BOOK REVIEWS

K. G. Cox, D. P. McKenzie and R.S. White, Eds. *Melting and melt movement in the Earth.* Oxford and London (Oxford University Press/Royal Society), 1995. x + 222 pp. ISBN 019 854 0787. Price £35.00.

This book comprises thirteen papers given at a March 1992 meeting convened, by the editors, on behalf of the Royal Society. It represents a review of studies that relate to melting, melt migration and extraction within the upper mantle, the chemical evolution of the upper mantle in response to melting, and melt production in specific tectonic settings.

The first four papers essentially deal with the problems of melt migration and extraction. Harte, Hunter and Kinny outline the textural relationships between melt and solid phase and how this enhances melt mobility, and then use these data to explore processes of flow, differentiation and metasomatism within the upper mantle, showing how this effects the formation of alkalic rocks within the mantle lithosphere. Spiegelman presents a review of flow in deformable porous media and derives numerical equations that describe the physics of melt extraction and magma migration. Daines & Kohlstedt outline a laboratory study to constrain the dependence of permeability on melt fraction and orthopyroxene content, and their relationship to melt migration. Culeneer and others present numerical models that outline the thermal and petrological consequences of melt migration within mantle plumes.

Three papers use isotopic data from basalts to discuss mantle chemistry. O'Nions and McKenzie constrain the fractionation of Th and U between a mantle reservoir and mantle derived melts and Gill uses U and Th series isotopes to demonstrate chemical disequilibria during melting and the subsequent derivation of metasomatic fluids within the subcontinental lithosphere. Kurz uses Th, U and He isotopes to demonstrate mantle heterogeneity between oceanic islands and indicates that mantle sources may change on extremely short time-scales.

Four papers relate to processes within, and above, mantle plumes. Takahashi and co-workers present an experimental study of the melting of a peridotite at up to 6.5 GPa, and comment on the likely source for primary, Hawaiian tholeiitic magmas. Frey and Rhodes summarise geochemical differences between Hawaiian volcanoes, and comment on their implications for plume dimensions, and magma derivation and ascent paths within those plumes. White estimates melt production rates within mantle plumes, and shows how the productivity of a plume is a function of temperature and flow rate and may change on timescales of a few million years. Cox uses the southern Africa Karoo province to comment on the importance of continental magmatic underplating during continental flood basalt volcanism. The final papers relate to tectonic settings other than plume related ones. Hasegawa and his colleagues use seismic data to constrain the deep structure of arc volcanoes and deep (22–40 km) seated magmatic activity associated with them. Hawkesworth and others outline trace element fractionation trends in island arc basalts and use these data to comment on the extent to which they are supportive of magma generation models based on major element variations.

I have three main, largely presentational, criticisms of the book. The title is definitely misleading. I believe the word 'Earth' to mean more than just the 'Mantle' and was disappointed to find nothing on melt migration and extraction within the crust. Secondly, the contents of the volume are poorly presented on the contents page. Only the first authors are listed for any paper, and paper titles listed in the contents, are often inadequate summaries of the full title of the paper. For instance "O'Nions; Chemistry of melting" on the contents page becomes "O'Nions & McKenzie: Estimates of mantle thorium/uranium ratios from Th, U and Pb isotope abundances in basaltic rocks" and "Hawkesworth: Partial melting in subduction zones" becomes "Hawkesworth, Gallagher, Hargt & McDermott: Trace element fractionation process in the generation of island arc basalts". I found this unnecessary and irritating. Finally, I would have liked to see the discussion of each paper immediately following the paper rather than included in a discussion section at the end of the book.

This book is an important one which provides an excellent overview of the processes related to what may be termed 'the extraction of black stuff from the mantle' and I have no hesitation in strongly recommending it to anyone interested in the topic. This is, though, a rapidly moving field as evidenced by the extremely large number of papers pertinent to this topic that are presented at any international geochemistry/petrology conference (see for example the abstract volume of the 1994 Goldschmidt meeting

in Edinburgh, *Mineralogical Magazine*, vol 58A, 1009 pages). As such, and despite the undoubted quality of the state-of-the-art papers included within it, this volume may have a remarkably short shelf life. P. J. TRELOAR

Heaney, P. J., Prewitt, C. T. and Gibbs, G. V., eds. *Silica: Physical Behavior, Geochemistry and Materials Applications*. Washington, D.C. (Mineralogical Society of America: Reviews in Mineralogy, Vol. 29). 1994, xviii + 906 pp. ISBN 0 939950 35 9. Price $28.00.

This volume in the *Reviews in Mineralogy* series deals with silica, a phase which many mineralogists and petrologists might be inclined to dismiss as being fairly simple; if so, they will assuredly find this book quite an eye-opener. In the contributions to this work, chapters 1 to 3 describe the crystal structures and phase transitions of silica and its 'stuffed' derivatives; chapters 4 to 8 bridge the relationship between the microstructural character of real silica minerals and the behaviour of silica in the geological environment; chapters 9 to 13 treat the basic physical properties of the phases of silica; and chapers 14 to 16 detail the uses of silica for industrial purposes.

Low-pressure silica polymorphs (quartz, tridymite, cristobalite) all experience displacive transformations that involve structural contraction with decreasing temperature, and in the first chapter P. J. Heaney outlines research over the past 30 years that has sought out the mechanisms that control these transitions. In chapter 2, by R. J.Hemley *et al.*, the behaviour of crystalline and amorphous silica under conditions of high temperature and pressure is reviewed. In chapter 3, D. C. Palmer reviews phases which comprise a silica framework topology with (alkali or alkaline earth) cations 'stuffed' into the framework cavities, with appropriate substitution of framework cations to ensure charge balance (e.g. β-eucryptite, $LiAlSiO_4$, as the Li-stuffed derivative of β-quartz, and nepheline as the stuffed derivative of tridymite).

As a framework silicate with strong Si–O bonds, quartz may be expected to be strong and refractory, but although this is true for dry quartz deformed under anhydrous conditions, under the relatively low-temperature conditions of the Earth's crust, hydrogen species at the surfaces and interior of quartz serve to interrupt the strong Si–O–Si network and assist processes of inelastic deformation ranging from crack growth to solution transfer and dislocation creep. The understanding of deformation features in quartz is further addressed by H.-R. Wenk in chapter 5, with a detailed consideration of preferred orientation in deformed quartzites. Chapters 6 and 7 break new ground with a study by H. Graetsch of the structural characteristics of opaline and microcrystalline minerals (chalcedony, quartzine, moganite and both microcrystalline and non-crystalline opal) and a review by L. P. Knauth of the petrogenesis of chert; both of these chapters will be essential reading for sedimentologists. Chapter 8 by P. M. Dove and J. D. Rimstedt continues this trend with consideration of the mineral–water geochemistry of the silica polymorphs, and in chapter 9 the thermochemistry of both crystalline and amorphous silica is outlined by A. Navrotsky, who points out that the wealth of polymorphism in the silica phases reflects the low energetic cost of changing the angles linking SiO_4 tetrahedra to produce a variety of crystalline and amorphous framework structures.

The next three chapters deal respectively with the elusive Si–O bond (G. V. Gibbs *et al.*), first-principles theory of crystalline SiO_2 (R. E. Cohen), ranging from potential models to self-consistent electronic structure methods, for bonding, structure, equations of state, thermodynamics and phase transitions, and a review (G. Dolino and M. Vallade) of the lattice dynamical behaviour of anhydrous silica, taking into account recent *ab initio* models which give a rather complete description of crystal structure and vibrational properties.

Chapter 13, by G. R. Rossman, gives a useful and up-to-date review of the coloured varieties of the silica minerals, including the amethyst, citrine, smoky and prasiolite varieties as well as those varieties which are mixtures of quartz and other phases (chrysoprase and jasper, prase, heliotrope, agate). The problem of iron substitution in quartz is considered in detail, and the diffraction effects responsible for the spectral purity of the colour of precious opal are discussed. It has been recognized that rose quartz usually occurs as massive vein deposits and only rarely as euhedral single crystals, but it is interesting to note that the latter variety is indeed different in containing 118 P atoms/10^6 Si and essentially no Ti; a synthetic P-bearing hydrothermal rose quartz is also reported.

The three remaining chapters also provide much food for thought. Chapter 14 by G. H. Beall on the industrial applications of silica as single crystals, in polycrystalline glass-ceramics and as ultrapure glass, outlines the use of the latter two materials in fibres, films and 'soot'; crystalline silica and its stuffed derivatives have a wide spectrum of thermal expansion behaviour from highly positive to negative, and the dimensional stability of silica fibres is important in the concept of an information superhighway. Silica zeolites and clathrasils are described in chapter 15 by J. B. Higgins, and the final chapter, by D. F. Goldsmith, is concerned with the health effects of exposure to silica dust.