Canadian Mineralogist
Vol. 21, pp. 161-164 (1983)

BOOK REVIEWS

CRYSTALLOGRAPHY. An Introduction for Earth Science (and other Solid State) Students by E.J.W. Whittaker (1981). Pergamon Press, Oxford (in Canada: Willowdale, Ontario), 254 pages. Hard cover $49.00, soft cover $29.80 (Can.).

Whittaker's *Crystallography* is a two-part introduction to the subject with a strongly morphological/classical approach on the one hand, and, on the other, a modern X-ray/electron diffraction approach. These two aspects of the book are represented, by and large, by the author's Parts I and II (untitled), and such an arrangement is to be expected for a book intended, as the author indicates, for undergraduate students in earth sciences and in other solid-state disciplines. The chapters in Part I include external form and cell structure, repeating patterns and space lattices (in part), crystal symmetry, notation for faces and zones, use of the stereographic projection, and the morphology of the holosymmetric classes of the seven crystal systems in one chapter, and of all 32 classes in another. The chapters in Part II cover the theory of X-ray diffraction and its application to crystals by both powder and single-crystal methods, including the essence of crystal-structure analysis; a full discussion of the fourteen Bravais lattices; the symmetry and nature of space groups; electron diffraction applied to minerals; irregularities in crystals (cleavage, twinning, polytypes, *etc.*); and a final recapping called "Morphology Revisited".

The essence of the author's approach is the laudable one, particularly for geology students, of drawing conclusions from the faces on actual crystals about the fundamental unit-cell character of crystals and the implied periodicity of their structures. The shape of the underlying building block or unit cell of a crystal implied by its facial development is an almost ever-present theme, and it serves to link the two aspects of crystallography represented by the two parts of the book, classical morphological and modern structural. No other author has attempted to combine the morphologbical and the structural aspects so fully in one introductory textbook. One might ask, how successful has the author been? Despite some reservations about the handling of certain topics, this reviewer feels that the author has indeed been successful and that this book deserves a wide readership. Whittaker's treatment of diffraction methods and structural crystallography in Part II is, in my view, more satisfactory than his treatment of the space lattice and point-group-symmetry topics in (mainly) Part I. The descriptions of diffraction and structural methods in the second part make available to the beginning student a succinct, practical introduction to all the modern X-ray-diffraction techniques except one (unfortunately, the single-crystal-precession method, Notwithstanding the author's disclaimer (p. 184), this reviewer feels it is inappropriate in a 1980s textbook to give a detailed description of the rarely used rotation–oscillation method to the exclusion of the widely used precession method. In sharp contrast, the concise description of electron diffraction and its comparison with X-ray diffraction, and the inclusion of typical electron micrographs showing structural details of minerals in a striking way, provide the reader with an up-to-date introduction to this powerful crystallographic technique.

Part I of the book is essentially a classical crystallographic textbook with well-executed drawings of crystals and descriptive diagrams, and a detailed description of the application of stereographic projections to crystals. It would have been helpful to the reader, especially the novice, if the axial directions x, y, z were shown on *all* drawings of crystals and stereograms and not only one-third of them. Regarding crystal form names, this reviewer is not persuaded by the author's argument (p. 65) of the wisdom of usages (p. 101) such as "24-hedron (3)" in $4/m\ \bar{3}\ 2/m$, 432 and $2/m\ \bar{3}$ for the long-established form name *trapezohedron*. Better that the actual name of less-common forms be included in lighter print than replaced by ambiguous and unorthodox terms like "24-hedron (6)" and "dodecahedron (5)".

However, a more serious criticism of Part I deals with the author's handling of the interrelated topics of space lattices and (nontranslational) crystal symmetry. At the outset of the book (Chapter 1), Whittaker uses two characteristics of well-formed crystals, the occurrence of their faces in zones and the constancy of corresponding interfacial angles, to imaginatively convey the fundamental nature of crystals, namely that they can be thought of as built from

building blocks (unit cells) and that they are, therefore, periodic structures. The nature of repeating patterns and lattices comes logically in Chapter 2 and, again logically, crystal symmetry in Chapter 3 where, after the nature of symmetry elements is described, the seven possible shapes of unit cells (as parallelepipeds) and their symmetries are derived by the application of symmetry to the most general (triclinic) cell. The author thus arrives at the seven crystal systems as expressed by the symmetries of their holohedral classes. This is a desirable and reasonable development of the subject, to which, however, this reviewer takes two exceptions. First, the limited elements of symmetry permissible in crystals are not, in Chapter 3, shown to be a *consequence* of the possible cell shapes; they are simply listed early in that chapter. Second, it can easily be shown that the 14 space lattices can be referred to the author's same seven differently shaped unit-cells, and that they fall into the same seven symmetry groups. Thus, as the expressions of the fundamental characteristic of all crystals, namely their periodicities, the symmetry groups should logically have been described in detail immediately following Crystal Symmetry in Chapter 3 rather than in late Chapter 11. A final criticism of the space lattices is that, in all the dozen drawings shown in Chapter 11, no points but only lines are shown, despite the author's emphasis (p. 158) that "it must be remembered that a lattice is an array of points, not any particular set of lines joining these points".

Enhanced by chapter-end problems and a glossary of terms, Whittaker's *Crystallography* is a lucidly written, well-illustrated and, for the most part, logically developed book that should fill a needed place as the text for a one-term or two-term course that introduces both classical morphological and modern structural crystallography or two-term students in geology as well as in chemistry, physics and metallurgy.

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CLAY MINERALS by Ernö Nemecz, translated by B. Balkay into English from *Agyagásványok*. Akadémiai Kiado, Publishing House of the Hungarian Academy of Sciences, Budapest (1981). Distributors: Kultura, P.O. Box 149, H–1389 Budapest, Hungary. 547 pp., 217 figs., 126 tables. Price approximately $48.00.

As the author stated in the preface of the book, geological conditions in Hungary are favorable for the formation of various clay minerals. It is not surprising for that country to record the important discoveries of chloropal (= nontronite) in the middle of the last century and illite (sárospatakite) in 1936. Hungary has always been closely related to clay minerals. Since the commencement of modern systematic research in the 1950s, a vast amount of data on clay minerals has been accumulated. There is a demanding need to summarize and systematize the data. This was the main task of the book.

Clay Minerals consists of three parts: (I) crystal structure of clay minerals (274 pp.), (II) identification of clay minerals (83 pp.) and (III) genesis of clay minerals (153 pp.). Each part is further divided into many small sections. Part I begins with general features concerning structures and composition of clay minerals and the clay-mineral nomenclature. The author, then, successfully describes detailed crystal-structures of clay minerals with a special emphasis on a historical account of their development. These descriptions certainly help readers to have a rapid and fairly full assessment of the crystal structures.

Part II deals with the methodology of clay-mineral identification. Methods applied include X-ray diffraction, thermal analysis, chemical analysis, infrared absorption, observations by electron microscopy and solvation with certain organic compounds. The author discusses the methodology in two steps; firstly, identification methods for each of the clay minerals and, secondly, those for their identification in mixtures. He develops his own elaborate system of clay-mineral identification after clay minerals are grouped by code numbers based on their d_{001} values. These are further subgrouped depending on their d_{060} values. Many Hungarian clay minerals are given as examples. These data are very valuable for those who are not familiar with the Hungarian literature on clay mineralogy.

Part III discusses clay-mineral synthesis, the natural formation and occurrence of clay minerals in various geological processes. Geological and mineralogical characteristics of hydrothermal argillization are presented by taking the cases of Velence Hills (granite), Tokaj Hills (volcanic rocks), Mátra Mountains and Börzsöny Hills (andesite) in Hungary. Examples are abundant and provide very useful information. The author also deals briefly with clay minerals in soils and in lake and marine deposits.

References cited are listed in the bibliography section at the end of each of the three parts, and an author index is given before the subject index at the end of the book. Literature referred

to in the book is that published before and during 1973. This may reflect on what the book is somehow lacking. It would be unfortunate if the lapse of time was due to translation, although the exact date of the original version is not known to me.

This book will certainly be used often for the diagrams, photographs, figures and other data, especially on Hungarian clay minerals. Unfortunately, my copy of the book contains a number of typographical and printing errors and is poorly bound. These, I think, could have been avoided.

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PLATINUM GROUP ELEMENTS: MINERALOGY, GEOLOGY, RECOVERY, edited by Louis J. Cabri (1981). The Canadian Institute of Mining and Metallurgy, Montreal. Special Volume 23, 267 pp., $40.

This volume was conceived, in the words of the editor, as "a reference source representative of the explosion of PGE information that has been published in the 1970's" (p. 3). The eight contributing authors have succeeded admirably in producing a monograph that should be useful to those interested in platinum-group elements (PGE) from the standpoint of mineralogy, petrology, geochemistry, geology or metallurgy.

The first chapter is a very brief introduction by the editor presenting the philosophy of the book. Chapter 2, by A.D. Westland, describes aspects of the inorganic chemistry of PGE that are particularly relevant to their mineralogy and geochemical behavior. Included are tabulations of various physical and thermodynamic properties as well as discussions of reactivity, speciation in solution, redox equilibria and and stereochemistry. The phase relations of the PGE and their important compounds are reviewed by L.E. Berlincourt, H.H. Hummel and B.J. Skinner in Chapter 3. An extensive tabulation of the stabilities and structures of binary, ternary and quaternary compounds is given along with 32 phase diagrams.

The geochemistry of the PGE in igneous rocks is reviewed by J.H. Crocket in Chapter 4, with the emphasis on elemental abundances in mafic and ultramafic rocks of the earth's crust and upper mantle. There is also a brief discussion of the affinity of PGE for various silicate, oxide, sulfide, arsenide and sulfarsenide minerals.

The techniques employed to prepare samples of rocks, unconsolidated materials and mill products for bulk chemical analysis and ore microsopy are described by L.J. Cabri and J.H.G. Laflamme in Chapter 5. J.H. Crocket and L.J. Cabri outline analytical methods used for PGE and PGM (platinum-group minerals) in Chapter 6. Included are mineralogical techniques such as microhardness and reflectance determination, X-ray diffraction and microbeam methods, as well as assaying and neutron-activation analysis.

The nomenclature, crystallographic data, physical and optical properties of the PGM are detailed in a monumental compilation by L.J. Cabri in Chapter 7. The major part of the chapter is a mineral-by-mineral description of properties useful in ore microscopy. Each of 75 PGM is dealt with under the following headings: ideal formula, general formula, optical and physical properties. distinguishing features, mode of occurrence, discussion, and selected references. Reflectance data for each mineral are presented in both tabular and graphical form, and many species are depicted in color photomicrographs or SEM micrographs. Electron-microprobe analyses of 76 PGM are tabulated and discussed by L.J. Cabri and J.H.G. Laflamme in Chapter 8. Also included are determinations of PGE concentrations in a variety of non-PGM (*i.e.*, minerals in which PGE are non-essential constituents). Information regarding the 140 unnamed PGM known as of 1979 is given by L.J. Cabri in Chapter 9. The optical and physical properties are summarized, and an opinion is offered in each case as to whether the mineral represents a new species or one that is already known.

A.J. Naldrett reviews the geology of the important PGE deposits and documents the tenor of PGE and gold in various ores in Chapter 10. The emphasis is on magmatic sulfide ores, although there are also brief discussions about placer and hydrothermal deposits. The chapter concludes with a genetic interpretation of the great range in absolute and relative PGE abundances in magmatic sulfide ores.

The final chapter of the book is a summary by L.J. Cabri of the mineralogical aspects of the recovery of PGE from ores. Included are discussions of the texture and grain size of PGM, the mineralogical distribution of PGE in various ores, and a brief account of the methods and efficiency of PGE recovery from certain productive deposits.

Mineralogy, geology and recovery are given equal billing in the title of this book but the degree of coverage is in fact rather uneven. Perhaps two-thirds of the contents are broadly mineralogical in character, whereas one-quarter is geological, and less than one-tenth deals

specifically with recovery. A reader particularly interested in the details of PGE recovery may be disappointed. On the other hand, the mineralogical chapters contain a wealth of basic information of primary interest to the process mineralogist.

This book is well edited, the chapters are arranged in a logical sequence, and there is a minimum of overlapping coverage by the different authors. The illustrations are generally clear and the text is virtually free of typographical errors. My one negative comment is that the book is printed on rather flimsy paper of a type that tends to discolor with age. The book strikes an appropriate balance between presentation of fundamental data and interpretation. The fact that it does contain such a wealth of data on the compositions of minerals, rocks and ores, as well as on the physical and optical properties of PGM, ensures that the volume will be a standard reference for geologists, mineralogists and metallurgists involved either directly or peripherally in the platinum-group elements and minerals.

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ERRATUM

In the paper on "Zonation of diagenesis and low-grade metamorphism in Cambro-Ordovician flysch of Gaspé Peninsula, Quebec Appalachians" by S. Islam, R. Hesse and A. Chagnon, which appeared in volume 20, pages 155 to 167, an error has been discovered on the colored map (Fig. 5, p. 161). Some oval-shaped anomalies for the illite crystallinity trends in the immediate eastern and western vicinity of the McGerrigle Mountain pluton and also in the late diagenetic zone west of the pluton should appear in *yellow*. Although these anomalies are outlined in black on the map, their yellow color, which would make them stand out distinctly, was changed to red or blue in the printing process.