BOOK REVIEWS

Ashworth, J. R. and Brown, M. (Eds.) *High-temperature Metamorphism and Crustal Anatexis*. London (Unwin Hyman), 1990. xx + 407 pp. Price £55.00.

This volume, the second in the Mineralogical Society Series, presents the proceedings of the 1988 Winter Meeting of the Mineralogical Society at which the 20th Hallimond Lecture was given by Professor R. C. Newton. The Mineralogical Society have changed their previous practice of publishing the Hallimond Lecture in an issue of the *Mineralogical Magazine* and members could rightly complain that an important review paper such as that given by Professor Newton was not made more widely available. In the last few years there have been several meetings concerning high-grade metamorphism, and granulite-facies rocks in particular, from which conference volumes have been prepared, for example, the NATO A.S.I. workshops edited by Bridgwater (1989) and Vielzeuf *et al.* (1990). These meetings have tended to be 'state of the art' meetings and the resultant publications include much unfinished work. Because the papers in this volume are largely the result of either concluded research projects, or projects at a stage where review and summary are appropriate, the editors have been able to produce a volume that does not overlap with others which cover similar topics. However, the claim in the back-jacket blurb that 'It gives a balanced presentation of the current state of research and so is a useful introduction for non-specialist geologists' is considered rather too hopeful even though some of the contributors have included a brief examination of some of the basics of their subject. What is presented is a very useful up to date account of the progress in understanding the links between several rather specialised aspects of geology. The mixture of theoretical, factual and speculative material combined with the widely distributed examples (e.g. Antarctica, Australia, Scotland and Sri Lanka) provides stimulating reading for the researcher.

The book begins with an introduction (Ashworth and Brown) written after the 12 research papers, extended versions of the presentations at the Meeting, were collected together. This introductory overview of the diverse responses of crustal rocks to diverse processes at high temperatures is used to explain what may be expected from the following twelve chapters. It also serves as the main explanation for the non-specialist of the many complex concepts discussed later and such readers must be aware of this. The Hallimond Lecture (Ch. 7) discusses the relationships between fluids and melting, granites and granulites in the now famous transition zone in South India. By default CO_2 is postulated to be an important component of the dehydrating fluid system, though the source and compositions of fluids in the deep crust are the subjects of considerable speculation. This paper presents a detailed discussion of this problem and introduces new experimental data concerning melting with a CO_2-dominated fluid phase. The paper provides the relevant phase diagrams for melting in a model crust and their application to natural systems. The conclusions are an attempt to further quantify the links that exist between granites and granulites and there is some speculation concerning application of the ideas to other areas. There is some debate regarding the merits of channelled versus pervasive fluid flow, with different stances being taken by other authors (Chs. 6 and 8). Allied to the problems of the granulites in South India are the granulites occurring in the Highland Series of Sri Lanka, which are discussed by Schumacher, R., Schenke, Raase and Vitanage (Ch. 10). Considerable advances have been made recently in the understanding of the relationships between the amphibolite and granulite facies rocks of this region and this paper provides an excellent discussion of the data and hypotheses currently put forward to explain the complex geology.

One chapter presents a discussion of graphical methods of analysis of the systems associated with granulite facies meta-pelites (Ch. 2 by Hensen and Harley). The explanation of the relationships between different systems and the use of chemical potential diagrams is very clear and serves as a good guide through the rather bewildering maze of possible reaction curves. This paper should prove extremely useful for research workers beginning their career in high-grade metamorphic rocks.

The theme of melting is followed through in several contributions. Rubie and Brearley (Ch. 3)

emphasise that the rate of melting is poorly understood and discuss the merits of equilibrium and disequilibrium melting. During metamorphism important mineralogical changes take place which will exert an influence upon the final results. Progressive reactions leading to melting are described by Schumacher, J., Hollocher, Robinson and Tracy (Ch. 9). The paper describes relationships of *P–T–t* paths, isograds and isotherms in the extensively studied central Massachusetts metamorphic belt. In such an extensively studied area the database is sufficient to allow a study of the interactions of *P*, *T*, time, chemical composition of rock and associated fluids and reaction kinetics. It clarifies the difference between metamorphic field gradients and *P–T–t* paths and introduces the possibility that some *P–T–t* paths may have no meaning because they are not the result of one continuous metamorphic episode. The formation and compositions of water-undersaturated granitic melts are discussed by Johannes and Holtz (Ch. 4). There has been long debate over the possibility of forming granitic melt whilst at the same time forming granulite-facies assemblages. This paper suggests lines of evidence that persuade the reader that this can happen. The mineralogy of leucosomes may tell us much about the conditions under which melting and/or crystallisation took place and something about the composition of the parent material. In chapter 5, Powell and Downes describe garnet-bearing leucosomes in aluminous meta-pelites from Broken Hill. On the basis of the modal mineralogy the compositions of the leucosomes are at odds with them representing partial melts. Their conclusion is that the appearance of garnet is controlled by an incongruent melting reaction. Once melt has aggregated and moved it may be difficult to establish what its origins were because magmatic processes such as fractionation as well as contamination by material derived from the crust through which the melt moves will modify its composition. Wickham (Ch. 6) considers the use of both stable and radiogenic isotopes as tracers to examine the relationship between granites and their source rocks. The possible crustal versus deep-seated origin of the fluids is also discussed, another theme that runs through several of the contributions. Following on from this there is a discussion of fluid-rock interactions from the Adirondack Mountains (Ch. 8 Cartwright and Valley) where attempts are also made to establish the origins of some of the fluids. The results of this study show that fluid movements may be very complex, occurring in a number of distinct episodes. Together with strong local control of the fluid composition the result is heterogeneous fluid–rock interaction.

Amphibolite–granulite facies rocks from central Australia with rather exotic textures and assemblages which formed at low pressures (2.5–4 kbar) and which have undergone partial melting are described by Vernon, Clarke and Collins (Ch. 11). These most unusual rocks are well-illustrated and, because of the abundance of important mineral assemblages, have allowed the *P–T* conditions to be tightly constrained. This has permitted a special case to be convincingly argued involving a local, abnormally high geotherm of 75 °C per km. The poly-metamorphic granulites from the Enderby Land region of Antarctica have demonstrated some equally exotic mineral assemblages that preserve evidence of extremely high temperatures associated with moderate to high pressures. Chapter 12, by Harley and Hensen, provides a well-written summary of a considerable volume of field, mineralogical and chemical data on these rocks. Further, there is a demonstration of the integration of theoretical and natural systems as FMAS grid data are taken from Ch. 2 and are calibrated so that interpretations may be applied. The last contribution (Cartwright) is a discussion of the relationships between anatexis, melt extraction and crystallisation associated with retrogression in the Scourian of north-west Scotland.

Each paper has an individual reference list and the volume has a fairly comprehensive index. It is well-illustrated and both the printing and binding are of a high standard. Considering the current cost of similar books this 407-page edition at £55 represents good value that will not become outdated too rapidly. It should be available to researchers in all Earth Science libraries though sadly it may not, I suspect, be pruchased by many individuals.

C. R. L. FRIEND

Kear, D. (Ed.). *Mineral Deposits of New Zealand*, Monograph **13**, Australasian Institute of Mining and Metallurgy, Parkville, Victoria, Australia, 1989. xiv + 225 pp. Price $A73.50.

This volume, sub-titled *The Gordon J. Williams Memorial Volume*, consists of a collection of papers summarizing the results of mineral exploration in New Zealand from 1974 to 1987; it effectively supplements the second edition of *Economic Geology of New Zealand* by the late Professor Williams published in 1974 as Monograph 4 of the Australasian Institute of Mining and Metallurgy.

There has been considerable activity by mining