difficult to read and use because of similar poor presentation.

This book may not be the comprehensive guide to heavy mineral identification and applications that one might have wished for, but it is nevertheless a valuable aid to heavy mineral analysis and it certainly succeeds in its aim to assist in the identification of mineral grains. An essential book for any sedimentary petrographer with an interest in provenance studies or other applications of heavy minerals.

G. Nichols

Voll, G., Töpel, J., Pattison, D. R. M., and Siefert, F. (eds.) *Equilibrium and kinetics in contact metamorphism.* 1991. Berlin, Heidelberg and New York (Springer-Verlag), 484 pp., 209 figs. Price DM 228.00.

The sub-title of this book, 'The Ballachulish igneous complex and its aureole' is a succinct summary of the nature of its coverage of the 'Equilibrium and kinetics in contact metamorphism'. It is said in the preface that this is probably 'the most comprehensive study of a single igneous complex–contact aureole system yet published', and this is not an understatement. The book represents the results of detailed, multidisciplinary investigation conducted in Edinburgh and Germany. It is divided into five parts: an introduction to the regional geology (2 chapters), the intrusive complex (5 chapters), the contact aureole and its rocks (8 chapters), interactions between the intrusion and the contact aureole (3 chapters) and a concluding discussion (3 chapters).

The introductory chapters provide a guide to the regional and local setting of the detailed studies, but fail to summarise the geology of the intrusive complex. A synopsis of the nature of intrusion complex and its aureole, and the timing of emplacement would have been highly useful, as one is not provided in the following chapters. This introduction is followed by a series of chapters detailing the petrography, mineralogy and geochemistry of the magmatic rocks of the Ballachulish complex. This information is linked into descriptions of the field relations to detailed discussion of petrography, mineralogy and geochemistry tied in with field relations to enable the emplacement and differentiation sequences to be determined together with the P–T–f_{O_2} of crystallisation and the water content of the magma. Details of pyroxene textures and sub-solidus behaviour, used to estimate crystallisation temperatures, and geophysical evidence on the 3-D form of the intrusion follow.

Discussion of the aureole is opened with a clear, well introduced discussion of pelite zones and reactions, plus relevant petrogenetic grids. Excellent agreement of natural and modelled assemblages is demonstrated, implying at least a gross approach to equilibrium. Melting reactions in aureole rocks are analysed, and the segregation of melts into 'hydraulic' fractures discussed. As with the magmatic rocks, there is an impressive collation of both field, laboratory and theoretical information used to describe and analyse the processes involved. A fascinating discussion of melt-component redistribution during crystallisation of the melt fraction of migmatites enables a rationalisation of the conflicting compositions of naturally- and experimentally-derived melts. This section on melting is of greater interest and importance than contact aureoles alone. The chapters on pelites and migmatites are profusely illustrated with photographs of both rocks in the field and thin sections—a welcome feature. Carbonate-rich rocks of the aureole are discussed both in terms of their petrology and the mechanism of reaction at two isograds. This is a rare case study of the mechanisms of reaction in an environment where temperatures were changing rapidly in a relatively well-constrained fashion. The idea that a decreasing degree of overstepping is encountered in a mineral zone travelling in a direction away from the contact towards isograd is developed and profitably used to expore the textural complexities. Quartz grain coarsening is modelled in conjunction with thermal model data, and again the agreement of field and laboratory data (this time over the role of water and its quantitative effects) is impressive. Also described are the kinetics of alkali feldspar ordering and exsolution and structural variations in cordierites.

The next section commences with evidence of P–T–A_{H_2O} conditions in the complex: impressive agreement between results of different methods for aureole and intrusion lead to the presentation of four temperature profiles through the aureole. Oxygen-isotope data indicate lack of hydrothermal circulation, and the authors speculate that the early, hot dioritic intrusion acting on the regionally-metamorphosed host rocks effectively sealed the aureole before the wetter magma of the granitic pluton core was emplaced. These two sets of data on aureole temperature distribution and the lack of hydrothermal circulation are essential input to a quantitative thermal model of the Ballachulish complex and its aureole. The resultant thermal model is crucial to all of the kinetic studies included in the book, and what 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