enthusiasts. The editors should be congratulated on imposing reasonably consistent style and, more difficult, nomenclature. The flavour of the original meeting is captured in the volume. Most significantly, a new IGCP project was conceived (277: Phanerozoic Oolitic Ironstones) and I suspect this collection of papers will serve as the base from which many new and exciting projects develop. In this sense, I suspect the volume will become 'required reading' for anyone interested in these fascinating rocks.

C. CURTIS

Bell, K. ed. *Carbonatites: Genesis and Evolution.* London (Unwin Hyman), 1989, xix + 618 pp., 235 figs, 57 tables. Price £85.

This book is timely. Much petrological interest is focussed on the geochemistry of partial melting processes in the mantle, and carbonatites feature strongly in such processes. The book stems from a carbonatite symposium held in Ottawa in 1986.

Of the 23 chapters which comprise the book, five examine the melting processes of variably metasomatized mantle and the nature of the carbonate melts produced, their Mg-rich character and whether they are related to kimberlites and lamproites: Ch. 18 (A. Jones), Ch. 19 (Meen, Ayers and Fregeau), Ch. 20 (Wyllie), Ch. 21 (Haggerty) and Ch. 22 (Eggler). Isotopes, particularly those of Sr and Nd (Ch. 12 by Bell and Blenkinsop) and Pb (Ch. 14 by Kwon, Tilton and Grunenfelder) are used to estimate the metasomatic state of the source mantle and its antiquity (*c.* 2000 m.y.).

Useful tools for modelling carbonatite magmas are provided by the new silicate–carbonate liquid immiscibility phase equilibria data and the silicate/carbonate distribution coefficients of *RE* and other elements determined by Hamilton and colleagues (Chs 15, 16), and by Treiman's new thermochemical and thermophysical properties of carbonate melts (Ch. 5). The chemical and physical characters of extrusive carbonatite lavas and pyroclastic deposits are graphically described by Barker (Ch. 3), Keller (Ch. 4) and Dawson (Ch. 11). Keller's photomicrographs of carbonatite lapilli, shards, spatter and flow textures illustrate well how carbonatite magmas behave.

Carbonatites are now almost commonplace with some 330 occurrences in both continents and oceans; and the Cape Verde occurrences are truly oceanic, being floored by oceanic crust (cf. p. 294). Woolley (Ch. 2) reveals many more in the U.S.S.R. than I had hitherto realized. Woolley and Kempe (Ch. 1) show that nowadays it is necessary to say what sort of carbonatite one is talking about and to give its mineralogy or chemistry. This inevitably leads to identifying carbonatite fractionation sequences. Useful chemical averages are given for calciocarbonatites, magnesiocarbonatites and ferrocarbonatites, which dispel Gold's old 'average carbonatite'.

The origin of carbonatites remains a controversial subject. Almost no support is expressed for the generation of carbonatite magma as a residue from crystallization fractionation of alkali silicate magma. Gittins (Ch. 23) prefers direct melting of partially carbonated mantle, the production of olivine sovite in the crust without the intervention of liquid immiscibility and an increase in the alkali content during carbonatite fractionation. My chapter (no. 17) argues to the contrary: that alkali silicate and carbonate magmas are commonly associated, that experiment shows these two magmas, which can be matched in the field, are related by liquid immiscibility (Ch. 15), and that the carbonate magma so produced could be Na, K-rich and be the source of the fenitization observed around the least fractionated carbonatites. It is also shown how diverse the many paths of carbonatite fractionation can be. Hogarth's chapter (no. 16) is particularly useful. He digests a vast amount of mineralogical data on pyrochlore, apatite and amphibole, much of it in Russian, and produces an invaluable resource for modelling carbonatite fractionation.

Bell has made an excellent job of bringing together so many disparate views into a readable text. However, as he says, not enough is said about fenitization and the role of alkalis, and these to me are among the 'hallmarks' of carbonatite magmatism. Nor are fenite data as sparse as he suggests. The book also fails to do justice to the other half of the carbonatite story, that is the associated alkaline silicate rocks.

Using single column rather than double column format by the printers is unfortunate, but it has forced use of a large print size which is good for those with poor eyesight. Even carbonatitologists will find the £85 excessively expensive. Every Earth Science library will need to buy a copy, as all petrologists, mineralogists and geochemists must consult this book.

M. J. LE BAS

Crawford, A. V., ed. *Boninites and Related Rocks.* London (Unwin Hyman), 1989. xxiv + 465 pp. Price £60.00.

Twice in the last twenty years petrologists have had to come to grips with a new addition to the familiar trilogy of tholeiitic, alkaline and calc-alkaline rock series. Komatiites are now familiar

in the literature, and within the last few years much attention has been focussed on boninites, a distinctive suite of magnesian intermediate volcanic rocks which forms an uncommon but genetically significant part of many ophiolite and island arc sequences. N. T. Arndt and E. G. Nisbet edited an excellent 1981 review volume entitled 'Komatiites', and now A. J. Crawford of the University of Tasmania has brought together an impressive companion volume dealing with the burgeoning field of boninite research. 'Boninites' differs somewhat from its precursor in that it contains much previously unpublished material, and is more a compilation of research papers than a review volume. All of the sixteen chapters were written by active researchers in the field, half of them graduate students and post-doctoral fellows, who reflect the predominant influence of trace element and stable isotope geochemistry on modern petrology.

As Crawford points out in his preface, boninites have a longer pedigree than most petrologists realize, having first been described and named in the 1890's. After a long period in obscurity, boninites have recently been recognized from a variety of localities worldwide. All the major boninite provinces are covered in this book, including the Tonga and Mariana trenches and the type Bonin Island locality of the West Pacific, the Mesozoic ophiolites of New Caledonia and Cyprus, occurrences from Baja California, Chile and the Aleutians, and Lower Palaeozoic ophiolites of the Appalachians and Tasmania. In addition, a chapter is devoted to ultrapotassic lamprophyres of the Mediterranean region which, it is argued by Foley and Venturelli, have petrogenetic affinities with boninites. The inclusion of chapters on high-pressure experimental phase equilibria is particularly welcome.

More controversially, 'Boninites' also includes chapters on magnesian intermediate magmas from Archaean greenstone terrains, from a continental environment in Antarctica, and from satellite intrusions to the Bushveld complex. Rocks from these localities have been identified as 'boninitic' on the basis of their geochemical characteristics, although their tectonic environment is clearly different from conventional boninites. The 'boninitic' tag on the Bushveld magmas in particular has led to the claim that boninites have economic significance as parent magmas to platinum deposits, and has enabled the publishers to target economic geologists as well as igneous petrologists in the back-jacket blurb. Some layered intrusion researchers have reservations about this claim, for reasons which receive timely discussion in the book. Sun *et al.* show that magmas with strong similarities to boninites can be generted by crustal contamination of komatiites, while Hatton and Sharpe (Bushveld magmas) and Kuehner (Antarctica) make the case for primary mantle-derived continental boninites. The issue of crustal contamination has become a central one in recent years, and these chapters should be of considerable general interest.

The controversy surrounding whether or not boninite magmas occur in continental environments boils down as usual to a matter of semantics. What, precisely, is a boninite, and would I recognize one if it outcropped in my back garden? From reading 'Boninites' it is clear that there is considerable confusion on this point. Arndt and Nisbet's 'Komatiites' devoted its opening chapter to settling the equivalent question, and it is unfortunate that Crawford didn't make more of the opportunity to do the same. In his opening chapter, he defines a boninitic suite as one in which the volumetrically dominant lavas or their precursors have more than 53% SiO_2 and Mg number greater than 0.6. It rapidly becomes clear that this broad definition allows a wide variety of tenuously related animals in through the gate. This probably makes the book more interesting, but it does nothing to alleviate the confusion surrounding the terminology. In subsequent chapters, we have to deal with 'high-Mg andesites', 'bronzite andesites', 'sanukitoids', 'bajaites' and numerous other terms which are never adequately defined. Crawford's definition presents problems almost immediately. He devotes much of the first chapter to erecting a subdivision of boninites into low- and high-Ca varieties, and makes a case for Bushveld parent magmas belonging to the low-Ca group. He then presents an interesting and well thought-out discussion of petrogenesis, in which he concludes that low-Ca boninites form as a result of subduction of spreading centres beneath intra-oceanic arcs. It will certainly come as news to many petrologists to find out that the Bushveld complex formed in an intra-oceanic subduction zone. I am sure that Crawford had no intention of suggesting that it did, but since it obviously didn't then why include Bushveld magmas in the same category as lavas from the Marianas Trench?

Part of the problem is that, while 'Boninites' provides a wealth of data on major and trace element geochemistry, isotopic systematics and plate tectonic settings, as well as pages of discussion of petrogenetic models, it is surprisingly light on basic petrography. What do these things look like? A revealing statistic is that, excluding the front cover, there are precisely two photomicrographs in the first 150 pages. (This arises from

the somewhat illogical organization: chapters on 'related rocks' are placed ahead of chapters dealing with the principal true boninite localities). Certain chapters can be excluded from this general criticism; in particular Cameron (p. 325) provides excellent descriptions and photomicrographs of boninites from New Caledonia, with whole rock and trace element analyses of the same samples on the following page. The general-interest reader who simply wants to know what boninites are would be well advised to start here. It is particularly frustrating that the one chapter which deals with the Bonin Islands type locality contains no petrographic data whatsoever, and hardly mentions the rocks at all. This is a matter of some concern, given the fact that almost all boninites contain some proportion of phenocryst material, and therefore most of the chemical analyses presented in the book do not truly represent liquid compositions.

Throughout the book, there is very little emphasis on what is surely one of the most characteristic and significant features of true trench-related boninites: they contain unusually large quantities of primary water. This fact seems to be somewhat taken for granted, and its petrogenetic significance has clearly been recognized by the contributors, but nowhere is it emphasized as being a potential discriminating feature of true boninites. Inclusion of high primary water content in a definition of boninites would go a long way towards relieving some of the terminological confusion.

A consistent theme throughout the book is the integration of major and trace element, isotopic, tectonic and experimental data into petrogenetic models. There is a broad consensus among most of the contributors that boninites owe their unusual characteristics to a combination of factors: a previously depleted mantle source, shallow depths of melting, and metasomatism of the mantle source by an incompitible-element-enriched hydrous fluid phase. The nature and derivation of this metasomatizing fluid is the main point of debate. Low pressure fractionation and magma mixing processes may also play important roles, as shown by Falloon *et al.* in a chapter dealing with lavas from the North Tonga trench.

I strongly recommend 'Boninites' as a source book for petrologists with active research interests in island arcs and ophiolites, particularly those researchers who enjoy plate-tectonic petrogenetic theorizing. Specific chapters will be of interest to workers on layered intrusions, Archaean greenstone terrains, lamprophyres and experimental petrology of basaltic rocks. General-interest readers are liable to find themselves bogged down in geochemical detail and are liable to find some of the terminology frustratingly vague. Geological research libraries should certainly acquire the book.

'Boninites' is very clearly laid out and printed, illustrations are consistently of high quality, chapters are individually referenced and there is a comprehensive index. The price is reasonable by present standards bearing in mind the excellent quality of the production.

S. J. BARNES

Xu, D.-Y., Zhang, Q.-W., Sun, Y.-Y., Yan, Z., Chai, Z.-F. and He, J.-W. *Astrogeological Events in China.* Edinburgh (Scottish Academic Press), New York (Van Norstrand Rheinhold) and Beijing (Geological Publishing House), 1939, xiv + 264 pp. 150 figs., 51 tables. Price £35.00.

This book is a progress report on six years' work by a team of Chinese geologists associated with the International Geological Correlation Programme. This team has studied stratigraphic boundaries in China which are marked by abrupt changes in the geological succession. Each of the main boundaries studied are accorded a chapter. About half the book reports studies on the Precambrian–Cambrian and Permian–Triassic boundaries. In contrast, the Cretaceous–Tertiary boundary is covered in only 12 pages. Other stratigraphic discontinuities described, in one chapter and with limited discussion, are the Ordovician–Silurian and the Devonian–Carboniferous boundaries. The discussion of causes and the significance of the evidence reported is wide ranging and does not always accord with contemporary western thinking. The book is strongest in illustrating stratigraphic sections in China and provides faunal and geochemical data on the samples analysed. Some hypotheses advocated here are at variance with most current western thinking and certainly could not be derived from the quoted evidence; for example a cometary origin for tektites is proposed. Further, the authors favour astrogeological events as the cause of the discontinuities mentioned and the terms event and boundary seem to have become synonymous in this book. The references are collated at the end of the book though not all of those quoted in the text are included. For those who need a well-written, English language text which gives an indication of the current stage of evolution of geological thought in China this book will serve well. As a contribution to the understanding of the causes of abrupt changes in the geological succession it is less successful.

A. L. GRAHAM