appears at first to be a simple situation is beset by complications. Measured thermal conductivities and diffusivities reveal strong anisotropy in the pelitic rocks. Intrusion geometry and sequence present a key problem, but one model showing markedly better agreement with the thermal profiles constructed from the real aureole is preferred.

The book is rounded off by chapters examining fluid behaviour in the intrusion and its aureole, which is compared to other contact and regional examples; intracrystalline processes and a general discussion. A number of interesting points are raised, including the predictable but significant correlation of aureole width with the presence of high conductivity quartzite and the orientation of country rocks and hence pelite conductivity-anisotropy. A general conclusion is that on a gross-scale, equilibrium was established, and that $A_{H_2O} = 1$ until melting commenced when it started to decrease in a predictable fashion to values as low as 0.2. Graphite-bearing pelites behaved in different way to graphite-free rocks, revealing local buffering of fluid and mineral compositions.

The book is not above criticism. As suggested above, the introduction does not set the scene as well as it might, and individual chapters vary in their introductions from bald statements to lucid outlines of the relevant background material. At least one chapter commences as if it were a paper in a journal and not part of a book on the Ballachulish complex and its aureole. A rather light editorial touch is also discernible when it comes to the writing style, which varies from chapter to chapter, with some being almost indigestibly dense. A few inconsistencies are also present: the same rocks are referred to as contact migmatites, pelitic migmatites and the chaotic zone. The same ^{18}O data are discussed differently in different places. Some concepts (such as ring and cylinder models of intrusion geometry for the thermal models) are referred to before they have been introduced. The grid used on the maps is the National Grid for Great Britain, but the way it is plotted on the maps is obscure to say the least. What *do* H and R stand for?

These criticism are minor, though, when compared to the overall value of the book in presenting a well-integrated set of meticulous and well-documented studies of the whole range of petrological and mineralogical processes occurring in a thermal aureole. The book deserves to be read by all petrologists, although I fear at the price it will be restricted to libraries rather than the bookshelves of research workers.

A. C. Barnicoat

Williams, P. A. *Oxide Zone Geochemistry*. London and New York (Ellis Horwood and Prentice-Hall), 1991. 286 pp. Price £52.95.

This book is an attempt to draw together chemical, geochemical and mineralogical knowledge related to the oxidised zones that occur where metal sulphide ores outcrop at the Earth's Surface (or reach, at near-surface, the zone of weathering). The author has adopted a broad approach, rather than attempting a comprehensive review, and has also tried to highlight deficiencies in our knowledge.

Following a brief introduction, wherein the key objectives (emphasising the relevance of the field to mineral exploration on the one hand and pollution studies on the other) are explained, there follow eleven chapters divided into two major sections. Part I, covering 'General Reaction Chemistry', outlines clearly and concisely the relevant chemistry and geochemistry, beginning with the reactions that take place during sulphide oxidation and going on to consider the associated weathering of non-metallic minerals and the role played by groundwater in these processes. As the author points out, many details even of the processes of oxidation of pyrite, the most geologically important sulphide mineral, are still not understood.

The second major section (Part II), under the heading 'Mineral Formation in the Oxide Zone' provides an overview of the mineralogy relevant to these systems. This complex subject (as noted in the text, one third of *all* known minerals occur in the oxide zone of sulphide orebodies) is dealt with clearly and informatively in chapters on 'Elements and Oxides', 'Secondary Sulphate Minerals', 'Carbonate Minerals', 'Halide Minerals' and 'Minerals Containing other Oxyanions' (phosphates, arsenates, molybdates, tungstates, chromates, vanadates, etc.). The emphasis here is on equilibrium constants, stability diagrams and the key reactions controlling stability relations.

References to the original literature are given at the end of each chapter (often numbering between one and two hundred). Perhaps unfortunately for the geochemists and mineralogists used to references with the full titles of papers, only the authors and journal volume, pages and year are provided in the style common to many chemical journals. References are also cited in the text using a number system rather than authors names, so that constant cross reference to the bibliography is needed when reading the text so as to check whose work is being cited. Numerous clear tables (mostly of mineral names and formulae or of thermodynamic data) are provided, as are clear, simple diagrams (many of which are stability diagrams). There is a brief subject index and also a rather longer and more comprehensive index of the minerals referred to in the text.

This is a well written and well produced book; even more importantly, it is a very timely survey of a field that is rapidly growing in importance with the much greater emphasis on 'environmental' geochemistry and mineralogy. It is to be strongly recommended to all mineralogists and geochemists with interests in these fields.

D. J. VAUGHAN

Kazmi, A. H. and Snee, L. W., Eds. *Emeralds of Pakistan: Geology, Gemology and Genesis.* Pakistan (Geological Survey of Pakistan) and New York (Van Nostrand Reinhold Co.), 1990. xii + 269 pp., 90 colour photos, 49 maps. Price £29.00.

This attractively presented book, with a foreword by Edward Gübelin, contains nine chapters by a variety of international experts. Each chapter has its own references but there is also a selected bibliography on worldwide emerald occurrences, with some 530 references.

In northern Pakistan the spectacularly rugged Himalayan ranges dissected by the awe-inspiring canyon of the Indus River, which reaches over 6100 m of relief in places, provide a fascinating background to the discovery and working of the emerald deposits in the Surat-Malakand-Mohmand area.

The gemmological characteristics of the Pakistan emeralds are fully documented by a chapter by E. Gübelin, who notes that they have refractive indices rather high for gem-quality emeralds, but which are in agreement with emeralds containing appreciable iron. This chapter also deals with both primary and secondary fluid inclusion from the petrographic viewpoint. In a later chapter, the chemistry of these inclusions is considered by R. R. Seal, who concludes that they were probably entrapped at 250–449 °C at a confining pressure of 900 bars. A joint contribution from staff of the U.S. Geological Survey and of the Geology Department of Oregon State University deals in detail with the major, minor and trace element composition of the emeralds from several Pakistan localities and also their host rocks; most of the emeralds owe their colour to the substitution of chromium for aluminium in the beryl structure (though a green beryl from Gandao has 13300 ppm V but only 340 ppm Cr). A further chapter by Jane Hammarstrom of the U.S.G.S. reports on the colour zoning shown by some of the emeralds and also demonstrates that the substitution of magnesium for aluminium in the octahedral site is charge-balanced by the entry of sodium into the channel site (these emeralds are notably poor in Rb and Cs).

The remaining five chapters are concerned with the geology and genesis of these emerald deposits, and in these the work of A. H. Kazmi, Director General of the Geological Survey of Pakistan, and of L. W. Snee of the U.S.G.S., point the way to a more fundamental understanding of the genesis of emeralds. In Pakistan all the emerald deposits are located in the Indus suture zone; most are associated with the Mingora ophiolitic mélange which has provided the chromium, whereas the beryllium came from later mineralising fluids from the younger granitic rocks. In a wider consideration of all known emerald occurrences worldwide, a possible classification takes into account the geochemical imcompatibility of Cr and Be and lists emerald deposits according to the source of the chromium (suture zones, granite-greenstone terrain or shale—metashale) and of the beryllium (generally pegmatitic or hydrothermal fluids but more rarely metamorphic fluids). With the exception of the Colombian occurrences, most emeralds exist as a result of crustal plate movements that juxtaposed chromium-bearing ultramafic oceanic plate movements with beryllium-bearing felsic continental rocks. Thus as the Editors suggest, we may marvel at each emerald crystal not only for its intrinsic beauty, but also for its untold tale of continental collisions.

R. A. HOWIE

World Gold '91 2nd Australian IMM-SME Joint Conference. Parkville, Australia (Australasian Institute of Mining & Metallurgy), 1991. 448 pp.

This publication contains sixty-five of the presentations made at a conference on gold deposits and mining held at Cairns in April 1991. The topics cover a variety of aspects, but fall into three categories: Metallurgy, Geology, and Mining, Finance, and the Environment. The majority (over half) deal with metallurgical aspects, and in particular concentrate on new advances in processing gold-bearing ores. The geological papers cover case histories of projects and mines, mostly in Queensland, but also in west Australia, Indonesia, and the western United States. The final section also concentrates on Australian Mining projects.

This is a well-produced publication which will be of most interest to those specifically interested in gold mineralisation and the working of gold