

BOOK REVIEWS

Crystal Chemistry and Refractivity. By Howard W. Jaffe. Cambridge University Press, New York, 1988, 335 pages. \$75 (U.S.).

In the process of reviewing this book I discovered that there were some sizeable gaps in my background in optical mineralogy. I can imagine that many others might find themselves in the same position, namely with a good background in the principles of optical crystallography and practical optical mineralogy, but an incomplete background in how mineral optics relates to structural crystallography. Here are a few questions that illustrate the point. You might remember the importance of optic sign in differentiating among some members of the epidote group, but do you know *why* a ΛZ is 30° in epidote and not some other value? How about the structural reasons for *why* the optic sign of rutile is positive? No? An easier one then, *what* structural feature accounts for the characteristically low birefringence of the feldspars?

This book presents a view of a part of mineralogy often overlooked in university courses: the interrelationship of crystal chemistry and mineral optics. Although many books with crystal chemistry as the central theme have been published in the last decade, few deal comprehensively with mineral optics. Certainly none have attempted to deal with the subject at the level of detail that Howard Jaffe does with this book.

The book is divided into two parts. The first part is essentially an introduction to basic principles in the fields of inorganic chemistry and crystallography, followed by a more advanced treatment of the principles of crystal chemistry and refractivity. The section on crystal chemistry deals with a variety of familiar subjects: ionic *versus* covalent bonding, bond strengths, polyhedron distortion, solid solution, and an introduction to crystal-field theory. *Refractivity* refers to the rule of Gladstone & Dale (1864), which empirically relates the index of refraction and density of a substance to its chemical composition. One of the bonuses of the book is a new compilation of specific refractivity constants, in which a correlation between specific refractivity and valence, type of chemical bond and coordination number is established. However, it is regrettable that the data were not previously published in some journal, where information pertinent to the derivation of the specific refractivity constants (*e.g.*, types of minerals and compounds used, statistical information) could have been presented.

The principles laid out in the first part of the book

are set to good use in the second part of the book, descriptive crystal chemistry. In this part, the crystal chemistry of the major classes of minerals is dealt with systematically. The breadth and evenness of coverage are quite good; in addition to the mandatory discussion of silicate minerals and silicate classification, there are also chapters on oxide and fluoride crystal-chemistry, borate minerals and borate polymerization, and the crystal chemistry of minerals with complex anions. Each chapter deals with the systematics of the topic in consideration, plus detailed discussions of the physical and optical properties and the crystal chemistry of selected mineral examples.

Although the title gives equal billing to crystal chemistry and refractivity, the emphasis is on crystal chemistry. The print quality is good, and the book abounds with excellent reproductions of line drawings and packing models of crystal structures. The book is intended for first-year graduate students with an undergraduate background in geology, but is clearly-enough written and general enough in its introductory chapters that it could easily serve as a textbook for an upper-year undergraduate course in crystal chemistry. Although the book is also intended for researchers, more up-to-date citations would have been of help [*e.g.*, the effective ionic radii of Shannon & Prewitt (1969) are given, not those of Shannon (1976) *Acta Crystallogr.* **A32**, 751], and Zachariasen (1963) is given as the sole reference in a discussion of bond strength – bond length correlations, when Zachariasen (1978) [*J. Less Comm. Met.* **62**, 1] would have been more practical.

Despite these few drawbacks, *Crystal Chemistry and Refractivity* is a good introductory textbook on crystal chemistry. Certainly, those who could not answer all the questions in the first paragraph of this review should consider putting the book in their library.

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Practical Problems in Exploration Geochemistry. By A.A. Levinson, P.M.D. Bradshaw and I. Thomson. Applied Published Ltd., Wilmette, Illinois, 269 pages. U.S. \$80.

Geologists and geochemists who enjoyed working through Peter C. Badgley's *Structural Methods for*

the Exploration Geologist will welcome the publication of *Practical Problems in Exploration Geochemistry*. Whereas this book utilizes the same problem-solving approach, the authors have improved on Badgley's original concept by basing problems on actual data from geochemical surveys contributed by mining company staff, teachers or consultants. Practical and theoretical components have been carefully balanced in the development of each problem case-history. Indeed, the Preface echos the introduction of Carey Croneis to Badgley's 1959 publication in that the book "is a purposefully practical book as the title succinctly implies".

Practical Problems in Exploration Geochemistry comprises forty case-histories logically grouped into reconnaissance, follow-up, detailed and integrated surveys. There are also a number of miscellaneous surveys dealing with such interesting and diverse topics as the variation in gold analyses, deep-ocean manganese oxide geochemistry and diamond exploration in southern Africa. Each problem is headed by a "basic data" section containing concise notes on the source on the data, geology, topography, climate, vegetation, survey type, survey conditions, material sampled and the analytical methods used to produce the data. This "basic data" summary is valuable, because it enables the reader to quickly develop a feeling for the case-history environment, geology, and survey approach. The data summary is followed by an introduction in which the problem is described, suggestions for procedures to approach the problem, the actual questions and a bibliography. Some of the problems, such as the integrated surveys in Fiji, are accompanied by abundant data and are clearly designed for those who enjoy handling larger data-sets. Other problems, such as the examination of gold anomalies in North Carolina soils, are shorter but equally thought-provoking. The questions often probe the full extent of the reader's geological and geochemical knowledge. Well-drafted, clear diagrams and geological maps accompany the problems. There is always some temptation to examine the detailed answers that follow the questions. However, intelligent use of the answers can readily stimulate further ideas on alternative interpretation of the problem data.

Practical Problems in Exploration Geochemistry is a publication that can appeal equally to the professional geochemist, exploration geologist or to the undergraduate. It is certainly a powerful teaching aid and suggests that the concept should be applied to other areas of mineral exploration, such as geophysics.

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Gold, History and Genesis of Deposits. By R.W. Boyle. Van Nostrand Reinhold Company, New York, 1987, 676 pp., \$76.45 (U.S.).

This volume, in which many of the classic papers on gold are reproduced, is a historical document. The account of gold that is presented, of its use, pursuit, recovery, and roles in economic development of nations, international trade and world affairs, is a sometimes fascinating story. The major task of the volume, however, is a historical tracing of information and theories on the geochemistry of gold, the character of different types of gold deposits, and the genesis of these deposits. Thus the volume can also serve as a valuable orientation to those with research and exploration interests in gold. In view of the present tremendous worldwide exploration focus on gold, however, and the consequent burgeoning of literature in this field, it must be emphasized that this book is not a source for the most pertinent and current information on the descriptive and genetic aspects of gold deposits. There is information here, of course, that bears on genetic questions, but this is very dispersed.

Forty-two contributions have been honored by Boyle by their selection as "landmarks" for reproduction in this volume. Many shorter sections and abstracts are also quoted and, in addition, Boyle has contributed some chapters, as well as introductions, linking text and commentaries. The first 7 chapters are largely by Boyle. Chapter 1 sets the stage with a general discussion of the geochemistry of gold and the types of deposits that are known. The next 5 chapters deal with what was known about gold throughout the range of history from the dim past (5000 B.C.) to the transition period to modern scientific views of the metal. Then a chapter outlining modern theories of the origin of gold deposits completes the setting of the stage for the main part (11 chapters) of the volume.

The selected publications on gold are arranged in chapters on the geochemistry of gold, the ore-magma genetic theory, the magmatic hydrothermal genetic theory, "paleoplacer" quartz-pebble conglomerates, gold placers, and on "special topics". Also, Boyle has contributed short chapters on the granitization and exhalative theories of genesis, genetic theories involving secretion, and on the economics of gold and gold mining. It seems unusual that no published contributions in the latter fields were judged worthy of inclusion in the volume, although appropriate references are cited.

In general, the contents of the volume seem to be well balanced, although the treatment (90 pages) accorded placer deposits seems excessive. The exhalative theory, however, does not get a favorable presentation by Boyle, and his 6-page treatment reflects a distinctly negative bias. This bias is reflected by his

introductory statement, which is not further elucidated, that... "Many thorny issues have been stirred up by this theory, most of which have not yet been adequately explained either by the syngeneticists or hydrothermalists". and by a closing comment that... "The exhalative theory as applied to lode gold deposits differs little from the metamorphic secretion theory suggested by a number of authors in the next chapter". Boyle does state (p. 313) that... "Certainly, many of the stratabound auriferous deposits in iron-formations and tuffaceous sediments seem to have had an initial exhalative origin..." However, his selections from the literature do not present the documentation behind this statement. One of the classical papers omitted is that by Fripp (1976, *Econ. Geol.*, p. 58) on gold deposits in iron formation in Zimbabwe. The other literature predating Haynes (1986) that could have been cited is extensive, but a short summary paper by Sawkins & Rye (1974, *Trans. Inst. Min. Metall.*, p. B56) can be recommended. A quote by Boyle concerning the application of the exhalite concept to gold deposits of the Meguma Terrane, Nova Scotia (Haynes 1986) seems a poor selection, because so many published papers present contrary evidence. Also, the quoted extracts from Ridler (1970) and Hutchinson & Burlington (1984) present the exhalative theory in an unfavorable light because they incorporate its inappropriate assignment to auriferous zones in highly carbonatized peridotitic komatiite lavas.

Other faults can be found with the volume. Discussion is lacking about the relation of gold deposits to major crustal structures. Although Boyle (p. 596) mentions "certain types of major structures that are usually self-evident in most auriferous belts", the papers quoted (Bain 1930, Mawdsley 1938, White 1943, Ebbut 1948) are biased instead toward controls by minor structures. Some of Boyle's suggested classifications, such as Olympic Dam (Roxby Downs) as possibly carbonatite-related, and Tetreault and New Calumet as auriferous skarns, may find little acceptance. Mesothermal and epithermal deposits are not clearly distinguished. It is presumably an unintended slight by Boyle of previously quoted contributions from Tyrrell (1912), Lindgren (1911) and MacKay (1921), when he (p. 518-519) raises questions about aspects of the concentration of gold in placer deposits and then presents additional accounts. Russian deposits of auriferous quartz-pebble conglomerate are not mentioned.

This is an attractive well-bound coffee-table-type publication. It is generally free of typographical errors, aside from some inherited in reproduced papers. One amusing, inherited, enigmatic remark by Pretorius (1975) is that the northwestern side of the Witwatersrand Basin was "episodically but continuously rising". Boyle's contributions are gener-

ally very well written, but a few exceptions were noted (p. 327, 455).

In summary, the nature of this volume dictates that it is not the place to look for succinct, up-to-date descriptive accounts or fully integrated genetic models for gold deposits. Its value lies in the broad perspective of gold it provides, historically and in terms of the wide range of deposit types and wide range of theories for their genesis. Theoretically at least, we will more greatly appreciate our current (lack of ?) knowledge if we know the route by which this state was achieved. Unless purchased specifically as an interesting story about gold or for its broad descriptive and genetic perspective on gold deposits, the volume, although thick and attractive, is expensive and will largely be purchased by institutional libraries.

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Compositional Analysis by Thermogravimetry.
Edited by Charles M. Earnest, ASTM, STP 997, Baltimore, Maryland, 1988, 293 p. U.S. \$59.

This publication, which fills a long-felt need, is restricted to thermogravimetry (TG), one of the most analytical of the thermal analysis techniques; it uniquely describes just one area of application, compositional analysis. The book contains the work of 48 authors, all internationally recognized in their areas of contribution, and represents the "state of the art". It is composed of 22 reviews organized under four headings: 1. General Papers; 2. Compositional Analysis of Polymeric Materials; 3. Compositional Analysis using TG Techniques and New Instrumental Concepts; and 4. Compositional Analysis of Inorganics, Fuels, Materials and Raw Materials. Further, the 255 references quoted represent a major contribution in their own right. This succinctly written, topical, well-illustrated and clearly set out publication also reflects the current resurgence in earth-science applications covering aspects ranging from coal and oil shale through mineralogy to gas-scrubber materials and fly ash in power-generating stations. The coverage is comprehensive and of excellent reference value, but not exhaustive. This leaves scope for a complementary volume containing the remaining aspects and related techniques, such as DTG and TM, which it is hoped will be forthcoming. The present volume will prove invaluable to the professional and specialist scientist, and is strongly recommended by the present reviewer to all practicing thermal analysts.

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Feldspar Minerals. 1. Crystal Structures, Physical, Chemical, and Microtextural Properties (second revised and extended edition). By Joseph V. Smith & William L. Brown. Springer-Verlag, Berlin, 1988, 828 p., US \$210.

This is the first of two volumes of a revised edition of J.V. Smith's authoritative *Feldspar Minerals*, published in 1974 as two volumes. Its publication, especially in co-authorship with W.L. Brown, can be regarded as a major event in mineralogy. The planned second volume of this edition, with Ian Parsons as a third author, will cover material (presumably phase relations and petrology) intended by Smith for a third volume of the First Edition but which never was published. One might ask, how successful is this revision of a potentially very important work? One can answer that, despite some difficulties, it does indeed achieve the high standard to be expected from authors such as Smith and Brown.

This Volume 1 embodies all the topics included in both Volumes 1 and 2 of the First Edition, but despite the considerable length of the present work (784 pages of text plus references), it is still only a little more than half the length (1247 pages) of the corresponding material in the First Edition. This reduction in length is most welcome; much of it was achieved by replacing the repetition of short or long sections in the earlier edition by only references to them. For example, on page 418 (the beginning of Nucleation, Growth, etc.), one is referred to p. 196-302 of Vol. 1 of the First Edition, '... most of which is still valid'. It follows that this Second Edition by no means replaces the First, and that it can be regarded in many respects as supplementary to it.

This volume is divided into four *Parts* whose titles, almost exactly the same as in the First Edition, are given below. Each *Part* is divided into several Chapters for a total of 20, the titles of most of which again closely duplicate those in the First Edition. In their separately written Preface, the two authors explain that each has taken responsibility for particular chapters, e.g., JVS for those in *Part 1*, WLB for most of those in *Part 4*, etc., and that they have '...accepted each other's text... without regard for any inconsistency'. The dual authorship enhances the book in that it permits each subject to be written by the person more familiar with that material, but at the same time it leads to the occasional discrepancy (acknowledged by the authors) such as in the composition limits of the disordered monoclinic alkali feldspar sanidine: on p. 18 and 19, Smith gives (for K- and Na-sanidine) $Or > 40$, whereas on p. 210 Brown gives (for sanidine) $Or 50-80$. However, such differences between the two authors' usages appear to be few.

In a work of this magnitude and detail that fol-

lows closely an earlier edition, a reviewer can only deal with a few of the most important matters that call for comment and criticism.

The material in *Part 1, Crystal Structures* (five chapters) will, because of its highly specialized character and extreme detail and complexity in places (e.g., Chapter 5, Complex Crystal Structures), have meaning mainly for crystallographers rather than petrologists. For the former, *Part 1* provides an extremely valuable up-to-date account of the nature and interpretation of feldspar structures. Chapters 1 and 2, Introduction and Crystal Structure of Feldspar, are a valuable extended abstract of the phase relationships and structures of the feldspars. However, most readers will have to refer to detailed material later in the text to get much meaning out of many of the descriptions and terms (e.g., Bøggild intergrowth in Fig. 1.4).

The all-important matter of Order-Disorder is the topic of Chapter 3, which is updated and somewhat expanded from the First Edition. The term 'order-disorder' applied to the feldspars usually refers to the tetrahedral Si,Al atoms, as is the case here, although it can also relate to the large cations K,Na,Ca. This chapter gives a good account of the mathematical and crystallographic aspects of Si,Al ordering, including matters such as the one-step and two-step ordering trends from high-temperature disordered monoclinic sanidine to low-temperature ordered microcline. It is well established that the Si,Al atoms are disordered in a highest-temperature phase such as sanidine; it is also almost universally assumed, including in this book, that these cations are ordered (completely segregated) in a lowest-temperature phase such as (maximum or low) microcline. Considering the importance of the ordering mechanism for feldspar phase relationships, one might have thought that a theoretical explanation of it, if one exists, would be a key part of this chapter, but none is given. The opening sentence of the book (p. 3) suggests a general thermodynamic reason, and in Chapter 3, the authors discuss several other authors' interpretations of Si,Al ordering in feldspars in terms of Pauling's electrostatic valence principle, Loewenstein's Al avoidance rule, and ionic and covalent bonding. However, neither in the conclusion of Chapter 3 (p. 52-54) nor elsewhere do the authors give their preferred explanation for the driving force behind Si,Al ordering with cooling. The reader is thus left in doubt about the mechanism, and indeed about whether or not the process even goes to completion.

Part 2, Physical Properties and Experimental Techniques (chapters 6 to 12) covers X-Ray and Neutron Diffraction, Cell Parameters, Light Optics, Nomenclature, Electron-Optical Techniques, Spectroscopy (IR, NMR, etc.), and Miscellaneous Physical Properties. Much relevant material in the previ-

ous edition is omitted here, such as that on X-ray diffraction in Chapter 6, but in general these chapters are a welcome updating of the earlier edition, considering the rapid advances and applications, in the last decade, of several experimental techniques such as NMR and EXAFS but especially those utilizing electron-optical techniques (TEM, SAD, etc.). Some comments one might make on these authoritative chapters are: (1) Because the X-ray material in Chapter 6 is considerably shortened from the first Edition, the practitioner of the single-crystal X-ray-diffraction technique for the feldspars, or even the interpreter of the results, would do well to consult the earlier edition. (2) In a further elaboration of the one-step and two-step Si,Al ordering paths on p. 144-146, the authors note that most natural K-feldspars 'believed to ... approach ... thermodynamic equilibrium' (low sanidine = orthoclase) fall close to the two-step path. The question arises, how relevant is the one-step path to minerals? (3) In Table 7.1 and on several of the figures in Chapter 7, so many heated, exchanged or synthetic feldspars are included that it is difficult for the mineralogist to decipher which ones are relevant to natural materials. (4) Chapter 10 on Electron-Optical Techniques is a description of TEM and related procedures that are proving so extremely valuable in elucidating the microstructures of all feldspars. This chapter is thus a necessary precursor to much of what appears later in Part 4.

Part 3, Chemical Properties and Experimental Techniques consists of only two Chapters, 13 on Techniques, and 14 on Chemical Properties. The first is extremely brief, and the reader is referred to the First Edition. The second is a remarkable compilation (by Smith) of an extremely large number of analytical data for all possible feldspar-containing elements in all types of terrestrial rocks and meteorites. Not only are these elements compiled (and this is no computer compilation), but some comment is made about most, and then several sections describe the likely substitutions in the various structural sites. It is hard to believe the author's statement (on p. 308) that 'It is quite impractical to give all the data on chemical substitution in natural feldspar', for he appears to have achieved this! The interpretation of results of future analyses of a feldspar should surely take account of the treatment of this subject in Chapter 14.

Part 4, Diffusion, Growth, Twins and Intergrowths is made up of Chapters 15 to 20 entitled (in brief) General Review of Phenomena, Diffusion in Feldspars, Nucleation and Growth, Twins, Intimate Feldspar Intergrowths, and Intergrowths with Other Minerals. There is such a wealth of observation, description and interpretation in the Chapters in this *Part* that it is difficult to single out particular topics for comment. Whatever one's many possible interests

might be, whether diffusion in glass or melts, growth morphologies, or chemical zoning, the relevant chapters are required reading. Chapter 18 on the important but complex subject of Twins has been rewritten by Brown from Smith's earlier edition. This rewriting is enhanced by the addition of some descriptive diagrams such as Figures 18.1, 18.3 and 18.4 and in other ways, but in other respects, such as the (implied) interpretation of, for example, albite twinning in terms of a twin axis (b^*) as an alternative to a twin plane [(010)] (p. 521, 522), this description is less satisfactory than the earlier. I would recommend that anyone interested in twinning in feldspars read the account in the First Edition as well as in this one.

One of the most valuable Chapters in *Part 4* for petrologists is 19 on Intimate Feldspar Intergrowths, and here Brown collects the invaluable TEM and related results and interpretations of the microstructures of numerous different feldspars, the credit for which he shares with Parsons, A.C. McLaren and a few others. Interpretive diagrams such as those in Figures 19.9, 19.14 and 19.17 may in time prove to be classics. The material in this Chapter illustrates the extreme importance of the TEM method to our understanding of the feldspars today, and a familiarity with the results as described here is essential for anyone working in detail with the feldspars.

This Volume 1 of the Second Edition of *Feldspar Minerals* may be difficult to read in many places because of the extreme detail, the massive amount of data, and the inherent complexity of some of the subject matter. However, this book is a *sine qua non* for any petrologist or mineralogist working with the feldspars, and it will amply reward the reader with patience and persistence to extract from it the data and ideas relevant to his or her own interests. At a cost of about CDN\$250, most researchers will probably have to fall back on their grants to afford it, but by whatever means, they should acquire it and read it!

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Minerals of Cornwall and Devon. By Peter G. Embrey and Robert F. Symes. British Museum (Natural History), London, U.K. and the Mineralogical Record Inc., Tucson, Arizona 85741, U.S.A. 1987, vi + 154 pp., 36 figs., 114 color photographs, 8 maps. Price: U.S. \$32.00 or U.K. £ 19.95 (hardcover), U.K. £ 9.95 (softcover).

Minerals have been extracted from Cornwall for about 3,500 years, and the golden age of production was over 100 years ago, so that now appears to be a good time to describe these mineral deposits as they

approach their twilight years. This book is not only justified on both scientific and aesthetic grounds, but also by the fact that the mercantile and industrial development of Britain relative to the exploitation of these mineral deposits adds a theme of historical, social and economic significance.

Eighty fine specimens provide a spectacular record of minerals with great beauty in both form and color. The accompanying captions provide a wealth of detail on the crystallographic features, paragenesis, locality and history. Everyone will have a different favorite specimen; however, mine is a bournonite specimen with a simple twin, which was just recently recognized, even though the specimen was purchased in 1862.

The regional mineral collectors and dealers, who are vividly described in this book, found specimens, mainly from bygone days, of minerals rich in Sn and Cu, some with Pb, Ag, W and As, and minor species containing Zn, Sb, Ni, Co, Bi, U, Fe, and Mn. The mines that produced unusual specimens or new mineral names are succinctly described. The better specimens were so sought after about 100 hundred years ago that fakes were made and are illustrated in this book. The maps and long list of references provide excellent documentation of these mineral deposits.

The intrusion of huge masses of granitic magma nearly 300 million years ago starts the short but lucid description of the local geology. Fundamental contributions have been made on mineral chemistry, paragenesis, morphology and metallurgy from these rocks. The state of Cornish mining is profusely illustrated with maps, diagrams, and old black-white and recent photographs of old workings, both above and below ground. The difficulties encountered in deep underground mining of these hydrothermal deposits created an environment in which special skills were developed and machines were invented to work these deposits more safely and more profitably.

This book will appeal to mineralogists, mining geologists, industrial archeologists, and historians. At an extremely reasonable price, both amateur and professional mineralogists worldwide will want to have this excellent book on their shelves.

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Eclogites and Eclogite-Facies Rocks (Developments in Petrology, 12). Edited by D.C. Smith. Elsevier Science Publishers, Amsterdam; Elsevier Science Publishing Co. Inc., P.O. Box 882, New York, N.Y. 10159, 534 pages, U.S. \$115.75.

mineralogists with eclogite (a rock consisting essentially of omphacite and garnet) has produced an inordinate amount of research in relationship to the areal exposure of these unusual rocks. Justification for this concentrated research becomes immediately apparent when the student of petrology learns that coexisting garnet and clinopyroxene compositions reflect the depth and temperature for the formation of eclogitic rocks. Microprobe analyses on a small chip, together with mineral assemblages, can provide nearly instant barometry and thermometry, which then can be translated into P - T histories of both prograde and retrograde recrystallization. Such P - T -time paths have been explored for eclogite xenoliths from the mantle and for eclogite pods within high-grade metamorphic terranes. Experimental studies have corroborated the chemical changes of the garnet and pyroxene at measured pressure and temperature in laboratories; within analytical and thermodynamic uncertainties, there appears no real controversy on the validity of using coexisting garnet and pyroxene to establish fossil P - T conditions. There has been, however, a long-term and sometimes bitter disagreement as to where and how eclogitic rocks form. What is the tectonic mechanism that brings the lower-crust or upper-mantle rocks to the surface? How can they preserve evidence of such extreme crustal or mantle conditions? Melting of eclogite has also been utilized as an important process in the generation of basalt magmas within the Earth's mantle. Because of its unusually high density of 3.4 g/cm³, geophysicists have also utilized the phase change of gabbro or basalt to eclogite to explain velocity anomalies in the upper mantle.

This book is the first to deal exclusively with eclogites and eclogite-facies rocks. The editor, David C. Smith, has been involved in mineralogical, petrological, and tectonic research on eclogitic rocks for the past twenty years and is himself often at the center of the eclogite controversy. The book is divided into eight chapters, with the first chapter, over 200 pages in length, by Smith, who gives a detailed and scholarly review of the Norwegian coesite eclogite province using crystal-chemical, petrological, geochemical, and geodynamic arguments that in some passages reveal his fervor. Eclogites from classic Norwegian localities most often occur in small discrete bodies tens of meters in size over a wide area in the Western Gneiss Region. The presence of inclusions of relict coesite in both garnet and omphacite requires pressures of 28 ± 5 kilobars; Smith asserts that these pressures are only obtainable within the mantle or lower crust, leading to his interpretation that the eclogite pods must be "foreign" and that they are introduced by "lithospheric interdigitation" of mantle or deep crustal fragments in the upper crust. This tectonic or *mélange* concept of Smith has not been accepted

The continued fascination of petrologists and

by all Norwegian eclogite experts, who contend that the field relationships indicate that the protoliths for the eclogites are minor mafic dikes and sills emplaced high into the Western Gneisses and later tectonically buried to great depths (> 70 km) and metamorphosed together with the surrounding gneisses as part of a continent–continent collision during Caledonian time (early Paleozoic). Smith makes a plea for re-evaluation of nonlithostatic overpressures and underpressures and suggests a possible compromise hypothesis for formation of ultrahigh-pressure rocks. Perhaps one of the first steps to resolve the eclogite controversy is to produce more detailed maps of these eclogite localities, along with precise structural histories, so as to reconstruct past stress-fields and deformation histories for both eclogites and their surrounding gneisses. In fact, there is no single geological map in his chapter to illustrate such relationship between metamorphism and deformation. No table listing mineral assemblages in different eclogite pods and their country rocks is given. Both geological maps and mineral parageneses are essential for readers to assess the validity of different tectonic models.

Many peculiar mineral, (*e.g.*, högbomite, kandite, lisetite, nyböite, *etc.*) and their chemical and petrographic characteristics are described and illustrated in numerous photomicrographs. Several new compositional plots, such as the “clinoamphibole half-cube”, “sphene (*sic*) pyramid” and “mica hexagon”, also are proposed; however, many of these are complicated and graphically difficult to portray. Chapter 1 summarizes many of Smith’s previous observations and interpretations, which appeared mainly in abstract form in previous publications. The detailed descriptions of petrographic features, crystal-chemical properties of the common and rare eclogitic minerals, as well as the diverse geometrical interpretation of crystallization, provide a wide-ranging menu for eclogite experts. For example, we were able to identify coesite and its quartz pseudomorphs from eclogites in central China by comparing textural and morphological features in these rocks to the photomicrographs presented in his chapter.

The succeeding chapters provide a rather uneven coverage of the eclogite problem. Ghent in Chapter 2 provides an elegant review of chemical zoning in eclogitic garnet as a function of both temperature and rates of volume diffusion for each element involved. He addresses the use of solid inclusions in zoned garnet to deduce the *P-T* evolution of eclogites, and the limitations and problems of such methods. He also examines the different variables involved in the homogenization of garnet and attempts to quantify closure temperatures from existing data on volume diffusion. Compared to previous summaries of zoning in metamorphic minerals,

this chapter addresses more specifically the applicability of the various diffusion-models to patterns of garnet zonation in eclogites. Rossi in Chapter 3 provides a similar review of clinopyroxene in eclogites and gives a really useful account of chemical variation as well as crystal structure. He suggests that the degree of order with respect to compositions of clinopyroxene could be used to decipher the thermal (and cooling) history of the rocks. The use of solvi and exsolution in clinopyroxene may prove to be a useful geospeedometer. However, this chapter does not address the effects of order–disorder in clinopyroxene on geobarometry, particularly in the light of some recent experimental results.

Godard in Chapter 8 presents a detailed summary of the occurrence and petrology of Hercynian eclogites from the southern Armorican massif in France; he proposes that three distinct groups of high-pressure rocks may have quite distinct origins and metamorphic histories. This chapter presents two useful techniques that are seldom used by petrologists: a combination of mineral modes, compositions and bulk-rock chemistry to identify the protoliths, and a petrofabric study to define the distinct stages of deformation in relation to the growth of various minerals in eclogites. Some eclogites, such as kyanite-rich and quartz-rich eclogites, may have formed *in situ* by crustal metamorphism, and nearly all have been retrograded to blueschist and epidote amphibolite. However, at least some of the eclogites have oceanic crust affinities and amphibolite precursors; their present position within continental crust may require abnormal tectonic transport or “lithospheric interdigitation”, as Smith suggests.

The long standing problem of “What are the silica-rich isofacial rocks of the eclogites?” has been clearly brought out by studies of Black, Yokoyama, and Brothers on the assemblages of eclogite-facies metaacidites in northern New Caledonia in Chapter 4, and by Schliestedt and Okrusch on the silica-rich metamorphic rocks associated with eclogites and glaucophanites in Sifnos in Chapter 5. In these two separate regions, the assemblage quartz + jadeite ± garnet + phengite (paragonite) is considered isofacial with eclogites, but no maps or photos corroborate that they indeed were metamorphosed together. In fact, these descriptions and our own personal observations in these same areas reveal tectonic imbrication of the various units.

Chapter 6, on xenolithic eclogites brought to the surface in kimberlites and alkali basalt pipes from southeastern Australia and the Colorado Plateau, by Arculus and others, discusses their mantle origin on the basis of *REE* distribution and $^{87}\text{Sr}/^{86}\text{Sr}$ and $^{143}\text{Nd}/^{144}\text{Nd}$ isotopic characteristics. The lower crustal geochemical evolution of granulites and eclogites was shown to be complementary. In Chapter 7, Helmstaedt and Schulze describe eclogite-facies

rocks as xenoliths in Colorado Plateau diatreme breccias that have affinities to metamorphosed ophiolites from high-pressure orogenic belts. They suggest that these xenoliths may represent earlier subducted oceanic rocks that became underplated to the North American plate during earlier subduction of Pacific Ocean crust.

This book is neither a compilation of case studies of eclogites and eclogite-facies rocks throughout the world, nor is it exclusively a study of new mineralogical, crystal chemical or geochemical tools applied to solve petrological problems related to eclogites. Nevertheless, it contains many references and a series of reviews, and incorporates a large quantity of petrographic detail accompanied by previously unpublished data that are certainly interest to most petrologists and mineralogists. We highly recom-

mend that they have a copy on their bookshelf. For the earth scientists who have only a casual interest in eclogites and want to learn more about them, this book will only tend to confuse. The eclogite facies is not clearly delineated, nor are the *P-T* conditions of formation of the different types of eclogite clearly outlined. The models for eclogite formation are fuzzy and conflicting. Geophysicists will have their worst fears confirmed that petrologists become entangled in endless discussions on unimportant issues and often fail to address the physical and tectonic parameters that may provide answers to the problem.

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THIRD INTERNATIONAL SYMPOSIUM ON EXPERIMENTAL MINERALOGY, PETROLOGY, AND GEOCHEMISTRY

EDINBURGH, UK April 5-7, 1990

University of Edinburgh, Dept. of Geology and Geophysics, West Mains Road, Edinburgh EH9 3JW.

Following the successful symposia at Nancy 1986 and Bochum 1988, this third meeting will be devoted to current progress in *experimental studies* in the fields of mineralogy, petrology, and geochemistry, to include crystal chemistry, ore deposits, rock deformation, crystal growth, fluid/rock interaction, element distribution, phase equilibria, physics of minerals and melts, and magma rheology. Papers presenting purely analytical results, or pure petrograph will not be considered. Sessions will consist of both invited and submitted papers. Sufficient time will be reserved for poster sessions.

The Symposium will be held at the Heriot-Watt University Campus, just west of Edinburgh, with on-site lecture theatres, restaurants and accommodation. Please write to Dr. G.M. Biggar, at the address above, with the provisional title of any planned presentation, as soon as possible. A second circular will be distributed in the autumn of 1989 only to those who have pre-registered, and will give details of sessions, abstract deadlines (probably 1 November 1989), social events, and accommodation. Apex air fares with a Saturday night stop-over are much cheaper. The conference finishes with a farewell lunch on Saturday included in the registration fee. There are very few direct (or same plane) flights from Edinburgh or Glasgow to Europe on Saturday afternoon or on Sunday. Several excursions to geological or tourist regions of Scotland will be offered on Sunday. There are flights to Paris, Amsterdam, Dusseldorf, Brussels, Hannover, Copenhagen or Frankfurt on Monday, without a change in London.