an otherwise excellent book), I couldn't find a single picture of what the Manson feature actually looks like from the ground (or air) today. I know that the crater is buried in glacial drift and has a town built on it – but surely there must be some giveaway that it is there?

There is an increasing perception of the role impacts have played in shaping the Earth's history. The relatively low number of well-studied craters has hampered interpretation of the cratering record. This publication, co-ordinated, logically organised and comprehensively indexed by the editors Koeberl and Anderson, provides a valuable insight into just one feature on the Earth's surface. The only other craters studied in similar detail are at Chicxulub (Mexico), now known to be the K-T impact site, and at Sudbury (Canada), where major mineral deposits are located. It is too much to hope that other craters not associated with 'newsworthy' features such as extinctions or precious mineral deposits can be studied in such detail, but this exercise on Manson has certainly provided a wealth of detail of immense use to impact and cratering specialists.

As usual, the GSA Special Paper Series has produced a scholarly body of work which will be the baseline reference material in this field for many years to come. It is an excellent publication, for which the editors must be congratulated.

M. M. GRADY