

supply would have come 5 years earlier if zeolites had not replaced less-efficient amorphous catalysts. With the discovery of huge deposits of zeolites in sedimentary and altered volcanic rocks, there is a distinct possibility of development of huge-tonnage applications for water-treatment and agricultural purposes.

Professor Barrer was a distinguished pioneer in discovery of new types of zeolites and in study of physical properties, and until his recent retirement directed a host of co-workers at Imperial College. To his great disappointment, the commercial opportunities were exploited more vigorously in the USA than in Great Britain. The present monograph capitalizes on his comprehensive research programme.

The introductory chapter 'The Zeolites: Their Nature and Some Uses', 31 pp., has a distinctly historical and personal flavour. 'Zeolite Frameworks, Cations and Water Molecules', 71 pp., is adequate, but weak in topology and subtleties of crystallographic aspects. Four-connected 3D nets are the key to zeolite frameworks, and several topological features described by A. F. Wells and others deserved mention rather than Fig. 2 (p. 35). Unfortunately the incorrect concept of zero-coordinated cations (pp. 76-7, 87) has been accepted even though it was quite implausible from the viewpoint of crystal-chemical theory: fortunately, new experimental data (Pluth and Smith (1979), *J. Phys. Chem.* **83**, 741) have shown that the original proposal of zero-coordination was based merely on computer refinement of experimental error! No account is taken of the systematic displacement of interatomic distances for atoms in sites of low fractional occupancy. Some distances in Table 21 (p. 94) must suffer badly from this effect. Recent interpretation of interatomic angles in terms of molecular-orbital theory (Gibbs *et al.*) came too late to be used on p. 97. Readers should also note that recent structure determinations of high-silica zeolites ZSM-5 and ZSM-8 and their pure silica analogues (Flanigen *et al.*, 1978, *Nature*, **271**, 512; Kokotailo *et al.*, 1978, *Nature*, **272**, 437) came too late for inclusion. Mineralogists will miss the d in feldspar and feldspathoid. Errors are few: e.g. Perrotta on p. 98.

Professor Barrer is at home with the next six chapters: 'Equilibrium', 59 pp., 'Energetics of Sorption', 62 pp., 'Entropy and Heat Capacity', 32 pp., 'Diffusion in Zeolites', 83 pp., and 'Chemisorption and Sorption Complexes', 68 pp. They contain extensive compilations of experimental data and theoretical interpretations. Most measurements were made under conditions not found in nature, but nevertheless these chapters are of considerable value to mineralogists and geochemists. In nature,

water is the prime sorbent, but the possibility of traces of other sorbents in natural zeolites has not yet been explored thoroughly. Furthermore the extent of diffusion in beds of natural zeolites is deserving of quantitative research.

The final chapter of 80 pages covers 'Sorption and Molecule Sieving by Layer Silicates'.

This monograph is highly recommended to all libraries catering to mineralogists, geochemists, and soil scientists. It complements and extends the existing monographs by D. W. Breck, 'Zeolite Molecular Sieves', Wiley-Interscience, 1974, and J. A. Rabo (ed.), 'Zeolite Chemistry and Catalysis', *Am. Chem. Soc.* In such a dynamic subject, readers of Professor Barrer's monograph will have their appetite whetted for the next meeting of the International Zeolite Association in Naples, 2-6 June 1980.

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Reedman (J. H.). *Techniques in mineral exploration*. London (Applied Science Publishers Ltd.), 1979. xii + 534 pp., 213 figs., 56 tables. Price £36.00.

This book is a well-organized and illustrated introduction to the procedures of prospecting and mineral resource evaluation. Unfortunately, because of the scope of the subject matter, a book of this size can only be an introduction to principles, but the author has used examples from his own experience and other case histories to demonstrate the application of many of the techniques described. The author is a professional exploration geologist with experience in many parts of the world and this is reflected in the practical suggestions and comments which complement the theoretical concepts discussed.

There are ten chapters, the first of which is a brief review of mineral resources as a concept, and the economic factors which influence the mineral industries. This is followed by descriptions of the main techniques of geochemical and geophysical exploration, and discussion of the applications of satellite image, aerial photograph, and remote-sensing techniques as aids to prospecting, together with brief comments on the geological mapping as an exploration 'tool'. There are good introductory chapters on surveying, 'soil' sampling (pitting, trenching, and shallow augering/drilling), and deep drilling methods. The text ends with two chapters devoted to ore-reserve calculation and prospect evaluation.

The volume contains as much factual information as possible and pleasantly little generalization. The scope of the work is perhaps a little too broad to allow as full a treatment of any of the subject

matter as one might expect in a manual. Nevertheless the fundamentals are clearly and accurately presented and the book will be useful to students, and teachers of applied geology, as well as practising geologists in mineral exploration. The reference lists at the ends of each chapter provide good starting points for literature searches into specific topics although in some cases only a few recent references appear; for example in the Ore Reserve Calculation chapter only three of the eighteen references relate to work published in the last decade.

The book can be particularly recommended to M.Sc. students studying aspects of mineral exploration and to new graduates in geology embarking on careers in the mining industry. It also provides a framework for a lecture course on mineral exploration and can be recommended to undergraduates as a complement to 'academic geology' literature—although sadly at this price (£36), it is a library book rather than one to buy.

The main modern alternative to this work is 'Exploration and Mining Geology' by W. C. Peters (Wiley), which is a simpler, student text. Both are partial replacements for Professor McKinstry's classic text 'Mining Geology' (1948). I prefer Reedman's practical approach to the subject.

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Carman (J. S.), Edited by Varon (B.). *Obstacles to mineral development: A pragmatic view*. New York, Oxford, Toronto, Sydney, Frankfurt, Paris (Pergamon Press), 1979. xvi + 178 pp., 8 photos., 6 figs. Price \$17.50.

Although not about mineralogy, this book is of interest to those mineralogists who care about how and where the economic mineral resources needed to maintain industrial society in the future are to be won. It consists of twelve trenchant essays edited from speeches made between 1965 and 1978 in various parts of the world by John Carman, a Canadian mining engineer with long company and government experience, who from 1958 to 1976 was deeply involved with the United Nations Development Programme and its special and revolving funds. He is concerned to find a solution to what appears to be the growing lack of understanding between those able to invest in, explore for, and develop mineral resources, including the multinational corporations, and the governments of the countries, both industrial and developing, in which the minerals may be expected to be found. The great changes in the scene resulting from the emergence of the Third World since the Second World War are analysed in some detail; and a reproduction of some of the headings from the first essay will give

something of the background: The Royalty Squeeze—the 'They Have to Come to Us' syndrome—the Non-Renewable Mystique—the 'Safe' countries—the Neocolonialism Hysteria. These and similar factors are discouraging mining company investment in developing countries where it is needed, and where, without investment and expertise, the resources will remain undiscovered; while, on the other hand, lower and lower grade deposits are being developed in the supposedly 'safe' industrial countries. Carman maintains that governments in Western and Third World countries alike impose levels of taxation and/or royalties so high that they are causing funds that would otherwise go into mining investment to seek outlets in other, more profitable, industries. In the face of these dilemmas he makes an eloquent case for intervention by United Nations, particularly the UNDP and the World Bank. The book gives a valuable concise survey of UN activity in the minerals field, involving since 1965 the expenditure of nearly 132 million US dollars against counterpart contributions of a little over 118 million. These figures he sets against an estimated valuation of the first twelve deposits discovered at 1336 million, with others to follow. He assesses fairly the merits and weaknesses of bilateral aid, which will also continue to be necessary. He looks forward to orderly development on minerals on a global scale under contracts negotiated in good faith, the terms of which are respected; but adds: 'When one considers the bewildering number of political philosophies and perception of self-interest existing today, one can argue that a "policeman" in the form of an international agency is vitally necessary to arrive at and ensure such a state.' These are well-chosen words. If he had said 'authority' instead of 'agency' that would have been too like H. G. Wells's shape of things to come for pragmatic possibility, but this milder approach has much to commend it.

In general, Carman maintains that proved reserves are now very much greater than at the beginning of the century, and on the average the price of minerals is less in real terms than it was then. He rejects, as do many others, the Forrester-Meadows conception that we shall be running out of economically recoverable minerals by the opening of the second millennium; but factors quite other than the exhaustion of deposits vitally affect the outlook for the future.

The book includes an interesting chapter on what to do to prevent ghost towns appearing in the wake of exhausted mines; in arid regions he suggests they should be planned from the beginning to become retirement centres when the mine finishes.

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