

original edition may be found in this journal, vol. 56, pp. 284–5. The earlier edition contained some nine specialist chapters by a suite of different authors. These have been removed from the new edition. The earlier part of the new issue, comprising the first seven chapters, is likely to be useful to earth science undergraduates with a good background in physics. The remainder of the book is more appropriate to postgraduate students with a special interest in mineral processes and in phase transformations, since the topics covered are mainly the subject of current research in mineral physics. The author himself provides a brief explanatory guide to the use of the book for students at differing levels and this review provides some additional notes.

All serious students of mineralogy are already conversant with the problems that form the subject matter of this book. They concern the likely behaviour of a macroscopic crystal when undergoing a phase transition with concomitant change in its unit cell constants. A good example is provided by the mineral microcline. This mineral may readily be recognized in optical thin section from the distinctive cross-hatched pattern of combined albite-pericline twinning which results through the loss of monoclinic symmetry. The pattern of domain structure in microcline is not susceptible to change under stress, at least at strain rates available in the laboratory, but, as noted in chapter 1, there are some mineral phases where the transformation-induced microstructure does change readily under imposed stress. In such a case, suitably imposed stresses yield a macroscopic strain pattern, including strain hysteresis, that is in many ways analogous to the behaviour of a ferromagnetic material in a changing magnetic field. This analogy leads to the definition of ferroelastic and co-elastic materials in chapter 2. It is usual to find that the observed strain at and below a ferroelastic phase transition is also a function of temperature and pressure and may be used to define a corresponding state variable.

Chapter 4 deals with the specific strain effects observed in ferroelastic and coelastic mineral systems and demonstrates that the spontaneous strain developed in a true single crystal at a phase transition may be used to define an order parameter ( $Q$ ) which may conveniently be studied in terms of the Landau free energy expansion which is itself a proper symmetry based thermodynamic description. The relevant aspects of Landau theory are dealt with in Chapter 3.

In many minerals the process of transformation is complex and involves not only a change in symmetry but also a change in atomic structure

associated with the ordering of certain atomic species. This is the case in microcline where the triclinic, heavily twinned structure has a new Al/Si distribution which was initially inaccessible under monoclinic symmetry. The extent of this atomic ordering process (order parameter  $Q_{od}$ ) associated with the phase transition may also be used to develop a Landau free energy expansion.

At this point, in Chapter 5, the author considers the important possibility of coupling and interaction between those aspects of transformation involving spontaneous strain ( $Q$ ) and atomic ordering ( $Q_{od}$ ). The practical result depends on the time-scale of equilibration in each case individually and, whereas this may be negligible in the case of the development of a purely spontaneous strain, substitutional ordering effects are notoriously slow and may demand a geological rather than a laboratory time-scale. In any event the description of the ideal interaction terms within the Landau expansion is quite straightforward and the author deals at this point with the most important practical examples namely bilinear coupling and linear-quadratic coupling between strain and order parameters respectively.

The book also provides a detailed account of practical aspects of the macroscopic behaviour of ferroelastic crystals in relation to domain structure and domain boundaries, and a mathematical treatment of their stability and mobility in Chapters 7 and 8. The final four Chapters of the book deal with more complicated aspects of the interaction between different ordering schemes, and between complex ordering patterns and strain. At this point the intending reader may find it necessary to have some background in group and group representation theory. The subject matter of this part of the book is extremely fascinating and highly topical and will certainly lead in the future to a much better quantitative understanding of the transformation behaviour of minerals.

J. D. C. MCCONNELL

Kilburn, C. R. J. and Luongo, G. (Eds.). *Active Lavas*, London (UCL Press), 1993. x + 374 pp. Price £65.00.

The book consists of 14 chapters by 18 authors of three nationalities (Italian, British and American) on the theme of flowing subaerial lava. Chapters are grouped into 4 Parts (Morphology, Monitoring, Modelling, and Mediating), each with a short preface by the editors. No indication is given of the circumstances under which the book came into existence.

In Part 1 Fink examines silicic lava flow emplacement and associated hazards; two particularly well-illustrated chapters describe observations of emplacement of blocky flows on Arenal (Linneman and Borgia) and Etna (Kilburn and Guest); and Lopes-Gautier summarizes current knowledge of flows on the Moon (? active lavas), Mars, Venus, and Io.

Part II includes accounts by Tilling and Peterson and by Pinkerton of the practicalities of making field observations; of active flows, by Hardee of the measurement and significance of convection heat transfer rates in molten lava; and by Rothery and Pieri of the 'black art' of thermal remote sensing of active volcanoes.

Part III begins with accounts of simple lava flow models by Dragoni and by Kilburn. Hardee then shows that heating by viscous dissipation during flow can maintain the temperature of a lava flow along its length, or even result in slight superheating downstream (komatite petrologists should note). A novel modelling procedure (the cellular automata method) is outlined by Barca *et al.* in which a flow is treated as numerous cells of discrete volume at various times and positions, rather than continuously in time and position. Sørensen's chapter 'A short introduction to continuum mechanics' aims to review the concept of treating collections of particles as continuous media. It is ill-judged; few readers will attempt to penetrate the 20 pages of maths when the author has made literally no attempt to apply the concept to lava flows.

Part IV is a single chapter by Peterson and Tilling on 'Interactions between scientist, civil authorities and the public at hazardous volcanoes'. Emphasis is on how and why the volcanologist must keep people informed during a crisis, and the need to develop effective communication skills, including, 'specificity, consistency, accuracy, certainty and clarity'. Can a volcanologist ever be certain about the risk of an eruption?

Unfortunately, the book lacks coherence because connections and continuity between chapters are not evident. I wonder what direction authors received from the editors.

The book is proposed as 'essential reading for not only researchers and field scientists involved in volcanology but also for mineralogists and petrologists'. I doubt it is essential, but most of the articles are very informative. The excitement of working on active volcanoes comes through strongly in several chapters, a quality that should rub off on the undergraduates and postgraduates who will use this book as a source of information for term papers and seminars on volcanology. Although expensive, the book should be on library shelves.

C. H. DONALDSON

Ashwal, L. D. *Anorthosites*. Berlin, Heidelberg and New York (Springer Verlag), 1993. xix + 422 pp. Price DM168.00.

Being almost monomineralic, anorthosites are unusual rocks, which require special petrogenetic processes. They range in age from Archaean to Tertiary, and are especially important in the Precambrian. Because so many anorthosites make up the bulk of large intrusions and layered complexes, these rocks present important tectonic problems. And anorthosite is the major crust-building component of the moon and possibly Mercury. Because of its wide mode of occurrence, the origin of anorthosites and their associated minor rocks such as gabbros, norites and diorites has long constituted a special and distinct subject. Thus Lewis Ashwal's volume follows a distinguished line of publications devoted to the 'anorthosite problem'.

Anorthosites are divided into six basic types, that form the basis of the main chapters. Archaean calcic megacrystic anorthosites, mid-Proterozoic massif-type anorthosites, anorthosites in layered mafic intrusions, anorthosites in oceanic settings, anorthosite inclusions in other igneous rocks, and extraterrestrial anorthosites. Each chapter, and in particular the first three, includes, where appropriate, a summary of the field relations, form, structure, textures, mineralogy, major and trace element geochemistry, ore deposits, age and isotopic compositions, more detailed descriptions of principal occurrences, petrogenesis, and tectonic setting. Finally, there is a summary-synthesis chapter that includes petrogenesis and timing of anorthosite formation. The reference list is very extensive, including, for example, Russian and Mongolian literature; I estimate about 1230 references.

I find this book extremely useful, because it is a very comprehensive review and thus provides an invaluable up-to-date data-bank of facts and ideas about all aspects of anorthosites. Frankly I have learnt a lot about these interesting rocks from this book. Ashwal writes with an enthusiastic style which is encouraging to the reader. The book is far from a dry compilation of data, because he has infused it with a good dose of ideas and concepts, often arguing the case for and against controversial opinions, and he is not afraid to contribute his own opinions. There is no doubt this is an essential companion for all anorthositologists. Because anorthosites are such important components of many Precambrian terranes, of layered intrusions, and extraterrestrial bodies, this book will be useful to a wide range of earth scientists, who will be encouraged by the modest price. Libraries should