BOOK REVIEWS

Hammond, C. *The Basics of Crystallography and Diffraction*. International Union of Crystallography Texts on Crystallography, Oxford University Press, 1997. xi + 249 pp. Price £14.99 (Paperback) [Also available in hardback]. ISBN 0-19-855945-3.

Crystallography isn't what it used to be or at least it isn't taught that way any more – and what a good thing too! I have occasionally wondered whether students still plotted stereographic projections and worked out interfacial angles for monoclinic crystals as they did thirty and more years ago. The old approach via morphology certainly provided plenty of intellectual challenge but was low on interest and had no very obvious bearing on what crystallography and its methods were actually used for.

The present text follows on from Hammond's earlier text entitled *Introduction to Crystallography* (for the Royal Microscopical Society's Microscopy Handbook Series) and it is hard to imagine anything further from F.C. Phillips' *Introduction to Crystallography*, which was the standard text for a whole generation of crystallographers. Hammond's present book certainly looks set to fill the same enduring role for the next generation of crystallographers.

IUCr publications have always been outstanding for quality of presentation and exposition and this book maintains that high standard.

The book starts with the most fundamental principle, the regularity of internal structure, and deals first with atomic packing and the description of crystal structures. Students seem to find this approach easy to grasp and Hammond subtly brings out its relationships to chemistry, materials science and mineralogy. Lattice geometry and symmetry then follow naturally and the reason for studying them is clear to the student who is gradually eased into the more difficult concepts of symmetry in three dimensions and the mathematics of Miller indices and zone axis notation. Direct and reciprocal lattice geometry is treated using matrix and vector notation, which must now be more familiar to students than it once was – I can still remember how its simplicity came as a revelation compared with traditional lattice geometry.

The second part of the book deals with diffraction and here the approach seems more traditional. To begin with, the subject is discussed in terms of optical diffraction from masks, which is the best that can be done to give the student a feeling for diffraction from lattices before he starts on the mathematics, which can be daunting. I was pleased to see that the explanation of why the diffraction maxima from a crystal are sharp was not evaded, as it sometimes is, but is carefully presented. The Laue equations, the Bragg law and the Ewald construction are dealt with and related to each other. The calculation of diffracted intensities follows, with enough examples to make the main points. The geometry of single-crystal X-ray and electron diffraction patterns receive the attention they deserve and at about the right level of detail; computer programs can do remarkable things but single-crystal diffraction is still the only way of seeing for yourself and being sure you haven't missed anything. The final chapter is a good introduction to diffraction from polycrystalline materials.

In the book as a whole, I particularly approve of the biographical notes on crystallographers mentioned in the text and the way Hammond describes the emergence of the ideas he is setting out. Students should know that science is practised by people who often had to struggle to work out the concepts which the student is himself struggling to grasp. I had one petty irritation, the use of rotation axis instead of rotation point in discussing symmetry in two dimensions.

The book is aimed at students in all the disciplines which use crystallographic methods. Some sections of it are of most use to metallurgists and materials scientists, for instance, but mineralogists and geologists are by no means neglected. If they are seriously interested in crystallography, this book is as close to ideal as they are likely to get and very good value too. And if, like me, you learnt your crystallography so long ago that you have lost touch with some of the basics, I thoroughly recommend Hammond's book as an enjoyable way of re-visiting old haunts. J.E. CHISHOLM

Drew, L.J. *Undiscovered Petroleum and Mineral Resources: Assessment and Controversy*. London and New York (Plenum Press), 1997. xiv + 210 pp. Price $59.50. ISBN 0-306-45524-2.

Having read the Foreword, Preface, and Introduction to this book I began to sense it would prove to be one of those publications that we all come across a few times in our lives that re-shape our thinking on some subjects significantly — and I was right. Admittedly I am not an oil geologist and so I was drawn intuitively more to the final chapters relating to mineral resources. However the first four chapters describing past and current attempts to develop a valid forecasting model for prediction of the total resources of oil and gas fields as exploration continues proved fascinating. Early predictions foundered in a morasse of unforseen parameters not least of which, and perhaps surprisingly in retrospect (always 100% accurate!), was the role of the oil price, with the long period of price stability being shattered by the 1973 and subsequent hikes by the Middle East producers. Much more fundamental factors, however, impact on forecasting, and foremost amongst these is the 'field growth' phenomenon, first commented on by Arps and Roberts in a classic paper in 1958 but then somewhat overlooked until, amongst others, the author and his colleagues began to evaluate the concept critically in the early 1980s. The numbers of fields discovered and accordingly assessed as being of a particular size category is a function of time but even more so is related to the number of (wildcat) holes drilled — a sampling problem equally familiar to the minerals geologist! Ongoing drilling, however, commonly leads to re-allocation of fields to different, usually higher-volume, categories and it is the ability to understand and statistically project such changes that is the main goal of the forecasters. Upward revision ('growth') of fields occurs in response to the discovery of new reservoirs in a field and to the recognition that multiple reservoirs may have some degree of connectivity and hence be larger than originally envisaged. Fields may also grow by recalculation of the ultimate projected recovery in recognition of increased porosity and permeability factors. It was these concepts that led Drew and colleagues to decry attempts to fit distribution curves to historical data and give more consideration to the *stochastic* processes that generate the distributions. Pitfalls and problems remain, however, including the concepts of field mortality and resurrection, often financially driven, which, together with field growth, contribute to a constantly shifting and evolving database. The databases themselves add to the complexity of the problem with some remaining 'static', reflecting the original discovery data, and others evolving, with each edition showing changes reflecting revision of field categories.

It is against this complex and challenging scenario that the 'discovery process model' has been developed and 'cumulative discovery profiles' constructed to provide more constrained predictive models for reserve evaluation. Drew completes this section of the book with a detailed discussion of this 'Modified Arps-Roberts Discovery Process Model' that was developed to assist in the 1995 USGS National Oil and Gas Assessment. This was prepared for offshore fields and was based on quartile estimates for cumulative discovery rate profiles for each field size class at various probability levels and adjusted for field growth and mortality. The next step is development of similar profiles for onshore fields... and long-term evaluation of the accuracy of the offshore-profile projections!

The remaining three chapters are devoted to the move towards quantification of mineral-resource assessments and the USGS's pivotal role in developing an appropriate philosophy and methodology. The approach, presented in some detail, involves integration of 'permissiveness criteria' (as assessment of whether the area in question displays many of the geological criteria normally associated with a particular deposit-type) with cumulative distribution data for tonnage and grade for the deposit types (published by Cox, Singer and colleagues in the 1970s and 80s) to yield ultimately a gross in-place value for the undiscovered resource. The assessment of occurrence probability is further underpinned by acknowledging known spatial links (commonly mirroring common genetic processes) between different styles of mineralization ('kin'), modelling these relationships as a series of vectors, and ultimately introducing an element of quantification using the occurrence frequency data published by Cox and Singer (1986; *USGS Bull.* **1693**). The application of this methodology to the Tongass National Forest and adjacent lands in Alaska in an effort to enable politicians and the public to make informed decisions on inclusion or withdrawal of land from proposed Wilderness Areas is highlighted.

The remaining two chapters then provide an extraordinary insight, albeit from one perspective, of the strong criticisms directed at this type of resource assessment within the USGS and even suggestions of scientific malpractice and fraud. Although compounded by financial, political, and personal factors within the USGS during the early 1990s, the scientific debate reflected two groups — the assessment geologists, known as the 'lumpers', and the deterministic geologists (the 'splitters') of whom Drew comments that they cannot acknowledge "the notion that geologic entities exist in probability

and can be described by statistical models; that is, observed mineral deposits, which are only samples, and undiscovered deposits belong to the same parent population". Suffice it to say that an external (to the USGS) review validated the science and methodology of the assessment methods used by the USGS group but it was subsequently recommended that a 'standard of care' code for the preparation of future such assessments be actioned.

This is an unusual and thought-provoking book. Surprisingly, the many parallels between the oil and gas forecasting and the mineral-resource assessment methodologies are not highlighted and one is left with a subconscious feeling that the two main sections of the book (chapters 1–4 and 5–7) were written independently; even the final chapters do not integrate completely. In places, the manner of writing is whimsical, almost journalistic, which sometimes appeals and other times irritates. The final chapter is highly personalized in its account of individuals' contributions to the fierce internal debates that surrounded the publication of the assessment models and results, all set against the funding and re-direction soul-searching that was wracking the USGS at that time. All in all an intellectually stimulating book describing different but overlapping techniques for assessing our natural resources; a book that will be of real value to senior resource company personnel, environmentalists, and senior exploration managers who are often guided by the same kinds of stochastic considerations, both financial and geological. In fact anyone at the exploration-exploitation interface will find much to reflect on, be they representing the corporate face or the general public, and it is precisely at this interface that we, as geoscientists, are reminded emphatically of the growing need for us to be able to communicate clearly and unequivocally with an increasingly concerned and involved public sector. R.P. FOSTER

Mitchell, R.H., Eby, G.N. and Martin, R.F. (Eds.). *Alkaline Rocks: Petrology and Mineralogy*. The Canadian Mineralogist Vol. 34, part 2, 173–484, 1996. Paperback, 311 pp. Price $38.00. ISSN 0008-4476.

This volume (a thematic number of the Canadian Mineralogist) is a collection of papers presented at a symposium on the petrology, mineralogy and geochemistry of alkaline rocks held in Waterloo, Ontario in May 1994, ten years after a similar symposium held in Edinburgh to mark, in turn, the tenth anniversary of the publication of Henning Sørensen's book *The Alkaline Rocks* in 1974. Like Sørensen's work, this volume starts with a contribution on the utterly insoluble problem of classification and nomenclature. Seven well-known experts, headed by Alan Woolley, bravely enter the nomenclatural minefield of lamprophyres, lamproites, kimberlites and the kalsilitic, melilitic, and leucitic rocks. If you have a wolgidite in your favourite field area you can now call it a diopside-leucite-richterite madupitic lamproite, which is pretty explicit provided you know that madupitic lamproites have, by definition, groundmass poikilitic phlogopite, whereas to qualify as an ordinary lamproite phlogopite can be present as a phenocryst phase. We can safely expect this paper to become a standard work of reference.

The second paper (O'Connor *et al.*) looks at the fascinating subject of glasses in mantle xenoliths, from the west Eifel. Whether these are pristine examples of deep mantle liquids, liquids formed on ascent, or samples of the host lava, or something between is the question, and in this case the authors plump for the first, and most interesting solution. Readers who like me are dismayed by the undefined use of 'enrichment' and 'metasomatism' will not find their day enriched by reading this paper, however. The next paper, by Pearson and Taylor, is concerned with metasomatism at high levels, covering the fenitization of a suite of alkaline ultrabasic sills in Western Australia. Mysteriously, the source of the metasomatising fluids is not known.

The next eight papers deal with intrusive complexes or provinces of alkaline silicate rocks. Wittke and Holm describe nephelinitic to syenitic dykes associated with the House Mountain volcano in Arizona and Potter describes the chemical homogeneity of feldspathoidal rocks over the 400 km Trans-Pecos magmatic province, which crosses unperturbed two distinct basement tectonic fronts. Bell and others take us to the type locality of turjaites and turjites in the Kola (there is a challenge to your knowledge of nomenclature!) and Moreau *et al.* introduce us to much younger agpaitic rocks in the Los archipelago, off Guinea. Landoll and Foland revisit one of the old problems of alkaline rocks, the apparent ability of magmas in some complexes (in this case Mont Shefford in Quebec) to evolve across the alkali feldspar join in petrogeny's residua system. They conclude that the nepheline syenite magma reacted with quartz-bearing country rocks and through a process of simultaneous assimilation and fractional crystallization (AFC) was able to cross the thermal barrier. They do not convincingly address the problem that adding silica to a liquid of nepheline