map area are the Carboniferous Limestone in North Wales and around Clitheroe, and the Namurian and certain acid intrusive rocks in North Wales. The Permo-Triassic rocks underlying much of the Manchester and Liverpool areas have uniformly low radon potential. Surprisingly, perhaps, there is no mention of selenium in soils of the agricultural areas covered.

Altogether this volume is extremely informative, dealing as it does with an area where the geological map alone can only give part of the story, because of the extensive spread of mining and industrial debris and contamination. The map of radon potential will be of considerable interest, and the degree of heavy-metal contamination in the soils to the west of Manchester should serve as a warning to future generations. The areas covered by published atlases in this series are creeping steadily south; it will be useful to have coverage of the whole of Great Britain on this scale.

R. A. HOWIE

Treloar, P.J. and O'Brien, P.J. (Eds). *What Drives Metamorphism and Metamorphic Reactions?* London (The Geological Society, Special Publication No. 138), 1998. vi + 287 pp. Price £69.00. ISBN 1-86239-009-6.

Understanding the causes of metamorphism has been one of the major objectives for metamorphic petrologists throughout the 20th century. Progress has been remarkable despite a few wrong turnings, from the invention of geothermometry by Goldschmidt in the early years of the century, through Eskola's facies principle to the recognition by Miyashiro, first that different patterns of metamorphic facies corresponded with different thermal gradients in the crust, and subsequently that these could be identified with different plate tectonic settings. Contrary to the impression given by the editors of this volume in their introduction, the developments of the last 20 years have largely been in the detail, but this work is gradually bringing us to a much more complete and dynamic view of orogenesis, tracking tectonics and structure, heat and burial, through time. Despite the breadth of its main subject, this book also finds room to include papers that deal with metamorphic processes and reaction mechanisms, and one that does not seem to have much to do with either theme.

Inevitably, with just 14 chapters to review most of what has interested most of today's metamorphic petrologists for their entire careers, the coverage is patchy. Nevertheless, there are some excellent chapters here which present the results from some of the most exciting work going on in the field. While readers of a philosophical bent will like Hodges' Gaia-like view of the Himalayas as a self organising system, I particularly enjoyed the modelling study of Barrovian metamorphism by Jamieson and her colleagues. This coupled thermal and mechanical model is presented with an honest account of its limitations, but nicely demonstrates the importance of the balance between subduction and radiogenic heating in the thermal development of an orogen.

Another paper that I found very valuable is that by Sandiford & Hand on the high-*T*, low-*P* metamorphism of the Australian Proterozoic. Most examples of such metamorphism are clearly associated with contemporaneous magmatism, and lead to the old debate about the distinction between regional and contact metamorphism in situations where volcanism means that the magmatic heat input to the upper crust was much greater than that contributed by the plutonic rocks remaining today. However there are a few areas, and this is the best known, where geochronology stubbornly refuses to support such a simple association, and these authors have produced a conductive heating model, based on the presence of anomalously radiogenic material in the crust. The more normal association of high-*T*, low-*P* metamorphism is discussed by Brown in the context of the classic Ryoke and Abukuma belts of Japan. These have been interpreted as having formed in the roots of an arc for many years, but Brown argues that it is actually ridge-trench interactions which cause such metamorphism, through the more voluminous basic volcanism that results. It is certainly an important point to recognize that on a spherical earth, triple junctions may migrate through any one point during the evolution of an individual belt, but the specific evidence for ridge involvement seems to remain elusive. Certainly in the example with which I am most familiar, that of Connemara in the Irish Caledonides, the arc was recognized in the first place in the early 1980s precisely because the mineralogy and chemistry of the basic intrusions had unequivocal arc characteristics. Back then we would have been much less certain if there had been a MORB signature to confuse the issue!

A final paper of note in this part of the volume, which also includes several meticulous case

studies, is that by Harley, reviewing the state of knowledge of ultra high temperature metamorphism. These are rocks whose assemblages are stable at temperatures in excess of 900°C, and indeed their very existence is doubted by the more devoted servants of cation exchange geothermometry, since simple thermometers give blocking temperatures in the normal granulite-facies range. Harley shows that, although such occurrences are relatively few in number, they display a range of *P-T* histories, and so are unlikely to all represent a single tectonic setting.

Papers on reaction mechanisms are serendipitous, but deal with some important aspects from very different angles. This is a first rate selection of papers that emphasise a wide range of aspects of metamorphism where an understanding of irreversible processes is essential to the final interpretation of a metamorphic suite, and I will highlight just two. Rubie gives an overview of the nucleation problem in metamorphism, and the situations in which it is most likely that assemblages present will not be the most stable. He rightly points out that this is not just a problem for dry metamorphism, such as deep burial of gabbro bodies, and emphasizes the potential for non-equilibrium where two phases must nucleate. Vernon revisits the remarkably controversial issue of mass and volume change during prograde metamorphism of sediments, which has seen structural geologists and metamorphic petrologists (or at least those with an understanding of the chemistry of open systems) go head to head in a debate that has closely paralleled the controversy over the scale of silica mobility during sandstone diagenesis between the 'BP' and 'Norwegian' schools. His careful appraisal of the evidence is a valuable point of reference for those of us who know that we already know the answer!

In summary, what this book lacks in coherence and in critical areas of the subject (such as high pressure metamorphism), it makes up in the quality of many of the individual chapters. It will be an invaluable collection for metamorphic petrologists for many years to come, although it does not comprise a comprehensive introduction for the outsider. My copy is already becoming well-thumbed, and if you work with metamorphic rocks you should go out and buy it.

B. W. D. YARDLEY

Gilbert, J. S. and Spark, R. S. J. (Eds). *The Physics of Explosive Eruptions*. London (The Geological Society, Special Publication No. 145), 1998. vi + 186 pp. Price £59.00 (£29.00 for Geol. Soc. members). ISBN 1-86239-020-7.

Until relatively recently, volcanologists could only theorize as to the origin of ignimbrites and the other massive flows resulting from explosive volcanism. These massive deposits could be seen in the field, but the rate and nature of deposition was very poorly understood. Films and pictures (some even taken from the space shuttle) of the progress and development of recent eruption columns have provided valuable insight into the processes governing this most devastating volcanic phenomenon. Apart from the academic interest in the genesis of these deposits, there is an urgent need to understand them now because of the serious ramifications for aviation and climate change. The fascinating subject of the recent leaps in physical and mathematical modelling of eruption columns and the deposits they produce were the subject of an Arthur Holmes meeting on the island of Santorini in 1996 and discussions at that meeting provided the enthusiasm and impetus for this book. *The Physics of Explosive Volcanic Eruptions* contains eight well illustrated review-styie chapters by active researchers in the subject. The first chapter illustrates the considerable progress that has been made in developing our understanding of explosive eruptions, and highlights the huge range of areas now ripe for further research. In particular, it is emphasized that closer collaboration is needed between seismologists, modellers, petrologists and physical volcanologists. Open and closed system degassing processes are discussed in the light of recent field, laboratory and theoretical studies and the conditions within the conduit and chamber needed to initiate and maintain Plinian eruptions are explained. Recent experimental progress in determining melt properties and the effects of bubbles and crystals on the physical properties of magma are illustrated with good quality diagrams and photographs. A particularly valuable feature of each chapter is that they end with a section looking to the future. In many cases, this is a 'wish list' of parameters that needs to be better constrained; further developmental work on physical modelling may make these realities sooner rather than later. A comprehensive index makes this a valuable reference book, which I would recommend for researchers and students of all aspects of explosive volcanism. H. RYMER