

The geology of the area is described in rather variable detail, covering the stratigraphic sequence intrusive igneous rocks, metamorphism structure and superficial deposits. Mineralizations of the area are fully reviewed as these represent a major influence on the geochemical patterns obtained.

The publication follows the pattern of the eighth atlas, *Regional Geochemistry of the East Grampians Area*, including the 42 × 30 cm bound format which though still comparatively unwieldy is much more ergonomic than the previous, larger, loose-leaf format. The style of the presentation of the results is based on digital geochemical imagery. The point data have been gridded using the Interactive Surface Modeling package to generate a smooth surface passing close to each data point and the surface has been processed to create colour classified digital maps.

The result is a series of superbly coloured maps for the elements based on percentile divisions of concentrations which show clearly the distribution and the locations of enrichments. Very usefully the simplified outline geological map is superimposed. In addition the statistics are given for the data set of each element and the data distribution is shown on frequency diagrams coloured with the percentile divisions. On the facing page the results are discussed with a synopsis describing concisely the levels and anomalies associated with the major rock divisions followed by short reviews of the geochemistry of the element and its behaviour in the surface environment. Detailed descriptions of the patterns of each element related to the main rock units and to known mineralization are given and an attempt is made to account for individual anomalies.

The innovation in this atlas is the presentation of combined element anomaly maps with four combining the anomalies of two elements: Ba and Sr, Cd and Zn, Fe and Mn, and Mn and Co, and four combining three elements: Ag-Pb-Zn, Ba-Pb-Zn, As-Bi-Sb and Cr-Mg-Ni. The presentation is by the elegant optical method of using primary colours for each element and coincident anomalies are shown by the colours produced by addition. The two element maps are particularly striking with red and green giving the single anomalies and yellow the coincident ones. The three element anomaly maps show clearly the coincidence of the anomalies of all three elements as white spots but the magenta and cyan overlaps are not so striking.

*Regional Geochemistry of the Lake District and adjacent areas* provides a wealth of information not just on the geochemical dispersion patterns in the stream sediments of the area but also a concise account of the geology of the Lake District and a summary of the geochemistry of the elements in the surface environment and five pages of references

make it an invaluable source book for the area. It also shows how the concept of the regional geochemical survey has evolved, broadening from the original idea of finding mineral concentrations to the relationship of geochemistry to the environment and to disease. It also continues the improvement and innovation in the interpretation and presentation of the results where it would have been very easy for the B.G.S. to churn out the series of reports in a standard, static formula. The result is a valuable and welcome addition to our knowledge of the Lake District.

R. J. L. COLVINE

Miyashiro, A. *Metamorphic Petrology*. London (UCL Press), 1994. xii + 404 pp. Price £24.95 paperback (£60.00 hardback).

Given the relative dearth of comprehensive textbooks on metamorphic petrology and petrogenesis, any new addition to the literature must be welcomed with optimism. This book is new, and in several respects different from Miyashiro's previous work, *Metamorphism and Metamorphic Belts*. It is divided broadly into three sections beginning with the principles behind approaches to describing and understanding metamorphism, followed by two sections that deal with metamorphic facies, *P/T* facies series or baric types, progressive assemblage changes in metapelites and tectonic contexts. An appendix on historical perspectives of metamorphic petrology, including a philosophical discussion of the development of paradigms, is a very valuable and important contribution which should be read in particular by those of today's researchers who seem to forget that metamorphic literature existed before the advent of computerised citation databases and the CD-ROM. It is well-produced with a clear text structure, reasonable index and neat figures complemented by a comprehensive glossary which correlates with terms introduced in bold face within the text. Overall, this is an accessible text with a good blend of scope and depth which should provide students with a good introduction to many, but not all, aspects of the study of metamorphism.

The general principles section (Part I) introduces the subject from a general background of equilibrium pressure-temperature controls and broad types of metamorphism in relation to simple settings, with a brief summary of Barrow's zones as an idealised case of regional metamorphism. Spatial variations in metamorphic grade are discussed, with the significance of relations between 'thermal peak' isotherms and isobars dwelt upon in detail. The phase rule and its applications are described and types of reactions defined, leading into a concise treatment of selected reactions, *T*-composition sections and fluid and

redox equilibria. The physical meaning of volatile behaviour in metamorphism is considered, and fluid inclusion evidence for volatiles briefly described. The most important composition–assemblage diagrams used to evaluate metamorphic rocks are introduced and their limitations and properties critically appraised. Buffering concepts are described with reference to  $T$ – $X_{\text{CO}_2}$  sections, with the importance of graphite stressed. Following a consideration of reaction monitors of fluid activities, a lengthy section is devoted to the reaction progress approach to quantifying fluid/rock ratios. Whilst this approach is important and has been influential, it is only one of several methods for evaluation of fluid/rock interactions and it is unfortunate that stable isotopic studies of fluid infiltration and advances in advective/dispersive front modelling are not introduced here or described.

Part II, 'Metamorphic facies and metamorphic belts', reiterates the importance of Eskola's facies concept and deals with its problems as well as providing a historical account of its further development before arriving at a modified working definition of facies. The three-fold  $P/T$  ratio facies classification as recognised through field  $P$ – $T$  curves is then expanded upon following Miyashiro's original concept. At this point a slightly unnecessary diversion is introduced with a detailed account of 'diachronous progressiveness' — essentially one type of age/grade relationship. Whilst the field array may indeed be diachronous, this section rather over-elaborates on a general concept that should be implicit. The 'petrographic characteristics' of facies are described through distribution graphs of minerals against grade or metamorphic zone, but few of the textural features that may be observed in the rocks are discussed. The tectonothermal evolution of belts is linked into Miyashiro's original postulate of paired metamorphic belts. Although recent detailed observations on proposed paired belts have cast doubt on generalised models for their occurrence, these problems are not remarked upon in this book. Examples of various  $P/T$  belts are given, including 'classic' terrains (e.g. Barrovian, Franciscan, Japan). A clear, if simplified, history of the Alps as a collisional belt is also presented. This, however, does not focus upon key aspects and controversies such as the ultra-high pressure metamorphism as seen in the Dora Maira Massif, and the role of extensional tectonics in unroofing. On the positive side, extension is considered in relation to low  $P/T$  belts such as the Hercynian. Almost all the more detailed examples of metamorphic terrains given in this part of the book are Phanerozoic, and it is doubtful whether students reading this text alone would be able to appreciate the abundance and diversity of Precambrian metamorphic terrains.

In part III (Individual metamorphic facies), each facies is described, from their general background features and some typical examples, to information on critical reactions and assemblage fields. Although brief, each section gives the reader some appreciation of the important issues and questions relating to many of the facies. For example, the granulite facies is considered in greater depth and with more insight than presented in other recent general metamorphic texts. The high  $P/T$  facies are also described with some attention being given to ultra-high pressure cases, if only briefly. Contact metamorphism only warrants five pages of this book — a treatment which in no way reflects the recent intense interest in the dynamics of this important form of metamorphism.

Although very recommendable as a good general text this book is by no means comprehensive, and it is unfortunate that several themes which are important in modern work are not explored or explained. For example, petrographic aspects such as metamorphic textures, their relations to deformation and the use of reaction textures in interpretation of metamorphic histories receive very little attention. The implications of related fields such as stable isotopic studies and geochronology for modern metamorphic petrology are also not given adequate coverage. A chapter dedicated to thermal models and their continuing development would be a valuable addition, as would greater treatment of extensional settings and metamorphic core complexes. Ultra-high pressure metamorphism involving coesite- and diamond-bearing eclogite facies rocks, surely a major area of new investigation and discovery with fundamental implications for crust/mantle dynamics, is only noted briefly. Despite these shortcomings, Miyashiro's book is superior to most other metamorphic texts available and the £24.95 paperback edition undoubtedly should become standard reading in many metamorphic courses.

S. L. HARLEY

Stanton, R. L. *Ore Elements in Arc Lavas*, Oxford (Oxford University Press), 1994. x + 392 pp. Price £85.00. ISBN 0 19 8540507.

The purpose of this monograph is two-fold, as stated clearly by the author: (1) "to investigate the patterns of behaviour of 'ore' and associated elements during the crystallization of a volcanic island-arc lava series" and (2) "to contribute to a solution of the problem as to whether exhalative ore deposits of the volcanic regime are derived from the melt by magmatic processes or by much later sea-floor leaching". The author elegantly establishes in the introductory chapters the close relationship between polymetallic massive sulphide formation and felsic