BOOK REVIEWS

TOWARD A HISTORY OF GEOLOGY. CECIL J. SCHNEER (ed.) MIT Press, Cambridge, Mass., 1970, 469 p. $22.50.

The 26 papers collected in this book were presented at the *New Hampshire Inter-Disciplinary Conference on the History of Geology before Darwin* organized by Professor Schneer in September 1967. As he concludes in his incisive Introduction, the Conference "Has called into being a new composite view of the development of geology up to the time of Darwin." Mineralogists and petrographers will be particularly interested in a fine paper by Cyril Stanley Smith detailing the importance of ceramics in the history of experimental petrology, and in papers by Martin J. Rudwick reviewing Lyell's work on Etna and Kenneth L. Taylor discussing the volcanic theories of Nicholas Desmarest. The paper by John G. Burke on mineral classification in the early nineteenth century contributes some interesting details, but suffers somewhat in appreciation of the technical background of the theories on which the classifications were based. Tikhomirov, perhaps the foremost historian of geology, was at the last moment unable to present his paper on the development of the geological sciences in the USSR. Those who do not read Russian might have expected to learn much from the text published here, but unfortunately the attempted coverage is so vast that the result is superficial.

WILLIAM T. HOLSER

EARLY PAPERS ON DIFFRACTION OF X-RAYS BY CRYSTALS. Edited by J. M. BIJVOET, W. G. BURGERS AND G. HÄGG. Published for the International Union of Crystallography by A. Oosthoek's Uitgeversmaatschappij N. V., Utrecht, 1969, xvi and 372 p. $13.50.

In 1965 the Commission on crystallographic teaching of the IUCr proposed the publication of early papers in X-ray crystallography, in the words of Guinier ". . . not only for the purpose of honoring those who had done the original work . . . but for the . . . *formation et la culture* of young crystallographers." Three distinguished editors began work in 1966 and this, the first of two projected volumes, was published in time for the 1969 Congress of the IUCr. It is principally concerned with the intensity of X-ray diffraction in kinematical and dynamical theory. The first reaction of a mineralogist (as opposed to physicists) might therefore be one of disappointment, but closer examination is reassuring. The development of X-ray crystallography and the early papers on Fourier methods, except for one suggestive paragraph from W. H. Bragg's 1915 Bakerian Lecture, will appear in the second volume. The editorial symmetry of beginning the first volume with the Friedrich, Knipping and Laue paper of 1912 and concluding the second volume with Patterson's 1935 paper, is a nice touch.

Invariably in any effort of this sort, the editors are confronted with hard choices. Selection is most critical and the editors have shown discretion and excellent judgment, including not only the papers which hindsight enables us to mark as correct, but the important stumbles and false leads which were equally significant in the development of the subject (as for example the paper by W. H. Bragg with the suggestion that X-rays follow avenues or tunnels between the crystal atoms). Besides the Bragg Law paper, the first papers establishing structures, (sphalerite, halite, pyrite, spinel) have been included—but not diamond. The comment by Tutton that ". . . it is the space-lattice of the crystal structure which is affording the figure, and . . . not the stereographic arrangement of the elementary atoms. . ." leads off a group of papers by Friedel, W. L. Bragg, and v. Laue on hemihedrism and intensities. The landmark papers of Ewald on the reciprocal lattice (Chapter II) are a high point in a forest of papers presenting the original concepts of the structure factor, the Lorentz, the Debye-Waller, and the atomic scattering factors, extinction, imperfections and absolute intensities. Incidentally, how was it possible in a field in which so many Nobel prizes have been awarded, that Ewald alone, of those towering figures, should have been passed over?

Some of the decisions made by the editors are not as happy as their selections of papers to be included. They decided not to translate so that the papers appear in their original languages, half in English, half in German with a few by Friedel in French. Also, the papers are abridged so that their usefulness to the historian of science is sharply limited. Nor is it possible to tell what has been cut unless the reader happens to have a Xerox of the original. There is no bibliography, critical or otherwise, and the index is limited. Full references are given in the Table of Contents, but only a partial reference is given at the beginning of each chapter and not even the author's name heads the individual papers (identified by serial number only). In at least three instances, the dates at the chapter heads are incorrect although they are given correctly in the Table of Contents.

In the effort to provide intellectual as opposed to merely chronological continuity, the editors have cut the papers (with "a pair of scissors and glue"), sometimes sandwiching a later paper between the two ends of an early paper. One particularly nice touch is the brief quotations which stellate the volume, serving to call the reader's attention to the significance of a particular piece or problem, as for example Ewald's admiring comment introducing C. G. Darwin's classical work on absolute intensities.

The growing concern with the intellectual roots of our science that has led to this volume, and promises in the next volume to cover the development of the principles of crystal structure and the Fourier method, is a sign of the maturity of the field. The volume will not be as accessible to students as one would have hoped but it is an indispensable source for the serious teacher and hopefully, a corrective to the tendency on the part of the uninformed research worker to confuse the present stage of the field with revealed religion. The quality of the creative imagination and the power of the trained intellect are displayed here to best advantage. The book is an invitation to serious conversation with men like v. Laue, the Braggs, Wulff, and Ewald in the years of triumph of crystallographic atomism. The sense of style, not literary but intellectual and scientific, which breaks through the mathematics and the sober verbiage, as in Bragg describing the spectrometer method or in the derivation of the Laue equations, makes this an engaging and intensely personal book, as well as the academic monument which it set out to be.

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INTRODUCTION TO MINERALOGY, 2ND Ed. by Carl W. Correns (translated from the German by William D. Johns). Springer-Verlag, New York Inc., 1969, $12.40. 484 p.

The title of this very fine reference/textbook is somewhat misleading. Nearly one half of the book is devoted to petrology, and it is important to consider its merits in that light. The translation from German appears excellent, and is highly readable English. An occasional Germanic or European usage survives in some of the tables and figures, but these should cause no difficulty at all. The original work was intended as a textbook, but there is some question as to how well it might fit into the traditional approach to teaching mineralogy prevalent in the United States. It would be a poor choice, from the student's viewpoint, if it were to be used only as a mineralogy text or only as a petrology text. Its ideal function would seem to be as a basic text or as a reference book in the more theoretical aspects of these two subjects as they would be required for the general student but not for the specialist. The teacher should find it an excellent base on which to build a lecture course. Material is so arranged that topics not considered applicable to a course of a particular level can be easily bypassed.

The book is divided into three parts: 1) Crystallography, 2) Petrology, and 3) Appendix. The first part contains chapters on Crystal Mathematics, Crystal Chemistry, Crystal Physics, and Crystal Growth. There is a sufficient introduction to a much wider range of topics than is usually covered in the popular American textbooks for mineralogy. Discussions of symmetry are carried to the space group level, and the discussion of X-ray diffraction introduces the structure factor and space group extinctions. Mineralogy enters into this section principally in the form of examples of the properties of crystalline materials. The crystal drawings, though generally good, often have the vertical crystallographic axis slightly tilted, thus causing some distraction.

Part 2, Petrology, contains chapters on Physico-chemical Fundamentsls, Formation of Magmatic Rocks, Weathering and Soil Mineral Formation, Sedimentary Rocks, Metamorphic Petrogenesis, and Geochemical Considerations. Phase diagrams are adequately discussed, both for igenous and metamorphic systems. The origin of mineral deposits of various types are discussed under the appropriate chapters, but only the briefest allusions are made to geographic occurrences. There is more than enough material here for any basic course in petrology.

Part 3, a series of appendices, attempts to provide a balance to the theoretical base of the first two parts. A number of quite adequate crystallographic tables are provided, including comparisons of various nomenclatures and notations. Particularly useful is a table correlating symmetry and physical properties. This is followed by a table of descriptions of 300 minerals arranged in a crystal-chemical sequence. Crystal data, physical properties including optical properties, and geologic occurrence are given. The petrologic tables are particularly attractive. Chemical and modal analyses are given for 51 igneous rocks, 29 sedimentary rocks, and 23 metamorphic rocks. For the igneous rocks, Niggli values are also included. Finally, a series of references is given in which there is a slight preponderance of German works.

The greatest shortcoming of the work as a textbook is the lack of adequate descriptive mineralogy and the almost total omission of references to geographic occurrences. There is no material on the older methods of qualitative mineral analysis, but this is not a serious omission. However, the range of theoretical material covered should make this book a valuable addition to any geologist's library.

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CONSTRUCTION AND USE OF ATOMIC AND MOLECULAR MODELS. By H. BASSOW. Permgamon Press Inc., New York, 1968. 213 pages. 35s ($4.20).

The author of this useful little book is the head of the science department at the Germantown Friends School in Philadelphia. From this, as well as the simplicity and clarity of the exposition, it is clear that the book is aimed at the upper secondary school level. Frankly the research crystallographer, if he can put up with the somewhat patronizing style which authors of textbooks feel obliged to adopt, should find it extremely useful around the lab.

"Units" one through six explain the reasoning behind atomic and molecular models and the construction of simple molecular models beginning with two different sized balls at the ends of a short rod representing the HCl molecule and concluding with instructions for joining several amino acid molecules to produce a part of a protein. Structural formulae are simply explained and instructions for constructing wave mechanical models of atoms (all the way through orbital models of HF, NH_3, and H_2O) are covered. The author likes styrofoam. "Because of styrofoam, a reasonably careful teenager can make a bigger, better looking model for a dollar and several hours of his time than a geology graduate student at Harvard could build from wood in an entire term and at considerable expense."

Unit 5 describes the construction of accurate molecular or space-filling models. Chemists delight in these models which involve slicing off portions of the styrofoam spheres to allow interpenetration of bonded atoms within the molecule. Accuracy of bond angles is insured by a simple method for the construction of cardboard jigs. Unit 6, which amounts to a laboratory survey of organic chemistry in 46 pages, covering isomerism, stereoisomerism and so forth, all illustrated by the construction of both ball-and stick and space-filling models, would alone be worth the price of admission.

The remainder of the book is concerned with the construction of accurate crystal models starting with close-packed metals and continuing through ice. It should be emphasized that the construction of models, both ball-and-stick and packing, is not described as an end in itself, but rather as illustration of basic crystal chemistry. The arithmetic and geometry of close-packing, the calculation of structure constants, radius ratios, coordination, etc. are all covered from first principles with exceptional clarity and a total of 114 good figures. An appendix lists such useful data as atomic and ionic radii, structural data for elements and compounds MX and MX_2. There are a few references, a list of sources of supplies and a brief index.

Mineralogists may grumble because the author does not tackle silicates but it is just as well that something is left for a course in crystal chemistry. Crystallographers will wince at the misuse of the word lattice, and class—how do we spell glycine (p. 115)? Still, I suspect that harassed students at a considerably higher level than Mr. Bassow's students will be grateful for his clever, clear introduction to structural chemistry.

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PROPERTIES OF WATER AND STEAM IN SI-UNITS. By ERNST SCHMIDT. *Springer-Verlag*, New York, Inc. 1969. 205 pages. $13.20.

Each successive set of steam tables that appears in the literature presumbaly reflects advances made in defining more accurate equations of state for the system H_2O and/or extension of these equations to a greater range of temperatures and pressures. In most instances numerical differences are slight; in fact, they are usually negligible in a geologic context. This book is the 13th volume of steam tables to be published since 1932. In contrast to the 14th (Keenan, Keyes, Hill, and Moore, 1969, *Steam Tables*, Wiley, New York) which is presented in English "engineering" units, Schmidt's steam tables are easy to use in scientific applications of the thermodynamic properties of H_2O.

The steam tables under review are presented in six languages: French, German, Russian, Spanish, Japanese, and English. The format is so arranged that each section is duplicated in all six languages, either in series or in parallel, dependlng on the material. The introductory chapter is brief, consisting of a short history of the compilation of steam tables, definition of symbols, discussion of thermodynamic relatlons, and lists of physical constants and conversion factors. The introduction is followed by a bibliography containing 101 references, and then by six tables of thermodynamic properties of H_2O. The specific volume, entropy, enthalpy, heat of vaporization, density, and vapor pressure of the liquid and gas phases along the saturation curve for H_2O are given in Table 1 for each degree of temperature from 0°C to the critical temperature. Pressure is given in bars, specific volume in m^3kg^{-1}, density in kgm^{-3}, enthalpy in kilojoules kg^{-1}, and entropy in kilojoules kgm^{-1}

$(°K)^{-1}$. Table 2 contains the same information as Table 1, except that it is arranged at even pressures from 0.01 bars to the critical pressure. The properties of superheated steam (specific volume, enthalpy, and entropy) are given in Table 3 at temperatures from 0° to 800°C and pressures from 0.01 bars to 100 bars at temperature intervals of 10°C and pressure increments increasing from 0.01 bars to 50 bars. The same kinds of data in the vicinity of the critical point are presented in greater detail in Table 3a. Table 4 consists of the International Skeleton Tables for 1963 and 1964, which is followed by heat capacity tables and tabulation of the dynamic viscosity, thermal conductivity, and Prandtl numbers for H_2O as a function of temperature and pressure. The last section of the book is devoted to formulation and extensive discussion of the equations of state used in calculating (with the aid of a computer) the numerical information given in the tables. A Mollier diagram and a temperature-entropy are included in a pocket at the end of the book.

Any geologist concerned with the chemical interaction of aqueous fluids with rocks will find a set of steam tables indispensable in carrying out thermodynamic calculations for geochemical processes. Although Schmidt's volume is far from complete (*e.g.*, coefficients of isothermal compressibility and isobaric expansion are not included in the tables), it represents one of the latest compilations available. Future versions will no doubt take into account the outstanding contribution made last year by Burnham, Holloway, and Davis (Thermodynamic Properties of Water to 1000° and 10,000 bars. *Geol. Soc. Amer. Spec. Pap.* **132**, (1969)) in extending the range of experimental data for H_2O from one to ten kilobars. In many respects the latter work is of paramount interest.

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X-RAY ANALYSIS PAPERS. William Parrish (ed.)./Centrex Publishing Co., Eindhoven, Netherlands, 1969, 310 p. $7.00.

Reprints of journal articles on X-ray powder diffractometry, X-ray spectrometry, and counter detectors by members of the staff of Philips Laboratories. Collected for use in Philips instructional courses. The new edition reprints 24 papers, compared with 15 in the first edition.

William T. Holser

GROUP THEORY AND ENERGY BANDS IN SOLIDS. by J. F. Cornwell. North Holland Publishing Company, Amsterdam. London, 1969, 288 p. $17.50.

Though the detailed crystal structures of a large number of minerals are now known, the electronic structure of only a few minerals have so far been determined. Yet it is the the electronic structure, which determines the electronic and other solid state properties of a mineral. One approach to this problem is the Energy Band Theory as developed by Bloch. It is the band gap, for example, which determines whether a material is a conductor, semiconductor or an insulator. This approach would be fruitful for sulfides and sulfosalts, the complexity of which has hardly been grasped by the solid state physicists. The application of group theory makes the calculation of electronic energy bands in a crystal particularly elegant. This is the main substance of the book under discussion.

After giving a brief introduction to basic group theoretical concepts, a general description of the space groups has been given in the first chapter. The second and third chapters are devoted to the theory of matrix representations of a group and the application of group theory in quantum mechanics respectively. In the fourth chapter, elementary electronic energy band theory is described. Crystallographers will find an elegant application of the reciprocal lattice concept in calculating Brillouin zones in this chapter. In the fifth chapter, energy band calculations are made for symmorphic space groups, *i.e.*, substances crystallizing with atoms at the nodes of a Bravais lattice. In the last three chapters, more advanced group theoretical concepts are developed and applied to energy band calculations in non-symmorphic space groups and double symmorphic space groups. Time-reversal theory and spin-orbit coupling have also been considered. In the appendix the group theoretical characters for the 32 crystallographic point groups have been assembled.

This book will be of interest to mineralogists with a background in group theory and quantum mechanics, who are interested in the energy band structures of minerals.

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PRACTICAL OPTICAL CRYSTALLOGRAPHY. 2ND ED. By N. H. HARTSHORNE AND A. STUART. American Elsevier Publishing Company, Inc., New York, 1970, 326 p. $11.50.

This book is generally very well written and provides a firm foundation in basic optical theory and modern microscopic technique. Changes from the first edition are not extensive, and include correction of minor errors, discussion on dispersion staining, and enlargement on the methods of detremining optic axial angles on the spindle stage. In addition the 'SI' '(Systeme International d'Unites) equivalents are used where appropriate.

Sufficient crystallography is included to reacquaint the student with this subject. A detailed discussion of the optical properties of crystals not only covers standard material, but relates optical anisotropy to crystal structure and atomic behavior; this is particularly valuable as the subject is tacitly ignored in most modern texts.

Some readers may object to the arrangement of subject material. Behavior of both uniaxial and biaxial materials are discussed under orthoscopic observations. This is followed by conscopic observations for both types. Although this is certainly a logical arrangement, it is difficult to relate to the standard course treatment in which all aspects of uniaxial substances are treated before proceeding on to biaxial types. In fact, details of the Becke test, which is usually performed as a prelinimary student laboratory exercise, do not appear until page 159. Another aspect of this book which will prove troublesome to the beginning student is a lack of techniques for distinguishing the various types of biaxial interference figures. The discussions on the use of the stereographic projection, preparation of materials, and use of rotational devices are fairly extensive and very well done. A final chapter dealing with the determination of optical properties of various materials forms a useful laboratory supplement.

The average American reader who is typically a user of German, American, or Japanese-made instruments will find certain aspects of the book rather annoying, as it is intended for use with British equipment. This emphasis results in opposite orientation of polarizing devices and accessory slots—as well as literature references and materials supliers which are predominantly European

The organization of the book (in terms of a laboratory course) and the problems in reorientation to more commonly used equipment would cause some difficulties in its adoption as a standard optical crystallography text. However, the excellent treatment of most subjects highly recommends usage as a reference volume for the practicing mineralogist or geologist.

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