

elasticity and the acoustic modes. Chapter 8 deals with the role of anharmonic vibration in relation to the onset of phase transformations and contains an exact model of a displacive phase transition. Chapter 9 is devoted to a brief account of the theory and practice of neutron diffraction in the determination of mode frequencies and Chapter 10 provides a similar coverage of infrared and Raman spectroscopy.

Chapter 11 makes a further return to theory and comprises a formal quantum mechanical treatment of the vibrations of the single crystal. Creation and annihilation operators are introduced and the corresponding form of the Hamiltonian defined. This formalism is used to provide information on the phonon population of the vibration modes.

The final chapter deals briefly with the application of relevant aspects of lattice dynamical theory to computer simulation studies on crystalline material. In this technique the random dynamic displacements and velocities of individual atoms in a chosen volume of the crystal (usually a simple multiple of the unit cell volume) are followed in real time and subject to chosen anharmonic interaction potentials. Extremely small time steps are used in order to avoid accumulated errors. The results of the extended simulation may be used to study selected features of the dynamic behaviour of the crystal. It is possible to control the temperature of the ensemble, and determine selected thermodynamic properties of the crystal. Anharmonic behaviour associated with simple displacive phase transformations can be reproduced. Of necessity periodic boundary conditions set a limit to the study of the vibrations throughout the whole of the Brillouin zone but by careful choice of the periodic unit of structure it is possible to sample the vibration spectrum at special points within the Brillouin zone. The author discusses the limitations of the method in some detail.

Overall this is a very well organised and helpful book on a topic which has very wide applications in mineral physics. It is strongly recommended to readers with a wide range of ability and practical experience in the subject. J. D. C. MCCONNELL

Kretz, R. *Metamorphic Crystallization* Chichester and New York, (John Wiley and Sons), 1994. xiv + 507pp., Price £22.50 (paperback). ISBN 0-471-94214-6.

Professor Kretz has long been an important influence in metamorphic petrology for his pioneering work in the 1960s and 70s on textures and segregation processes, and I viewed the announcement of his textbook with considerable interest. It is a fat paperback, abundantly illustrated, and crammed with samplings across the subject. The precise level

at which it is aimed is not entirely clear: the opening chapter assumes a high degree of familiarity with much of the subject matter of the remainder, and although terminology is introduced from first principles, it seems more likely that this is intended as a graduate student text.

The work is divided into five large chapters, followed by a range of appendices. The first introduces the basic concepts of metamorphism, and this is followed by chapters on mineral thermodynamics, phase equilibrium, chemical kinetics and granular microstructures and crystallization mechanisms. There is no systematic treatment of specific field areas, rock types or facies series; instead individual topics are illustrated with specific examples, many of them drawn from the high grade rocks of the Grenville province of Canada.

The approach to thermodynamics is classical, but with a strong emphasis on mineralogical examples. However, although a little thermodynamic data is tabulated, there are neither worked examples of calculations, nor problems, so that the treatment is very much theoretical. With everything from Maxwells relationships to Margules models in a single chapter, the main value is likely to be in helping students with an existing thermodynamic background to learn to apply it to petrology: the true beginner is likely to be daunted by the copious equations, impossible to cross reference because they are not numbered except for a small block of about 70 in the middle of the chapter. Furthermore, the book is rather reminiscent of an earlier generation of petrology texts, in providing copious equations that are never subsequently used.

In a similar way, the kinetics chapter provides a detailed introduction to classical chemical kinetics, again without any worked examples, but is remarkably weak in explaining how these ideas apply to metamorphism. On the final page the author notes that in nature factors such as the rate of heat supply may be important in controlling reaction rates, but there is no attempt to amplify this point or introduce the relevant literature. Furthermore there are many new developments in mineralogical kinetics from the material sciences which are not mentioned here.

The sections dealing with metamorphic textures and processes were the ones of which I had the highest expectations, but they consist primarily of a summary of Kretz's own work, as originally published, with no new insights into the subject and precious little attention to what has been done by others. For example corona textures are illustrated with an example from an earlier paper by Kretz and co-workers, which is described in some depth, but there is no mention of the debate in the literature by other workers of whether or not coronas form in a closed system.

An advanced text book should present its material in a clear and logical fashion, should provide a reasonably balanced view of the subject and should be up to date. While I like the overall concept of this book, it has to be said that it fails on all these points. The book is very poorly structured, with long sections ranging over diverse material without the benefit of sub-headings; for example the section headed 'corona microstructures' includes a page devoted to the interaction of silver chloride with sodium iodide (neither of which is included in the index). There is little cross-referencing, and a plethora of un-numbered equations. I was particularly disappointed to see that in the areas where Kretz has made important contributions he provides neither a perspective on his own work nor an evaluation of that of others: often a bald list of citations, with no comment or indication of content, is all the reference to major contributions since the mid-80s. The most serious failing of the work is that much of it is hopelessly out of date. It is certainly good to be reminded of the origins of many ideas that remain important, but it is hardly appropriate to entirely ignore new developments. Some random examples: B.M. French certainly pioneered calculations of C-H-O gas equilibria in the earth sciences, but his work is nearly 30 years old, and is no longer the state of the art; the plagioclase ion exchange experiments of Orville are not the main basis today for plagioclase solid solution models, measurement of diffusion in silicate minerals has continued apace since the early 1980s, and modern diffusion studies are no longer best illustrated by the example given of diffusion in zeolites, measured over 30 years ago: modern measurements use techniques such as the ion probe that are not hinted at here.

In summary, this book provides a refreshing approach to metamorphism that is not rigorously bounded by classical considerations of phase equilibrium, facies or rock type. However it attempts to cover a vast amount of ground in a limited space and fails to adequately teach its subject matter or to effectively integrate aspects of physical chemistry into earth sciences. I think that many teachers will find inspiration here to reconsider the structure of their own courses, but the detailed contents are so out of date that they will need to extensively re-research material to find the state of the art today.

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Bucher, K. and Frey, M. *Petrogenesis of Metamorphic Rocks*. Berlin Heidelberg and New York (Springer-Verlag), 1994, xiv + 318 pp. Price (paperback) £19.95 ISBN 3-540-57567-7.

This is the 6th edition of Winkler's textbook, entitled *Petrogenesis of Metamorphic Rocks*, which was a

standard reference book for both undergraduate students and research workers studying metamorphic petrology, during the late 1960s and 1970s. Bucher and Frey have completely revised the book, but have retained the emphasis on quantitative petrology and geochemistry. Consequently, the book has a familiar feel to it, and much of the text is devoted to the detailed description of the metamorphic assemblages formed in common rock types. The book is aimed at the advanced undergraduate and graduate student.

After reading the book, I was left with a feeling that there is more to metamorphism than this! While the book does not claim to be comprehensive, its appeal seems likely to be limited, because its scope is so restricted. Winkler's approach of stressing the chemical and mineralogical aspects of metamorphism undoubtedly was of great value in its time, and still forms a core component of metamorphic teaching. However, modern studies of the formation of metamorphic rocks require a broader approach and student textbooks should reflect this, and include assessments of such things as, micro-textures, deformation, various $P-T$ paths, chemical equilibrium and an appreciation of the full range of tectonic environments in which metamorphism may occur. In this book, the only picture of a metamorphic rock is on the front cover, and there are major omissions from the possible tectonic settings, including obduction and high grade metamorphism linked to extension.

The book is presented in two parts; Part I deals with basic principles of metamorphism, including chapters on definitions, protoliths and graphical techniques of representing mineral assemblages, processes, and various methods of assessing metamorphic grade. In these early chapters, many significant aspects of metamorphism are briefly covered, but are not explored further. Other topics, such as geothermobarometry, are covered in greater depth; however, many of the general principles tend to be lost in the wealth of specific details, details which are potentially of limited value to the targeted readership. The inconsistent use of references (Chapters 1 and 4 include references in the text, Chapters 2 and 3 do not) adds to an impression of a book written, in a series of distinct segments by different authors, and the general lack of direct reference to other work detracts from its value as a reference book. Part II (chapters 5-10) documents the metamorphic assemblages developed in a succession of common lithologies. Advances in understanding metamorphic processes in recent years have been on many fronts, and the principal area where this textbook reflects these advances is in the use of thermodynamic databases to assess $P-T$ conditions and construct phase diagrams to depict assemblage changes. The immensely detailed infor-