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BOOK REVIEWS

The Manson Impact Structure, Iowa: Anatomy of an Impact Crater. Edited by C. Koeberl and R.R. Anderson. Special Paper **302** of the Geological Society of America, P.O. Box 9140, Boulder, Colorado 80301-9140, U.S.A., 1996, 476 pages, US$99.50, softbound (ISBN 0-8137-2302-7).

This volume contains twenty-two papers dealing with various aspects of the ~38-km-diameter Manson impact structure in Iowa, U.S.A. Manson is a complex impact crater with a central uplift, and is buried by 100–300 m of glacial drift. The target rocks consist of ~1–4 km of Cretaceous, Paleozoic and Proterozoic sediments overlying Proterozoic crystalline basement. Although relatively well preserved, Manson is no more remarkable than many other terrestrial impact structures. Why then was there this interest in Manson? As the editors point out in the preface, the attention devoted to Manson stems from an earlier suggestion that it was related to the Cretaceous–Tertiary (K/T) boundary 65 Ma ago.They also note that it is somewhat ironic that the more recent studies stemming from the focus on Manson indicate that the Manson impact event is not K/T in age, but occurred ~74 Ma ago.

Much of the volume is devoted to papers characterizing materials recovered during a drilling program in 1991–1992. Following descriptions of the general character of the over twenty impact structures currently known in the United States, historical aspects of research at Manson and details of 1991–1992 drilling program, the volume offers a series of research papers dealing with the geophysical, petrographic and geochemical character of Manson and its rock types. Finally, there are works on the effects of post-impact hydrothermal activity and alteration, $^{40}Ar/^{39}Ar$ thermochronology, an attempt to define the impact angle and direction, and the effects of the Manson event on the biostratigraphic record in South Dakota and Nebraska.

According to the preface, it is the hope of the editors that this volume will not only document a successful multidisciplinary project, but will also serve as reference on a well-studied impact structure. The studies are certainly multidisciplinary in nature, and the volume is clearly a reference to Manson, with copious amounts of geochemical data, in particular. The question, however, is whether or not Manson is well studied as an impact structure. The answer is equivocal. Whereas the overall character of Manson as expressed in geophysical data is well described, as are the details of the petrography and geochemistry of core materials, one does not get a sense of a dramatic new breakthrough in knowledge regarding Manson commensurate with the level of effort devoted to the study of the structure. It is not that there are specific studies missing; the editors have ensured that almost all relevant topics on Manson have been covered. The problem is that there was precious little to work with in the first place. The drilling program consisted of 12 holes for a total depth of ~1.9 km, with ~1.3 km of core recovered. Most importantly, however, the maximum depth of any drill hole was ~250 m, far too shallow to characterize Manson effectively in the third dimension.

The volume is up to the usual high technical standards of the Geological Society of America and, as expected in a compendium such as this, the individual papers vary in quality. In some cases, I have the impression that the review process was fairly lenient; in others, it was clearly inadequate. For example, the work describing the petrography of shocked lithologies, in particular the occurrence of shock-produced planar deformation features (PDF) in quartz, states that PDF orientations with angles of 26–30° to the **c** axis of quartz were assigned arbitrarily 50:50 to the so-called ω and π orientations. The authors and the reviewers have failed to understand the correct methodology for indexing uniquely the orientations of PDF, and to recognize that the display of such angular data on PDF in histograms is only for display purposes. Planar deformation features cannot be uniquely indexed through the use of histograms. Such a basic error in methodology casts doubt on the utility of the entire work on shock metamorphism.

The main problem, however, with the volume is terminology. This is a previous and continuing problem within Manson. Initially, breccias from Manson were classified according to the rock types contained in them. There was no consideration of genesis or the standard terminology used for impact lithologies. In the volume, some works use this terminology, some a hybrid between lithological and genetic classifications, and some use the standard impact terminology. This leads to major problems for the reader in moving from paper to paper. It also leads to major problems in interpretation. For example, a paper on the "sedimentary-clast breccias" likens the "Phanerozoic-clast breccia" to the Bunte breccia at the well-studied Ries structure in Germany. The Bunte breccia is also dominated by sedimentary clasts, but most of these are due to the secondary incorporation of surface materials, as this

deposit of ejecta interacted with the local surface exterior to the impact structure. As the "Phanerozoic-clast breccia" at Manson occurs within the structure, this analogy requires complicated scenarios involving redeposition by debris flows or backwash action, although it is not certain whether Manson occurred on land or in a shallow epicontinental sea. To compound the issue, other papers classify the "Phanerozoic-clast breccia" as a suevite breccia, another type of breccia for which the Ries is the type locality. The genesis and character of Bunte and suevite breccias at the Ries are completely different. The net result is that the non-expert will be completely confused, and the expert on impact processes, frustrated.

This volume cries out for a summary paper that would put all the works in context, with respect to new information, and that would address some of the issues, such as terminology. I looked in vain for a reasonable cross-section detailing the "before" and "after" picture following the drilling program. In my opinion, this volume fails to deliver on its promise to illustrate the anatomy of an impact crater. The editors started out with a difficult problem, namely, a high-profile multidisciplinary study program that for various reasons was not well conceived. In some ways, they did the best of a bad job in, at least, covering the spectrum of potentially useful studies. They failed, however, to bring it together or provide context in terms of standards, particularly with respect to terminology and interpretation. As one editor favored the lithological and the other the standard impact classification of brecciated lithologies, perhaps too this alliance was also not well conceived and was clearly not to the benefit of the general or expert reader.

In conclusion, who will buy this book? Workers in the field who wish a compendium of data related specifically to Manson might consider it for their personal library. The more general reader would be better off giving it a skip and relying upon their institution library, if it receives Geological Society of America Special Papers as a matter of course.

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Tectonic Evolution of Southeast Asia. Edited by R. Hall and D.J. Blundell. Geological Society, Special Publication **106**, London, U.K., 1996, 566 p. US$132 or £79 (Geological Society members, US$65 or £39) (ISBN 1-897799-52-7).

I anticipated that this book would bring me up-to-date on the status of geological studies in Southeast Asia, and I was not disappointed. This authoritative compilation of excellent papers is the result of a conference on the *Tectonic Evolution of Southeast Asia*, held at the Geological Society in London in December 1994. In part, the conference marked the retirement of Dr. A.J. Barber, who was instrumental in developing the program of the Southeast Asia Research Group, based at the Department of Geology, Royal Holloway, University of London. About 30% of the papers in the volume are authored or coauthored by scientists affiliated with that group. The other authors represent diverse institutions and widespread geographic locations, including many in southeast Asia.

As the editors point out in their Introduction, Southeast Asia is a geologically remarkable area that has much to tell us about plate collisions, yet the geology of much of this complex region is not well known. This impressive book demonstrates clearly that significant geological progress is being made in this politically and economically important region of the world. For example, with all the recent publicity in the media in Canada about the Busang gold discovery in Kalamantan, I read with special interest the paper by C.S. Hutchison on the "Rajang accretionary prism" and "Lupar Line" problem of Borneo, which discusses the complex geological setting of the area, involving juxtaposition of an accretionary prism, volcano-plutonic arc, and a microcontinent, and subsequent basin inversion.

The book is divided into two unequal parts. The first part (seven papers) deals with Present-Day Tectonics. Understandably, the papers emphasize seismic data, with the notable exception of the paper by R. McCaffrey on Slip partitioning at convergent plate boundaries of southeast Asia, which utilizes GPS measurements and earthquake-slip vectors to examine how oblique convergence is partitioned on separate structures accommodating normal and shear components of motion. The seismic profiles in the other papers are of exceptional quality, and reveal well the structural features associated with active subduction and plate collision.

The second part of the book (27 papers) deals with the Tectonic Development of Southeast Asia. It begins with three overview papers. I. Metcalf reviews the pre-Cretaceous development of Southeast Asia, which involved amalgamation of allochthonous terranes originating apparently in Gondwana. G. Packham examines the Cenozoic development of the region from the perspective of its numerous geological components. R. Hall relies more on paleomagnetic data to present an outstanding series of color maps documenting the evolution of the region at 5-million-year intervals, from the present back to 45 Ma. The remaining papers deal with specific geographic areas throughout the region, from Thailand and Sumatra in the west to Papua New Guinea in the east, and finishing with two papers on southern China. Coverage of this region is reasonably complete, although Vietnam and some parts of central Indonesia are not directly represented.

The papers range from detailed (*e.g.*, Origin and tectonic significance of the metamorphic rocks associated with the Darvel Bay Ophiolite, Sabah, Malaysia, in which S. Omang and A. Barber document the petrology of metamorphic lenses in the ophiolite and interpret them to have been deformed at high temperatures and low pressures along a transform fault) to the regional syntheses noted above. Techniques employed range from the utilization of SAR and LANDSAT images to assist in the interpretation of structures associated with the Mentawai fault zone (The Mentawai fault zone and deformation of the Sumatran Forearc in the Nias area by M. Samuel and N. Harbury) to equally interesting and effective, but more traditional field observations (*e.g.*, The Tertiary evolution of South Sulawesi: a record in redeposited carbonates of the Tonasa Limestone Formation, in which M. Wilson and D. Bosence nicely document the results of syntectonic sedimentation).

Overall, this book does not contain much of direct interest to mineralogists, but petrologists, especially those concerned with the interaction of tectonics and magma genesis, will find much of interest, including the papers by S. Bergman, D. Coffield, J. Talbot, and R. Garrard (Tertiary tectonic and magmatic evolution of western Sulawesi and the Makassar Strait, Indonesia: evidence for a Miocene continent–continent collision), W. McCourt, M. Crow, J. Cobbing, and T. Amin (Mesozoic and Cenozoic plutonic evolution of Southeast Asia: evidence from Sumatra, Indonesia), and P. Vroon, M. Van Bergen, and E. Forde (Pb and Nd isotope constraints on the provenance of tectonically dispersed fragments in east Indonesia). The book will be very useful for those who teach Global Tectonics or Regional Geology courses; for teaching purposes, it is noteworthy that many papers are well illustrated with tectonic models, in some cases in color. Outstanding in this respect are the color figures in the paper by R. Hall, described above.

Production of the book is of very high quality; I found no typographical errors, and the illustrations, a number of which are in color, are excellent. This book would be a valuable addition to university libraries, and seems well worth the cost, considering the size and attractiveness of the book, and the large number and diversity of papers. I expect that it will be a standard reference on southeast Asian geology for many years.

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Boron: Mineralogy, Petrology and Geochemistry. Edited by Edward S. Grew and Lawrence M. Anovitz. Reviews in Mineralogy, Volume 33. Mineralogical Society of America, Washington, D.C. 1996, 862 pages. $US32 ($US24 for MSA members) (ISBN 0-939950-41-3).

This is a welcome addition to the Mineralogical Society of America's *Reviews in Mineralogy*; it meets or exceeds the excellent standards of other volumes in this series. *Boron* is a detailed and thorough review of the mineralogy, petrology and geochemistry of B prepared by expert researchers. It includes chapters on: 1. Introduction (L.M. Anovitz and E.S. Grew); 2. Crystal chemistry of boron (F.C. Hawthorne, P.C. Burns and J.D. Grice); 3. Experimental studies on borosilicates and selected borates (G. Werding and W. Schreyer); 4. Thermochemistry of borosilicate melts and glasses (A. Navrotsky); 5. Thermodymanics of boron minerals (L.M. Anovitz and B.S. Hemingway); 6. Continental borate deposits of Cenozoic age (G.I. Smith and M.D. Medrano); 7. Boron in granitic rocks and their contact aureoles (D. London, G.B. Morgan VI and M.B. Wolf); 8. Experimental studies of boron in granitic melts (D.B. Dingwell, M. Pichavant and F. Holtz); 9. Borosilicates (exclusive of tourmaline) and boron in rock-forming minerals in metamorphic environments (E.S. Grew); 10. Metamorphic tourmaline and its petrological applications (D.J. Henry and B.L. Dutrow); 11. Tourmaline associations with hydrothermal ore deposits (J.F. Slack); 12. Geochemistry of boron and its implications for crustal and mantle processes (W.P. Leeman and V.B. Sisson); 13. Boron isotope geochemistry (M.R. Palmer and G.H. Swihart); 14. Similarities and contrasts in lunar and terrestrial geochemistry of boron (D.M. Shaw); 15. Electron-probe micro-analysis of geological materials for boron (J.J. McGee and L.M. Anovitz); 16. Analyses of geological materials for boron by secondary ion mass spectrometry (R.L. Hervig); 17. Nuclear methods for analysis of minerals for boron (J.D. Robertson and M.D. Dyar); 18. Parallel electron energy-loss spectroscopy of boron in minerals (L.A.J. Garvie and P.R. Buseck); 19. Instrumental techniques for boron isotope analysis (G.H. Swihart).

Boron is packed with up-to-the-latest-minute information on research into borates, borosilicates and B geochemistry. It is not your average bedside reading, but it will be the standard reference text for researchers, teachers and students for the next two decades. Chapter 1 (Introduction) covers historical aspects, and concludes with a table of the 198 named and 10 unnamed B minerals, that includes localities and references. A second useful database, on formulae, end members and crystallographic properties, is buried as Table 1 of Chapter 5, and would have been more effectively positioned in either the Introduction or Chapter 2. The chapters on crystal chemistry and borosilicates are significant monograph research contributions, the chapter on experimental studies is an important starting point for all future work in this under-researched area

of experimental mineralogy and petrology, and the chapters on tourmaline in hydrothermal ore deposits, crustal and mantle geochemistry, and boron isotope geochemistry will all be greatly appreciated by specialists and students alike. The last seven chapters review various new analytical techniques that have added new dimensions to the study of B mineralogy and geochemistry, and hint at a much more important role for this element in earth sciences research in the future.

Boron contains evidence of hasty preparation in some chapters, *e.g.*, error in the title to Table 1 (Chapter 5), and missing Figure 15 (Chapter 11; "this space is vacant"). In terms of its contents, *Boron* is not totally comprehensive, but 862 pages are surely enough for one book. However, from my perspective, I would like to have seen a chapter on NMR spectroscopy, and more emphasis on aspects relating to 3- and 4-fold coordination, B–O *versus* B–OH bonds, B–Si order/disorder, *etc.* The utility of a reference text of this size and scope would be greatly enhanced by the inclusion of an Index, although I realize that production-time constraints make this impossible. However, acronyms are a major obstacle to browsers like me, and editors could encourage authors of individual chapters to redefine them in each new section.

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