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BOOK REVIEWS

AN INTRODUCTION TO CRYSTALLOGRAPHY. Fourth edition. By F. C. Phillips. John Wiley and Sons, Inc., New York, 1971. 351 pages, $12.50.

To those many readers already familiar with the third and earlier editions of F. C. Phillips' honored and widely used treatise (*Amer. Mineral.* 49, 1506) it is only necessary to say that changes in the fourth edition are few and minor. Ten of the thirteen chapters remain substantially unaltered. Appendices I and II of the third edition, concerning two– and three–circle goniometers, have been consolidated and incorporated into Chapter 5, "Goniometry." Appendix III of the third edition, on line and band ornaments and plane groups, has been included in Chapter 10, "The Symmetry of Internal Structure." Approximately two pages on colored symmetry have been added to the treatment of space groups. The format and type size have been slightly enlarged for easier readability.

For those who have not previously used Phillips' book, the work may be described as a general introduction to crystallography of wide scope, requiring no previous knowledge of the subject. The style is easy, graceful and readable, but precise and clear. The fundamental philosophy of crystallography exposed is "outside in," beginning with crystal morphology and external symmetry and progressing to the internal structure. Symmetry, crystal projections, goniometry, the seven systems, the thirty–two classes, twinning, crystallographic calculations, crystal drawing, plane and space lattices, space groups, the diffraction of X–rays by crystals and the structural significance of crystal habit are all treated. Hermann–Mauguin notation is used throughout but Schoenflies notation is explained in an appendix. All 32 point groups and all 230 space groups are described, but not rigorously derived. Five hundred and thirty seven clear, well–drawn and strategically located figures illustrate the text, which is further illuminated by brief biographies in footnote form of twenty–three of the most eminent crystallographers.

Unfortunately, some shortcomings mar this fine work. Non–standard forms of the Hermann–Mauguin symbols for many of the point and space groups are used, and the generally accepted modified Groth nomenclature for classes and forms is given only as a second choice in most cases. In the Isometric, non–standard names are used throughout. Nearly ten times as much material is presented on the stereographic projection as on the gnomonic, and crystal drawing on the axial cross from the stereographic projection is given priority of place and more ample treatment than the generally more useful method of drawing from the gnomonic. The only fully worked-out crystallographic calculations are made from single–circle measurements, using Napierian methods. No use is made of projection constants or reciprocal parameters, and although the angular coordinates φ and ρ are briefly explained, no calculations are made involving them. Defects, dislocations, vacancies, and imperfections of crystals in general are not mentioned. Although twinning is described rather fully, no discussion is given of the modes of production of twinning or of energy relations in twinning.

Although these omissions somewhat diminish the value of the book in elementary teaching, they are of less moment to more advanced students seeking a review of crystallography, to whom the compactness, clarity, and felicitous

style will appeal, especially in the treatment of such subjects as the Donnay–Harker generalization of the law of Bravais.

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INTRODUCTION À LA CRISTALLOGRAPHIE. By Claudette Delepine. Dunod, Paris, 1971, 242 pages. 40 Fr.

This paperback represents a written document accompanying a series of nine television broadcasts lasting approximately eight hours, emanating from the Commissariat à l' Energie Atomique. Since it was received without further accompanying material, this reviewer must assume that the book is intended to be used autonomously as well. As such it does not have much to recommend itself to English-speaking readers over such classics as F. C. Phillips's Crystallography, Harold Hilton's Mathematical Crystallography, or Martin J. Buerger's recent Introduction to Crystal Geometry. For French readers to whom these English language texts are not accessible, Mme. Delepine's text may well fill a need.

Although geared to a modern medium of instruction, *Introduction à la Cristallographie* is not modern in its approach. Taken by itself it is rather dogmatic, and geared to rote-learning. For example, on p. 27 the reciprocal lattice is introduced as follows: "The reciprocal lattice has no physical existence, but its introduction facilitates computations concerning the direct lattice and the interpretation of the X-ray diffraction spectrum by crystals." Without further motivation the vector definitions of the reciprocal lattice follow. One has the impression that the book represents essentially a digest of definitions and formulas, and that the entire motivation comes from the television broadcasts. By itself the book proceeds rather grimly, though accurately and logically. The material covered is standard, and its presentation is not particularly clear or elegant. In his preface Hubert Curien refers to the pleasures of teaching geometrical crystallography and its inherent beauties. One could wish that a little more of this pleasure had been evident in the present text.

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MINERALOGY FOR STUDENTS. By M. H. Battey. Oliver & Boyd, Edinburgh, 1972. 323 pages. £ 4.

Although there seems to have appeared a plethora of "updated" introductory textbooks of mineralogy–crystallography in this country during the last decade or so, one is not so jaded as to fail of a sense of anticipation that the new work in hand may be *the* book to resolve the many problems associated with selection of material to be covered and presentation of the complexities of crystallography and mineralogy to the beginning student. Perhaps this is not *that* book, but it is a good textbook, well worth examination because I believe that it will hold its own with comparable American books of recent years.

The book seems to be aimed at a year's course intended to bring the student

to a level necessary to undertake the study of rocks with the petrographic microscope, since it includes within it a complete, if condensed, course in optical crystallography. The order of arrangement of topics is sensible. The initial presentation of crystallochemical principles is probably a good way to warm the student up by explaining what goes on inside crystals before hitting him with the (sometimes) dry concepts of classical morphological crystallography. The author does the crystal chemistry part well, and gives a more detailed than usual account of chemical bonding (including as he does the *dative* bond of which this reviewer had been in ignorance for years). The concept of ion sizes is competently treated, as are those of critical radius ratio and coordination and packing. The author might have been more explicit, both in textual matter and illustration, in his excessively brief development of closest packing of spheres, which becomes so important to the discussion of crystal structures generally.

After the rather detailed account of the chemical bond, I was prepared for a somewhat different introduction to the crystallography section, which is essentially standard morphological crystallography. Space group operations other than pure translation (Bravais lattices) are not discussed, although patterns and periodicities are interestingly considered. At least a brief explanation of glides and screws would have been a good addition and could have provided a tool useful in discussion of the structures ably considered in Part II, Descriptions of Minerals. The problem of class and form names is easily resolved in this book—they are dropped. With the exception of a few special cases, Miller indices alone are used throughout. I choose not to sit in judgment of this decision, but I think some of us shall be a little nostalgic on the day sonorous terms such as "dihexagonal dipyramidal" no longer trip from the tongues of aspiring students of mineralogy. Class names are relegated to Appendix I. Considerable emphasis is placed on the stereographic projection and its utility in morphology. The section on Physical Properties includes an eight-page treatment of how to measure specific gravity ("density"). Magnetism, piezoelectricity, fluorescence, and phosphorescence are well handled, although some examples of causes of coloration in specific minerals would have helped.

The treatment of optical crystallography is as thorough as one could ask in 45 pages. One wonders how well the student having studied this section would be able to work out the properties of a biaxial mineral. I would have preferred a few more pages of application of the optical theory presented rather than the theoretical discussion of the behavior of reflected light which follows in the section on ore microscopy. My personal mnemonic devices were also taxed by interpretation of optical phenomena based on an accessory slot oriented SW–NE.

A section on X-ray diffraction emphasizing the powder method is succinct and probably adequate for the purpose of the course for which the book is intended. The selection of a Straumanis-type film to illustrate the powder method, with no adequate explanation of the peculiar appearance of the arcs and no explanation of the measuring procedure for this particular film mounting, is unfortunate. Film shrinkage is mentioned as a source of error but there is no discussion of how it can be corrected for. Indexing procedures are considered in some detail.

A 16-page section devoted to Mineral Associations concludes Part I. I enjoyed this treatment but wished that more space were devoted to metamorphic rocks.

Part II consists of 121 pages of mineral species descriptions which are grouped conventionally according to an anionic chemical classification. The descriptions are well done and the choice of species representative. An exceptional and valuable feature of this section is that almost every mineral is described in terms of its structural arrangement and many are illustrated. The author has gone to a great deal of work to ferret out these structures and to prepare illustrations of them. I presume that many of the illustrations are newly drawn and some of them, the structure of orthorhombic sulfur, for example, are excellent. In a few instances, however, more comprehensive figure captions would have assisted the student in his visualization of a given structure. In comparison, one is reminded of the marvelously detailed captions in Bloss' *Crystallography and Crystal Chemistry* (Holt, Rinehart, and Winston, Inc., New York, 1971). Another unusual feature is the inclusion of reflectivity data, where appropriate, in the mineral description. Diagnostic X-ray diffraction spacing and intensities are not included, although the student is referred to the ASTM index.

Students benefit from systematic determinative tables, such as those found in Hurlbut's *Dana's Manual of Mineralogy* (18th ed., John Wiley and Sons, New York, 1971), in an introductory text. The work being reviewed does not include them, nor, regrettably, are problems posed at the ends of chapters. My perusal of the lists of titles for suggested further reading at the end of each chapter reveals that they are not up to date. For example, the first edition (1946) of F. C. Phillip's *An Introduction to Crystallography* (John Wiley and Sons, New York) is listed although the book is in its third (1963) edition.

Surely consistency of designation of units has caught up with us at last. Page viii has a table of the SI units used throughout the book. The nanometer offers no surprises, but I feel uncomfortable confronted with the meganewton ($1\ MN/m^2 = 10$ bar). The cover of my copy is paper on cardboard and was slightly damaged as received. The binding does not seem to be as sturdy as those of most American books. One could wish that the type font were a little larger.

Withall, the author writes well and interestingly and has written a book which can profitably be examined by all teachers of the introductory mineralogy course.

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HOW TO KNOW THE MINERALS AND ROCKS. By Richard M. Pearl. McGraw-Hill Book Company, Inc., New York, 1955. 192 pages, paperback, $1.95.

This volume, reviewed in the American Mineralogist in 1957 (42, 578–579), is now available in paperback form.

WILLIAM T. HOLSER

Landolt–Börnstein: Numerical Data and Functional Relationships in Science and Technology. New Series. Editor in Chief: K.-H. Hellwege. Group III: Crystal and Solid State Physics. Volume 6. STRUCTURE DATA OF ELEMENTS AND INTERMETALLIC PHASES. By P. ECKERLIN AND

H. KANDLER, with the assistance of A. STEGHERR. Editors: K.-H Hellwege and A. M. Hellwege. Berlin, Heidelberg, New York: Springer. 1971. 11 × 27 cm. xxviii + 1019 pages. $179.10.

The well known Landolt–Börnstein compilation of *Zahlenwerte und Funktionen* launched its new series in 1961. Six groups of sciences are being covered: I. Nuclear physics and technology (4 volumes had come out by 1969). II. Atomic and molecular physics (5 vols. by 1967). IV and V are still in the planning stage (IV: Macroscopic and technical properties of matter; V: Geophysics and space research). VI. Astronomy, astrophysics and space research (vol. 1, 1965). Of greatest interest to mineralogists is undoubtedly Group III, which has been most actively pushed: vol. 1 (1966) (*Amer. Mineral.* **53**, 1068–1069) and its supplement, vol. 2 (1969) (*Amer. Mineral.* **55**, 1451–1452), deal with elasticity, piezoelectricity, piezo–optics, and electro–optics; vol. 3 (1969) treats ferro– and antiferro–electricity; vol. 4 (1970), magnetism (of oxides) (*Amer. Mineral.* **56**, 607). The next three volumes are devoted to crystal data, starting with organic compounds (vol. 5, 1971) to end with inorganic compounds (vol. 7, in preparation). Projected vol. 8 is to be entitled "Epitaxy data, X–ray spectrum and chemical bond". These volumes are the successors of a single volume, entitled *Kristalle,* which was part of the 6th edition and appeared in 1955. Present volumes are still written in German; title page and introduction are in both English and German.

In vol. 6, reviewed here, the substances are chemically subdivided into 4 sections: elements (238 entries), borides (417), carbides (611), hydrides (181), and intermetallic phases (8,248). The references fill 113 pages; over 60 percent of them are dated 1960 or later. The tables themselves occupy 903 pages, covering 410 square feet. Within each section the chemical formulae are listed alphabetically, the elements in the formula being themselves alphabetized (with a few rules and exceptions one had better master before attempting to look up a compound!) The data are tabulated in 10 columns. Col. 1 gives a serial number N, to which footnotes can be referred; it comprises the last two digits of the rank R of the entry in the section ($R \equiv N \bmod 100$), so that it also helps count the entries. Col. 2: chemical formula, with metallographic phase designation if need be. Col. 3: remarks on composition wherever called for. Col. 4: space group, in Hermann–Mauguin notation. Col. 5: cell edges and inter–edge angles not fixed by symmetry; also temperature of data taking, if known. Col. 6: cell content, either "Z" formula units or "[A]" atoms. Col. 7: density, either measured "ρ_{exp}" or calculated "$[\rho_x]$" or both. Col. 8: melting point "T_s," or transformation temperature(s) "$[T_k]$" defining the stability range of the modification at hand. Col. 9: crystal–structure type, when reported; diffraction method, "Einkristalle" or "Pulver"; "N" (neutron), "E" (electron), "X" (X-ray), the latter usually omitted; heat treatment; assessment of the structure, 'komplett" (atomic coordinates determined), "mit H" (H is located), "partiell" (only some atoms are located), "qualitativ" (no intensity calculations to buttress the structure). Col. 10: abbreviated reference(s), the coding being similar to that of Wyckoff; for example, "58 Don3" means the year of publication, the first three letters of the name of the first author, the 3rd paper under 58Don. The full reference is easily located in the bibliography at the end of the section. Cross-reference to *Strukturberichte* or *Structure Reports* is made by volume (up to vol. 26, 1961) and page. Footnotes are used rather extensively to add a remark

and give the latest reference; they also help assign responsibility for certain data that do not come from the main reference. An alphabetical index of German mineral names includes English synonyms that are sufficiently different. The authors' names, "Eckerlin/Kandler," are printed at the bottom of 1040 pages.

In the Introduction, one table explains the symbols of symmetry elements. The $\bar{3}$ axis is here called "three–fold inversion axis"—a very common mistake [the number 3 refers, not to the *multiplicity*, but to the *period* $2\pi/3$ of the rotation component: $\bar{3}$, like $\bar{6}$, is a six–fold axis; likewise $\bar{1}$ is a two–fold axis]. Another slip is the use of the word "trigonal" instead of "hexagonal" in the terms "trigonal lattice" and "centered trigonal cell". The *d* glide plane (*d* for diagonal), which in English has been dubbed "diamond glide plane" in allusion to the lozenge shape of an ace of diamond (M. J. Buerger, 1942) is now officially translated into *Hochdeutsch* as *"Diamant"-Gleitspiegelebene*! The term "structure data", which would have been justified in the 1955 edition, in which the atomic co–ordinates were given, should have been relinquished now that the co–ordinates are omitted. The sequence in which the substances are listed is not structural, nor is it crystallographic or determinative or even chemical, for that matter, since the entries come in alphabetical disorder. For this reason the choice of the cell and its orientation is not critical, and the literature setting is usually retained. As to criticality and reliability, the data up to 1961 were taken from secondary sources (*SB* and *SR*) and were not checked; for the period 1962–67 the original papers were consulted "when accessible" to the compilers.

Publication of volumes 5 to 7 of the new Landolt-Börnstein series duplicates that of CRYSTAL DATA (1st ed., 1954; 2nd ed., 1963; 3rd ed., in press). Such duplication of effort is not wasted and not to be deplored. On the contrary. We all know how frightfully difficult it is to prevent errors from creeping into a book of this sort. Having two compendia available to cross–check the information will be extremely useful. As general editor of CRYSTAL DATA, I am pleased to see that many features of our 2nd edition, particularly on how to assess the quality of a structure, have been adopted by the Drs. Hellwege. I salute the competing Transatlantic Team and congratulate authors, editors, and publisher on their beautiful book.

This volume, we are told, was published "without any outside financial support". Even at the forbidding price, one wonders whether the publisher will break even.

J. D. H. Donnay

W. E. Tröger, OPTISCHE BESTIMMUNG DER GESTEINBILDENEN MINERALE, TEIL 1 BESTIMMUNGSTABELLEN: 4th ed. By H. U. Bambauer, F. Taborsky, and H. D. Trochim. E. Schweitzerbart'sche Verlagsbuchhandlung, Stuttgart, 1971. 188 pages, approx. $13.50.

The new edition of "Tröger's Tables" confirms the richness of his legacy and the dedication and energy of his followers and publishers. While the old edition was out of print, the shortage of "Tröger's" became acute. The new edition renews the supply and sets new standards for usefulness. This volume is a companion to the descriptive text contained in Part 2 (*Textband,* Stuttgart, 1967).

Data are given for a thoughtful selection of 244 rock-forming minerals. Each of these is plotted on a key diagram of birefringence versus refractive index, now expanded to both endpapers, which allows quick identification of the likely candidates for an unknown mineral. The explanation of nomenclature, symbols, etc. has been translated into English and French near the front of the book. The tables themselves, still in pithy German, are now typewritten. They are very clear, and those who mourn the passing of the older calligraphy will be pleased to find intact such niceties as the exclamation points when you are about to get into trouble, and the succinct description of titanaugite dispersion.

The diagrams of optic orientation continue to be models of clarity. Some are redrawn to convey new information, and many are added, such as those for chrysotile and pumpellyite. For the amphiboles, the traditional optic orientation based on the body-centered (*I*) cell is sensibly retained, and the *I*-cell β angles are quoted in the tables for cummingtonite and actinolite. However, as in the old edition, *C*-cell β angles are quoted for richterite, glaucophane, and arfvedsonite, and both *I* and *C*-cell angles are quoted for riebeckite. The new drawing for magnesioriebeckite on p. 88 shows a wildly misplaced a axis, and $Y\Lambda a$ should be 19–31° (not 17–29°) based on the correct value of *I*-cell $\beta = 106°$.

Graphs of optical properties are extensively updated, and many new ones are added in the plagioclase section. Some inconsistencies appear in the newer drawings. In the glaucophane–magnesioriebeckite series the change in optic angle through zero does not coincide with the junction of the two higher refractive index curves. The extinction angle for Mg-arfvedsonite on p. 95 disagrees with the orientation drawing on p. 89.

The chemistry of zoisite could be clarified further. Readers may wish to follow Myer (*Amer. J. Sci.* 264, 364–385, [1966]) in identifying "zoisite" and "pseudozoisite" as ferrian zoisite (Fig. 139–1) and iron-free zoisite (Fig. 139–2) respectively. The manganese content of thulite deserves mention.

Supplementary material is highly useful, as before. This includes the usual optical nomograms; density graphs; lists of dispersion, color and pleochroism; and newly-added *d*-values of the four strongest lines for the powder diffraction pattern. The summary of interference figures on cleavage flakes has been dropped.

The index of mineral names gives the page numbers of figures, diagrams, density, *d*-value, color, and further information.

Foldouts at the end of the book display two plagioclase stereograms and the Zeiss version of the Michel-Lévy interference color chart, complete with birefringence data for cholesterol and maltose as well as for many minerals.

This is a delightful book, and the most valuable single compendium for the practising petrographer. Publisher and authors are to be congratulated for maintaining this classic work in the spirit of the original.

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