BOOK REVIEWS

Ahmedali, S. T., Ed. *X-ray Fluorescence in the Geological Sciences: Advances in Methodology*. (Geological Association of Canada, Short course 7), 1990, 297 pp.

This book is a collection of papers presented at a Geological Association of Canada short course aiming to bring together advances in methdology of XRF analysis of geological materials over the five years up to 1989. As such, the style varies substantially, from Abbey's almost verbatim transcript of his lecture, to highly mathematical contributions by Lachance and Rousseau, of which the latter includes 60 pages (!) of synthetic and modelled data tables. This and a lack of index, does not allow easy reference use of the book. However, the contents are wide-ranging and make for mostly interesting reading. Abbey's contribution deals with the compilation methods used in obtaining 'recommended values' for element concentrations in international standards. While this is important background knowledge for the XRF analyst, I felt that too much emphasis was placed on the minutae of the semi-statistical methods used, and far too little on the potential shortcomings of the data that the compiler has to deal with. The main problem is that different analytical techniques have very different errors, both in absolute numerical value, and in the likely *nature* of the error. Abbey shows very different histogram distributions for Eu, Sm and Th versus Ni, and Cr and Co in granite AC-E, and interpolates 'recommended values' without using an understanding of the reason for the differences. This is probably because Eu, Sm and Th will largely be INAA determinations with ca. 5% errors, while the transition elements will be mostly XRF/ICP values with perhaps 5 ppm errors at a 5 ppm concentration. I long to see a standard compilation which takes into account errors in the supplied data: this is vital as the standard data provide the only check on the accuracy of an XRF method.

Sample preparation is discussed in papers by Claisse and Kocman, the former giving details of a fusion procedure which will be of use to those starting new laboratories, but it did not appear to me to be a recent advance in methodology. Lachance and Rousseau provide complex discussions of XRF interelement correction procedures, of which I found the comparative treatment of Lachance the most interesting. Neither would be easy to apply in a new laboratory, however, and for many elements I suspect that the increased numerical refinements cannot be justified by standard data quality. In a second article, Rousseau does however continue to describe a XRF data-processing program to apply his algorithms. When this is made available, it should prove most useful: I especially enjoyed Rousseau's plea to manufacturers!

Papers by Willis and Harvey I found both interesting and potentially immediately useful. Willis gives an excellent description of the use of scattered radiation for matrix correction, and also discusses in depth problems of infinite thickness and background corrections. Harvey gives some fairly detailed suggestions on the use of XRF in exploration geochemistry, including machine conditions and interferences, for a wide variety of elements. Readers should however take note of his comment that his list of interferences is not exhaustive: he doesn't list the major interference of Ti on V! Finally, a paper by Kocman gives useful ideas for analysis of gypsums, though his section on carbonates is rather too concise.

In summary, the book contains a number of useful contributions to XRF and analytical techniques, but is rather flawed in organisation. Further, although it claims to present advances in XRF methdology, these are not very helpful when they are difficult to apply in practice. I would nevertheless recommend it for XRF analysts, and not exclusively to those with geological interests.

M. F. THIRLWALL

Geyh, M. A. and Schleicher, H. *Absolute Age Determination: Physical and Chemical Dating Methods and their Application*. Berlin, Heidelberg and New York (Springer-Verlag), 1990. xi + 503 pp., 146 figs + 1 fold-out chart. Price DM 98.00

This book is about the use of physical and chemical processes with fixed or known rates as methods for determining the age at which the process began and the relevance of that age to

some event. To call such an age 'absolute' is a bit strong since it is always dependent on model assumptions, but I suppose that it is the way such ages are known by the intended readership. This readership could be large indeed because this book is certainly not just for the specialist but for all those who need a quick introduction in dating methods. The book covers some 80 different dating methods from the commonly used, such as Rb/Sr, Sm/Nd, K/Ar and ^{14}C, to the esoteric and the obsolete. The scope includes the traditional geological applications depending on half-lives from millions to billions of years and the archaeological and palaeoclimatological ones depending on half-lives of thousands of years. Environmental research employing the short half-lives of only tens of years of both cosmogenic and man-made nuclides are also covered. Various dating methods based on the effects of radiation such as fission track, thermoluminescence and electron spin resonances are also covered, as are chemical dating methods based on more or less constant reaction rates such as amino-acid racemisation and the highly fashionable DNA clocks based on nucleotide substitution in mitochondrial DNA. Least 'absolute' are the methods based on variations in $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ with a few well-defined time markers. Arguably the 'most' absolute methods such as counting varves, tree-rings or growth-zones in corals or molluscs are only mentioned indirectly.

Treatment is highly structured in a more or less standard way which makes finding information fairly easy. Most topics include sections on age range and precision, the nature and required amount of sample and its pre-treatment, the basic concepts and the analytical techniques, scope and limitations and non-chronological applications. Clearly only limited detail can be given on each method but the basic coverage is sufficient to give non-specialists the background information that is usually left out of geochronological papers in geological journals.

There are over 50 pages with nearly 2000 references which always include the first proposal of a method and subsequent major advances; the latest references are up to 1989. A 22 page glossary and a comprehensive index further improve the accessibility for the non-specialist. The analytical section deals with standard mass-spectrometry and activity counting techniques and also laser resonance ionisation and accelerator mass spectrometry which are practised in only a handful of laboratories world-wide; there are also some useful hints on sample collection, packing and storing!

The book has some characteristics of a vademecum although my soft-bound copy may not have the durability for such use. Typographically, the layout is clear, paragraph numbers and fonts make for easy searching and only in a few figures is the finest ornamentation a bit faded. The German origin of the book is evident from the names in some figures but the text translation is excellent with very few 'germanisms' or incorrect jargon. The same is not true for typo's which occur at a rate of one per page in some chapters.

This truly compendious book belongs on the shelves of every scientist who practises dating but is, like me, not *aux fait* with the whole scope of dating methods. It is certainly a good buy for libraries in earth and environmental sciences and archaeology departments.

P. VAN CALSTEREN

Harris, D. P. *Mineral Exploration Decisions: a Guide to Economic Analysis and Modeling.* Chichester and New York (John Wiley and Sons), 1990. xviii + 436 pp. Price £59.00.

Mineral exploration is a risk business and practitioners earn their daily bread by answering questions such as . . . Should we risk the cost of another drillhole? Where is it best located? Will the resulting new data contribute critically to a decision to stop or go? Or . . . What are my chances within budget of finding more deposits within this mineralised region or geological environment? Big or small? Potential profitable producers or technical successes only?

This 418 page text demonstrates how such management decisions can be enhanced by disciplined and professional use of economic analysis and modelling. It is for digestion by specialist mineral economists, who will find a text based on theory throughout, with liberal doses of mathematics. But it is also for tasting by those many practical but perhaps less numerate explorationists who seek in one handy volume an appreciation of the capabilities and limitations of the growing discipline of economic analysis and modelling.

Two introductory chapters and a final 5 page Summary chapter—that is the one to read first for the flavour—are linked through 12 chapters devoted to statistical methods. Best practice in geology and exploration technology is assumed, and the author deals with topics such as 'geoprobability models' and economic filters, methods of accounting for the risk of loss due to exploration failure, Monte Carlo computer simulations, fre-

quency distribution patterns and models, search theory, Bayesian statistical decision theory, with a brief excursion into geostatistical methods.

The author has backed up explanatory theory and comment with 19 illustrative case studies (some 60% of the text) taken from the literature and professional reports and studies between 1957 and 1988. These range from Allais' classical study (1957) of the economic feasibility of mineral exploration of the Sahara, through various oil plays and metallic mineral exploration cases, to a demonstration of the mathematical methodologies involved in a most detailed simulation (Harris and Ortiz-Vertiz, 1981) of roll-front sandstone uranium deposits, exploration procedures, and modelling of development and mining operations and costs, with consideration at all stages of economic factors and risks.

The contribution of economic analysis to the overall efficiency of the exploration process is optimised in situations where the objective of exploration is cost-effective extension of known mineralised environments, blessed by a rich data base. This point is demonstrated by nearly 75% of the case study material referring to oil, porphyry copper and sandstone uranium deposits. Enthusiasm for guidance by statistical analysis may, by contrast, be unwelcome in situations where greenfield discovery could be impeded by the cold touch of unimaginative statistics and economics. Some exploration managers guard against imposing on talented explorers those constraints that may stifle such qualities as flair, enthusiasm and geological inspiration that lead to discovery of the unexpected—cases where no model exists until the new find is made—for example Boddington and Olympic Dam. Like other exploration tools, economic analysis and modelling may be used or abused, and its proper application should be understood.

The book is well presented, with few typographic errors, clear diagrams (nearly all reproduced from earlier sources) and with ample help around the text from a 9 page index, many sub-titles in the text, a catalogue of Contents covering 7 pages, and a useful if not comprehensive 7 page reference list of the subject matter.

This volume will be very useful in libraries of specialist teaching and professional institutions and exploration companies, but not many individuals will wish to spend £59 for material that is, by and large, already available in the literature.

G. R. DAVIS

Dunham, K. C. Geology of the Northern Pennine orefield–Volume 1. Tyne to Stainmore, London (British Geological Survey), 1990. x + 300 pp., 10 plates, 46 figs. Price £32.00.

This volume describes the geology of the important carbonate-hosted lead/zinc deposits in the North Pennines district of Northern England. It is the second edition of the original 1948 publication and contains a large amount of additional information which has been derived during the last 40 years, much of it from the continued mining activity.

The first part of the text includes descriptions of the mining history, regional geology (of the granite, the host Carboniferous sediments, and the Whin Sill) and the regional structure. Then there follows a general description of the mineral deposits, including the primary and secondary mineralogy, paragenesis and zoning, wallrock alteration, age, and genesis. The second (and major) part is devoted to detailed descriptions of the individual deposits in the orefield, and includes numerous maps and sections.

The most valuable aspect of this publication is the presence of several diagrams showing the form of the ore 'shoots' and the structural and lithological controls to the mineralisation. Unfortunately, thoughtless binding means that some of the diagrams cannot be viewed fully, and this has marred their otherwise high quality and value.

The style of the text is rather ponderous and does not make for easy reading. In addition, some of the editing could have been better. A cursory glance through the reference list revealed several mistakes—including misspelling the names of BGS personnel! Most of the text is however informative, although the part which deals with the genesis of the deposits does appear rather dated. For instance the mineralisation is thought to be due to aqueous solutions as 'melts of the minerals could not exist within the introduced mineral suite'. Similarly, there is a discussion on whether saline brines necessarily point to a source from granites. Such discussions are unnecessary; it would have been much better to include some comparisons with similar deposits worldwide and make reference to recent conclusions concerning their genesis.

As a reference work for the location, form, geological setting and characteristics of these deposits, this is an excellent publication. Researchers involved in the North Pennines district or carbonate-hosted Pb-Zn-F-Ba deposits in general, will find it useful for this. However, it says little about their status as

Mississippi-Valley-type Pb/Zn deposits, and throws little new light on their genesis.

D. H. M. ALDERTON

Carswell, D. A., Ed. *Eclogite Facies Rocks.* Blackie (Glasgow & London), Chapman & Hall (New York), 1990. xv + 396 pp. Price £77.00.

This is the second book ('book 2' here) to appear which is devoted to eclogite-facies rocks, the first ('book 1' here) being: Smith, D. C. (Ed.), '*Ecologites and Eclogite-Facies Rocks*', Elsevier Science Publishers (Amsterdam & New York), 1988, xxii + 524 pp., price £60, which constituted n° 12 in the Elsevier Series 'Developments in Petrology'. Although they are both multi-author books with about 20 authors each, they are complementary rather than competitive. Thus whereas book 1 dealt in great detail with a few selected topics (since earlier special volumes of three journals (ed. Smith, D. C.) dealt with many other selected topics), book 2 attempts to provide a comprehensive review of all relevant topics but in significantly less detail. Unlike book 1, book 2 is however one of those books where editorial control is exercised strongly by the editor being coauthor of most of the chapters, only 5 of the 13 chapters having escaped.

In chapter 1 D. A. Carswell introduces his versions of the definitions and classifications of eclogites and of the elusive eclogite facies; unfortunately chapter 1 reviews only certain favoured opinions and perpetuates some well-entrenched but disputable ideas without attempting to find a consensus such that it cannot succeed in providing a major advance for the 1990's. A. Mottana, D. A. Carswell, C. Chopin and R. Oberhänsli describe eclogite-facies mineral parageneses for various kinds of bulk-rock compositions (chapter 2) and thus provide a petrological basis for the rest of the book.

A pair of chapters by S. L. Harley and D. A. Carswell and D. A. Carswell and S. L. Harley respectively summarise a number of experimental studies on natural and synthetic rock compositions (chapter 3) and a range of geothermobarometric methods relevant to eclogites (chapter 4); however, despite a well-organised approach, there are several notable omissions for supposedly comprehensive reviews, whereas one receives an overdose of 'evaluation tests' by Carswell and Gibb (1980a, b, 1987a, b) and of their rather subjective assertions of 'superior' geothermobarometric methods based on dubious philosophic foundations.

D. C. Rubie explains modern ideas on the kinetics of mineral reactions (chapter 5) and D. Gebauer provides a modern review on isotopic systems used for the geochronology of eclogites (chapter 6); both of these chapters are particularly important when dealing with polymetamorphic terrains, which is often the case of eclogite-bearing terrains.

The subsequent chapters principally concern one or more specific geographical regions displaying eclogite-facies rocks. Thus M. Schliestedt reviews low-*T* eclogites in California, New Caledonia and Greece (chapter 7), whereas high-*T* eclogite xenoliths in Kimberlites and other diatreme environments are reviewed by W. L. Griffin, S. Y. O'Reilly and N. J. Pearson (chapter 12) and/or by J. B. Dawson and D. A. Carswell (chapter 13). The three principal medium-*T* eclogite-bearing orogens in Europe are dealt with in reviews by S. J. Cuthbert and D. A. Carswell (Caledonides: chapter 8), P. J. O'Brien, D. A. Carswell and D. Gebauer (Variscides: chapter 9) and G. T. R. Droop, B. Lombardo and U. Pognante (Alps: chapter 10).

In chapter 11 L. G. Medaris and D. A. Carswell summarise the available data on Mg-Cr garnet-peridotites in Europe, these rocks representing certain utlrabasic bulk-rock compositions at high *P* which is a subject where Carswell does have a solid reputation.

The various chapters incited innumerable praiseworthy comments but also innumerable condemnations such that the first version of this review almost became a new 'book 3'. However space limitations necessitated the present format which is obliged to concentrate on repudiating one appalling chapter (n° 8) which sets the clock back a decade just when most petrologists are preparing for the new models of the next century as the coesite saga blossoms with further discoveries of ultra-high *P* metamorphism in China, Russia, Switzerland and Germany in addition to the already-classic discoveries in Italy and Norway; indeed the publications on the Norwegian occurrences are now being treated as reference descriptions by other researchers so it is essential to get the record straight concerning Norway. All of the references cited below may be found in book 1.

Chapter 8 reviews various aspects of eclogites in the Scandinavian Caledonides in a superficially elegant fashion which helps to hide the fact that the authors lead the reader into a minefield otherwise known as the 'Norwegian eclogite controversy'. This began in the 1960s and was based essentially on the recognition of a significant difference in *P* between very high-*P* eclogites (in the range 20–40 kbar) and lower-*P* country-

rock gneisses such that the eclogite lenses had been tectonically introduced as foreign bodies (e.g. the 'foreign' school of Lappin, 1966; O'Hara, 1976; Lappin and Smith, 1978; etc . . .), and the refusal to recognise any *P*-difference such that the eclogite lenses had simply been metamorphosed co-facially *in situ* within the country-rock gneisses (e.g. the '*in situ*' school of Bryhni, 1966; Mysen and Heier, 1972; Krogh, 1977; etc.). The controversy has evolved considerably and starkly contrasting recent reviews are available in Griffin (1987) and Smith (1988).

The collision between an immovable object (the *in situ* school's amazingly fixed belief in relatively low-*P* eclogitisation, which has gradually increased over the years from 7 kbar up to about 20 kbar, see review Table 1.6 in Smith (1988)), and an irresistible force [the relatively high-*P* eclogitisation, ≥about 30 kbar, subsequently confirmed by the presence of definite coesite by Smith (1983, 1984)], has inevitably led to the generation of much friction. An amusing consequence of the fixed belief is the publication of a series of deduced eclogite *P–T* trajectories which run parallel to and very close to the line of the albite = jadeite + quartz reaction, very close merely because they were politically not allowed to traverse the line despite the absence of any scientific contraints (e.g. Cuthbert *et al.*, 1983; Griffin *et al.*, (1985; see points 1.6.1.(g) and (h) in Smith, 1988).

In conformity with the traditional mafia-like techniques of certain members of the *in situ* school, chapter 8 proceeds with misleading imprecise reporting and with diversional non-reporting, rather than with exact reporting followed by scientific criticism of those points that the authors do not believe (see the evidence presented below). The need to discuss a number of key points in the controversy is neatly avoided by referring the reader to the 'comprehensive reviews' of Cuthbert *et al.* (1983), Griffin *et al.* (1985) and Griffin (1987) which are all largely identical in promoting the relatively low-*P* *in situ* model in a characteristic unbalanced fashion, and by not referring to a long detailed review (Smith, 1988) which challenged, if not demolished, much of the data and conclusions of those earlier reviews and which was published in book 1 well before book 2 went to press. To avoid repeating the same challenges, many of which had previously been published but rarely counteracted, the reader is referred to Smith (1988) (which, incidentally, openly declared (p. 5) that its section 1.6 was biassed in order to redress the balance) such that only a few points in chapter 8 of book 2 will be criticised here.

1. (p. 185, 193, and 200): That the high-*P* *jadeite + quartz* association 'has not been reported' in Norway is untrue (e.g. see the descriptions thereof by Kechid and Smith (1985) and Smith (1988)). Likewise the existence of several other relevant high- or very high-*P* indicators in the eclogites are ignored, such as coexisting magnesite + diopside (e.g. Lappin & Smith, 1978, 1981); nyböite (e.g. Ungaretti *et al.*, 1981; Smith and Lappin, 1982); etc . . . That *nepheline* 'has not been described from retrograde eclogites' in Norway is also untrue [e.g. see the descriptions of Ca-Na-nepheline by Rossi *et al.* (1984) and Smith *et al.* (1986)]. Again many other indicator minerals recorded in retrograded Norwegian eclogites are not mentioned although they are relevant to any petrological discussion, e.g. preiswerkite (Smith and Kechid, 1983); pumpellyite (Smith, 1984); lisetite (Rossi *et al.*, 1984; Smith *et al.*, 1986); etc . . .

2. (p. 185): *P estimates* in the country-rock gneisses '*compatible* with those derived from eclogites' is a widely-publicised but pathetic argument based on the overlap of the highest *P* estimates for *certain* gneisses with the lowest *P* estimates for *certain* eclogites which are quite different from the coesite-eclogites such that there is still no evidence yet that any, let alone all, of the gneisses passed through the same ≥30 kbar metamorphic stage as the coesite eclogites. Cuthbert and Carswell avoid mentioning the *incompatibility* between certain published field descriptions and what one can actually observe in the field; notable discrepancies include a key locality at Midöy (Carswell and Griffin, 1985) about which substantial doubts were expressed by several members of the 1987 International Eclogite Excursion (see point 1.6.1.(n) in Smith, 1988).

3. (p. 187): Three different kinds of *reaction pathways* are described which can lead to the creation of *c.* 20 kbar eclogites by pressurisation. A fourth pathway, by depressurisation, from the ≥30 kbar coesite-eclogite facies into the quartz-eclogite facies is totally ignored in the text. It does however appear in the legend to Figure 8.6 where the authors mention the '*possible* presence of coesite' in Norway despite the publications with microphotographs of critical textures and of unequivocal physico-chemical data to confirm the coesite nature of the SiO_2 structure (e.g. Smith, 1984; Boyer *et al.*, 1985). The *maximum P* in the Scandinavian Caledonides is clearly expressed twice (p. 194–196) by Cuthbert and Carswell as being at about 20 kbar in absolute conflict with the presence of coesite which hence does not fit into the geotectonic model proposed in chapter 8.

Where evidence of the previous higher *P* event in the gneisses exists (e.g. the presence of typical symplectites after omphacite), the authors follow the *in situ* school in assuming that the earlier high-*P* event was the *same* one as that in 'the' eclogites without any evidence whatsoever for any identity in *P* or *T* (or in time) with the coesite-eclogite facies metamorphic event.

4. (pp. 201–3): The statements that the Western Gneiss Region (WGR) was 'largely a coherent body during eclogite-facies metamorphism' and 'It is now clear that these "type B" eclogites are not "geologically out of place", but shared their entire metamorphic history with the high-grade gneisses in which they lie' both fit in nicely with the overall *in situ* school's model of a single, around 20 kbar, quartz-eclogite facies metamorphic event with a regional *P–T* gradient; Cuthbert and Carswell however ignore various data indicating that the metamorphism was neither single, nor constrained to 20 kbar, nor even regional with gradients (see section 1.6 in Smith, 1988). Apart from the scandalous neglect of *definite* coesite (see also p. 348), the major problem is the flagrant inability of the *in situ* school to conceive that different localities of eclogites displaying differences in field relations and textures, in mineral assemblages, compositions and reactions, in bulk-rock chemistry, and/or in *P–T* estimates might represent completely-different geological events. The authors do recognise differences between the WGR and certain other Scandinavian regions (Bergen, Tromsö, Seve) but they unjustifiably lump together *all* of 'the' eclogites in the WGR; this is analogous to declaring that *all* of 'the' granites in Scotland shared the same history but that they do different from those in Cornwall or Donegal!

If ever it can be reasonably shown that the *entire* WGR did experience ultra-high *P* coesite-eclogite facies metamorphism (e.g. by the discovery of coesite or of its traces at many widespread localities of the different types of country-rock gneiss), then, perversely, both schools would have simultaneously won and lost:

—*lost* by the *in situ* school since their repeated attacks on ultra-high *P* would have been erroneous and/or unjust, *won* since the *in situ* metamorphism model would have become credible;

—*won* by the foreign school since their consistent maintenance of ultra-high *P*, in the face of a cascade of ridicule, would have been vindicated, but *lost* since the foreign tectonic introduction model would have become unnecessary.

In conclusion, the publication of a book is also an event, both scientific and politico-scientific. Chapter 8 thus has to be considered in the context of other politico-scientific events such as:

(i) the publication of book 1, followed by its diversionary, hence destructive, review by Carswell (1990, *Mineralogical Magazine,* **54**, pp. 345–7) which contrasts with all the other published reviews of book 1;

(ii) the *in situ* school's successfully-orchestrated attempt at the Second International Eclogite Conference (Vienna, 1985) to convert a programmed debate on the *significance* of coesite found in eclogites into heated, but wasteful, dispute over the *existence* of coesite;

(iii) The fact that the symposium on *High-P* Metamorphism' at EUG VI in Strasbourg in 1991 was reorganised after the sudden replacement of the originally-invited convenors (including D. C. Smith) by another group (including D. A. Carswell) because 'in some cases politics is at least as important as science' (the official explanation confirmed in writing by the EUG VI presidential office: 3 August 1990); and

(iv) Carswell's audacious coauthorship of an open letter (10 September 1990) inviting geologists to come and join discussions at this symposium on 'exciting . . . developments', including the fact that 'coesite is now being found increasingly in Europe'.

If it is true that Carswell at last believes in the *existence* of coesite in Norway, then one may contemplate whether chapter 8 has any value at all.

As for recommending, or not, that this book be bought by libraries and individuals, I do not repeat Carswell's (1990) attempt to place only one of books 1 and 2 on bookshelves. Both books have sufficient merit for library acquisition, and honest uncensored science requires that both books 1 and 2 stand side-by-side to provide the widest possible access to the often-conflicting data and ideas available to readers wishing to formulate their own opinions, which, to be independent, must be based mainly on *critical* examinations of the data in *original* articles rather than on other peoples' *uncritical* reproductions thereof. Likewise specialists on metamorphism should have both books handy, regardless of the contrast between a book 1 limited to detailed specific topics and a more comprehensive book 2 with blinkers on.

D. C. SMITH

[We regret this review was received late: it refers to an earlier review of a book on the same topic in *Min. Mag.* (1990) **54**, 345.]

Campbell, J. D. *Hidden Gold: the Central Norseman Story*. Parkville, Victoria (Australasian Institute of Mining and Metallurgy: Monograph **16**) 1990. 128 pp. (2 vols), 81 figures and plates. Price $A 75.00.

The two volumes of this monograph trace the development of exploration and mining of the main gold-bearing reefs in the Norseman district at Western Australia. Campbell commences the story of systematic exploration with the 1934 structural model of H. J. C. Connolly—a moderately dipping main shear system intersected by flatter dipping shears (his 'links') that produce gently plunging tabular bodies of mineable grade mineralisation.

He demonstrates the early exploration failures and successes and development of the 'favourable horizon' hypothesis to account for regional distribution of ore shoots on the main reefs. This is a documentation of continuous development of models to predict ore occurrence and the empirical process of testing and modifying these models as underground headings and diamond drilling provided new information.

This work is almost unique in that it covers the continuous exploration and development programme of a mining camp throughout its history of systematic exploitation and demonstrates how mines require adequate reserves to be blocked out well ahead of mining. Some readers might criticise Campbell for not including modern data on petrology/mineralogy, alteration assemblages or microstructural detail. Reference is made to recent academic studies but these volumes are essentially the story of empirical models where exploration is done with a jackhammer rather than a microscope.

The superb illustrations in this monograph, with 81 figures and plates, give a clear picture of the models proposed and provide a permanent accessible record of the geometry of the orebodies. It is a useful text for students of mining geology and perhaps also a good lesson for older exploration geologists. Both innovative geological techniques and drilling technology were developed by the people at Norseman: how many geologists have used Connolly's contour method to aid interpretation or the Clappison wedge to control their diamond drilling?

T. LIVERTON

Jaffe, H. W. *Introduction to Crystal Chemistry* (Student Edition). Cambridge and New York (Cambridge Univ. Press), 1989. xii + 161 pp. Price £15.00.

Jaffe, H. W. *Crystal Chemistry and Refractivity*. Cambridge and New York (Cambridge Univ. Press), 1989. xii + 335 pp. Price £55.00.

The text 'Crystal Chemistry and Refractivity' is presented in two parts. The first part on the principles of crystal chemistry and refractivity has also been published as a student edition entitled 'Introduction to Crystal Chemistry'. The review of 'Crystal Chemistry and Refractivity' that follows, therefore, implicitly also applies to the shorter student edition.

These volumes are aimed at senior undergraduates, and attempt to integrate ideas on bonding, atomic packing and cation distribution. These ideas are then applied in order to explain the physical properties of minerals, with special emphasis being given to their optical characteristics.

In part I of the larger volume, the initial chapters introduce the basics of atomic structure, electron orbitals and bonding. In Chapter 3 the covalent bond is discussed in more detail, and the structures that are adopted by compounds exhibiting this bonding are reviewed. Subsequent chapters concentrate on the ionic model, and introduce and apply Pauling's Rules. The ideas of symmetry and crystal field theory are presented, and their influence on crystal structures outlined. These chapters are followed by a more general discussion of crystal chemistry, the formation of solid solutions, and their effect on density and crystal structure. All the foregoing is fairly standard stuff, and presented very well. The final chapter of part I is quite unusual, however, with a detailed discussion of refractivity and polarisability. This is a welcome contribution, since most optical mineralogy texts do not discuss the physical origins of refractive index in any detail. Jaffe also provides students with a good review of the Gladstone-Dale laws, and their various extensions and applications.

Part I stands by itself (hence the shorter volume, 'Introduction to Crystal Chemistry', is quite viable, and may appeal to some students). Part II, only found in the larger volume, consists of a series of chapters in which the structures of silicates and oxides are discussed in the context of their physical and particularly optical properties. Throughout, the structures are illustrated by some clear and well produced line drawings. They are also illustrated by some rather less clear and unattractive black and white photographs of obviously home-made packing models. These packing models may well be ideal, hands-on teaching aids, but they do not translate well onto the printed page.

In conclusion, these are interesting books, with some valuable features. They are somewhat idiosyncratic, but nevertheless should be on the shelves of all institutions involved with mineralogy. I doubt, however, if they will catch on as major teaching texts.

G. D. PRICE

Fleischer, M. and Mandarino, J. A. *Glossary of Mineral Species 1991.* Tucson, Arizona (Mineral Record Inc., PO Box 35565, AZ 85740, U.S.A.), 1991. vi + 256 pp. Price $15.00 plus $1.00 postage and packing ($2.00 foreign).

This, the sixth edition of what has become a truly indispensable reference, contains some 200 new mineral names, bringing the number of valid species close to 3500. New published results since the 1987 edition have caused changes to be made in about 900 of the older entries, and six new mineral groups have been added. As before, the listing contains the formula and crystal system for each mineral, together with a reference, generally to the *American Mineralogist*, giving the first description, or to a significant recent paper.

R. A. HOWIE

Nickel, E. H. and Nichols, M. C. *Mineral Reference Manual.* London (Chapman and Hall) and New York (Van Nostrand Reinhold), 1991. vi + 250 pp. Price £9.95.

This alphabetical listing claims to provide data for more than 3700 species, the names being based on the latest recommendations of the IMA Commission on New Minerals and Mineral names, including diacritical marks. Each entry includes the name, formula, currently accepted status (A approved by CNMMN, D discredited by CNMMN, G 'Grandfather' status, i.e. minerals introduced before formation of the CNMMN but generally accepted, P polytypes not specifically given approved species status, and Q questionable status), crystal system, hardness, measured and calculated density, type locality, classification (avoiding the use of mineral group names and based on a combination of letters and numerals), and selected literature references (including for the structure determination when available). There is also an abridged synonymy, mainly for recent changes; this, for example, includes sphene = titanite, but vesuvianite is in the main list. The style and price invites comparison with *Glossary of Mineral Species* now into its sixth edition (see above), but there are clearly a number of errors which will need to be rectified before the next edition (which we are promised will include a definitive list of type locality information).

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