BOOK REVIEWS

SPECTROCHEMICAL ANALYSIS, BY L. H. AHRENS, 364 pp., Cambridge, Mass., Addison-Wesley Press, Inc., 1950.

WAVELENGTH TABLES OF SENSITIVE LINES, BY L. H. AHRENS, 92 pp., Cambridge, Mass., Addison-Wesley Press, Inc., 1951.

Spectrochemical analysis of natural materials is still largely an art despite the fact that great progress has been made in the past 10 years in making such analysis reproducible from laboratory to laboratory. In preparing the two volumes here reviewed, Professor Ahrens, one of the leading American practitioners of the spectrochemical art, has performed a great service to those engaged in making spectrochemical analyses and to those who use them.

Professor George R. Harrison, in his foreword to the first volume, states well the need for the book:

> Several excellent books which deal with the basic theory and application of spectroscopy to the analysis of materials have appeared recently, but there has been great need for a series of volumes dealing more specifically with the detailed problems that arise in analyzing samples of one given type or another. The present volume will go far toward meeting this need insofar as the mineralogist and the metallurgist are concerned; after discussing spectrochemical analysis briefly it concentrates on the special problems met with in analyzing rock, ore, mineral, and soil samples, and conveniently integrates the accumulation of new lore for which a vast and rapidly growing literature must otherwise be combed.

In his preface, Professor Ahrens sets forth the scope of the book:

> In recent years spectrochemical analysis has been effectively employed to an ever-increasing extent for the analysis of a very wide variety of materials. Included in this list are minerals, rocks, soils, ceramic materials, refractories, slag, and biological ash. . . . There exists an urgent need for books on the analysis of the various substances which have been noted above and this book has been written in the hope that it will partly fulfill this need. It has been prepared chiefly for the analysis of minerals, rocks, and soils, but much of its content applies also to the analysis of ceramic materials, refractories, slag, and biological ash. . . .
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> The source of excitation that has been most extensively employed for the analysis of minerals, rocks, soils, and related material is the d.c. arc, and this book restricts itself to the use of this source. . . .
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> This book has been divided into two sections. The first, based partly on a course in spectrochemical analysis given by the author in the Department of Geology at the Massachusetts Institute of Technology, covers theory, general principles, techniques of analysis, and other pertinent aspects of spectrochemical analysis. In the second section the *spectrochemistry* of each element is discussed. *Instrumentation has in the main been omitted from this book.* Most necessary information of this type (description and discussion of spectrographic equipment) may be found in some of the general texts listed in the bibliography.

Part I, General Principles, consists of 10 chapters, covering Introductory Remarks, The Origin and Interpretation of Spectra, Some Physical Features of the D.C. Arc Discharge, Power of the Arc Source, Qualitative Analysis, Selective Volatilization, General Principles of Quantitative Analysis, Effect of a Change of Composition on Line Intensity, The Photographic Measurement of Radiant Energy and the Construction of a Working

Curve, and the Emission of Band Spectra from the Arc. There is a wealth of material in these chapters thoughtfully and authoritatively discussed, such as, for example, arc temperatures, electrode shapes and sizes, compositional effect in qualitative analysis, and the very important subject of sampling and preparation of specimens. The discussion of this last subject is restricted to methods of sampling and preparing material received in the laboratory. The larger question of sampling in the field for spectrochemical analysis perhaps has no place in this book; but it is a subject badly neglected and one needing more research and discussion than it is currently receiving.

Part II, The Elements, consists of 13 chapters containing discussions of general semi-quantitative and quantitative methods applicable to a large number of elements and to appropriate groups of elements. The information in these chapters is detailed and will be found of inestimable practical help to those engaged in the analytical procedures. Of particular interest is the discussion in chapter 23, Common Elements Usually Present as Major Constituents (Si, Al, Ca, Mg, Fe, Mn, Ti, K, and Na).

The book concludes with an extensive but selective bibliography, an adequate author index and general index, wavelength tables, and the periodic table of elements. The wavelength tables, a notable feature of the book, are the basis of the second volume here reviewed.

This second volume, Wavelength Tables, gives in tabular form "the most sensitive lines of the elements in the arc and possible interfering lines within ± 0.4–0.5 Å of each sensitive line. Prepared particularly for the analysis of minerals, rocks, soils, meteorites, and related materials." Information is given for 68 elements and includes general comments on line sensitivity, line interference, excitation potentials, and a table showing the detection-limit concentrations of the elements in the d-c arc. There is also a separate table showing the most sensitive lines of the rare-earth elements and a table showing line sensitivities for visual (spectroscopic) analysis. Revisionary data on the well-known M.I.T. wavelength tables are included, together with some line coincidence data and a bibliography.

The wavelength tables constituting the body of the work are arranged alphabetically by elements. A most notable feature of the tables is the listing of interfering lines.

The two volumes have substantial bindings, pleasing formats, and are printed on non-glare paper. The second volume, Wavelength Tables, is printed on a gray paper that is particularly pleasing to the eye, and the tables are easily read.

These two books can be heartily recommended to spectroscopists, geologists, geochemists, metallurgists, soil scientists, and all others who have a use for spectrochemical analyses.

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ELEMENTI DI MINERALOGIA, BY PAOLO GALLITELLI, Nistri-Lischi Editori, Pisa, Italy. 1951. xvi and 575 pages, 455 text figures, 14 plates. Price, paper bound, Lire 4,000.

It is extremely interesting to compare, from time to time, the evolution of modern mineralogy as reflected in textbooks. It is with the greatest sympathy that the reviewer follows the efforts of leading teachers of mineralogy and authors of textbooks in order to see how they try to harmonize the requirements of routine instruction in geometric and physical crystallography and of descriptive mineralogy with the principles of basic physical chemistry, structural investigations or geochemistry.

One may have different opinions as to the actual usefulness of the "orthodox" or "conservative" as opposed to the "revolutionary" types of textbooks that have preserved or broken with the traditions of the Berzelius chemical classification or the Dana textbook style. This is especially true if the book is to be designed to attract not only specialists in

mineralogy but also students in chemistry, engineering and practical geology. Often the problem has arisen whether or not it is advisable to introduce a chapter on petrology into mineralogical textbooks. Most authors have not, since they were of the opinion that the inclusion of such a chapter would increase the size beyond reasonable limits. The fact remains, however, that most students of mineralogy must combine a fundamental knowledge of rock-forming minerals and of rocks with a good understanding of the basic methods of mineralogical determination by optical techniques or by x-ray diffraction. This also holds true for geology students interested in sedimentary rocks.

This dilemma of teaching mineralogy and writing mineralogic textbooks brings about an astonishing number of individual viewpoints. In this respect this book by an outstanding Italian mineralogist is most pleasing, because the techniques of presentation are combined for maximum usefulness to the reader. The author has found it possible to reconcile the "orthodox" and the "revolutionary" approaches due to his wide experience in instructing chiefly students of chemistry and general science at the University of Modena. He emphasizes the need of a good practical knowledge of geometric crystallography, including methods of crystal projection, calculation of the axial elements and projection. In addition the author stresses x-ray methods, from the Laue diagram and powder patterns to the rotation and Weissenberg goniometric method, including the application of the Ewald construction, the reciprocal lattice, and the simplified Fourier and Patterson analysis. Equally comprehensive are his discussions in the fields of applied mineralogy. The instruction is even extended to the techniques of examining polished and etched sections in reflected light. The reviewer is pleased to note that a mineralogical author discusses all these items not merely in a few paragraphs but in considerable detail based on his own broad experience. The discussion is not restricted to natural minerals, but is extended to include numerous inorganic crystal structure types, such as alloys, intermetallic compounds, etc. The reviewer does not recall many mineralogic textbooks of a similar size which give their readers an equally impressive introduction into applied mineralogy.

In the physical-chemical discussion of mineral genesis, the origin of magmatic rocks is not outlined in detail, but the importance of the Gibbs phase rule is stressed. Crystallochemical principles in relation to geochemical problems, minerogenesis and mineral stability are likewise emphasized. The application of V. M. Goldschmidt's and L. Pauling's laws of ionic replacement, ionic radii and their ratios, especially of the polarization phenomena are treated in carefully prepared special sections.

In comparison with the 450 pages comprising the general chapters, the 100 pages devoted to "Examples of Special Mineralogy" may appear very inadequate. However, it may be stated that additional information on the most important minerals is found also in paragraphs of the general part. Therefore an evaluation based only on the number of pages devoted to the "examples" does not do full justice to the essential minerals that the author selected. The author came to the conclusion that by far most of his students are interested in the description of ore minerals from which the fundamental metals are obtained (Fe, Al, Cu; Pb, Ag, Zn, Cd, grouped genetically together; Sn, Hg, Au, Pt, Ni, Co, Mn, Cr), and the metals of "modern metallurgy" (Ti, W, V, Ta-Cb, Li, Be, Sb, As, Bi). The "non-metalliferous" minerals including those of Na, K, Mg, B, the nitrates, apatite, those of Ba, Sr, the ornamental stones, fluorite, S, pyrite, graphite, the radioactive minerals, and the rock-forming silicates are discussed in 30 pages, and classified according to Strunz's structural scheme, with the Machatscki type formulation. It is surprising how satisfactory the information given here really is, in such a brief space devoted to "special mineralogy." Of considerable aid are the photographic reproductions of selected minerals which are, with a few exceptions, of excellent quality.

It would be surprising if such a new approach toward writing a mineralogical textbook would not meet with some objections. The generally high level, however, on which the

author has made his selections makes evident how carefully he surveyed the modern and classifical international literature of crystallography and physical chemistry. It would be erroneous if the reader would consider it as "elementary" throughout. On the contrary, the reviewer was sometimes surprised to find highly interesting and still unsolved problems discussed. The following may be mentioned as a single example. On page 142 regular intergrowths of quartz and calcite are referred to which E. S. Dana (*Am. J. Sc.*, (3) **12,** 448, 1876; *Zeit. Krist.*, **1,** 39, 1876) described from Specimen Mt., Yellowstone Park, in which $(01\bar{1}2)$ of calcite is intergrown parallel to $[10\bar{1}1]$ of quartz. This rather neglected observation (not cited in Dana's "System of Mineralogy," new edition) is related to the rare twin law of quartz with $(10\bar{1}1)$ as the twinning plane (in the "Reichensteiner Quarzgruppe" described as "Griesental law" by V. Goldschmidt (*Tscherm. Min., Petro. Mitt.*, **24,** 157–166; 174–179, 1905). A re-examination would be highly desirable with an extensive study of the structural conditions for regular intergrowths and the meaning of what Goldschmidt defined as an "induction effect" (Begünstigung) by the calcite as host phase.

It may be regretted, on the other hand, that in the crystallographic-optical chapter (p. 288) the elementary Fresnel construction for the determination of extinction directions in random sections of crystals with low grade of symmetry is not described. This also would have contributed to a better understanding of how the indicatrix is oriented by the universal stage method, which is indispensable for the identification of natural and synthetic crystals. Some doubts might be expressed as to whether an average reader would be able to follow profitably the recommended study (p. 308) of the highly mathematical theory of circular birefringence recorded in the papers of M. Born and B. Y. Oke (*Proc. Roy. Soc. London*, **150,** 84, 1935; **151,** 339, 1936). A quotation from the classical "Lehrbuch der Kristalloptik" by F. Pockels (Leipzig, 1906, especially pp. 307 to 335) with a short discussion of V. von Lang's double-shelled wave surface would probably have sufficed. In the chapter on the optical examination of opaque minerals (pp. 314–318) a reference to the excellent paper of M. Berek (*Fort. Min.*, **22,** 1–104, 1937), especially on the photometric methods for the determination of the orientation of the absorption indicatrix, seems necessary. Special mention should be made of the prevailingly excellent crystallographic illustrations, especially in the chapter on crystal growth and twinning (pp. 125–144).

The reviewer has discovered certain minor defects in the text such as erroneous names of authors and localities which can be remedied in a future edition. Also a few additional suggestions may be added. In the discussion of the symmetry and space groups (pp. 58, 168) the symbols and deductions of A. Schoenflies are used exclusively. The reviewer is of the opinion that the internationally adopted Mauguin-Herrmann symbols must also be used in modern structure discussions.

In the special part, on page 477, speaking of stannite, associated with cassiterite, the important mining locality of Llallagua is not mentioned. This would have offered a good opportunity to call attention to the highly instructive occurrence of cassiterite formed from gel minerals by the decomposition of sulfo-stannates in the oxidation zone of the deposits.

Somewhat surprising, at least for an American reader, is the omission of kernite which is by far the most important boron mineral on the American continent. On page 535, the polymorphism of $CaSiO_3$ is not mentioned, although the occurrence of the complex group $[Si_3O_9]$ as a structural unit is referred to. Pseudo-wollastonite is a typical devitrification product in window glass melts.

Surprisingly short is the discussion of the clay minerals which are briefly characterized on page 219, and Fig. 300, as having the H_2O interlayer structure of vermiculite (Hendricks), but only kaolinite is given a few general remarks. Halloysite, montmorillonite, nontronite, and the hydromicas (illite, etc.) are either referred to very briefly or omitted. This can not do justice to the great importance of these minerals in sedimentary mineral-

ogy and soil formation, not to speak of their importance in fuller's earth (e.g. fibrous attapulgite) or as catalysts for low-temperature organic syntheses, etc.

These few selected criticisms are offered as suggestions in the revision of the book in forthcoming editions. The Italian mineralogists can in all events feel very happy to see this fine book given a position of merit in international mineralogical literature.

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CHEMISCHE ANALYSE DER GESTEINE UND SILIKATISCHEN MINERALIEN BY J. JAKOB, Verlag Birkhäuser, Basel, 1952. Clothbound, 180 pages. Price 18.70 Fr. for bound copy.

This is Volume VII, chemical series, of Lehrbücher und Monographien aus dem Gebiete der exakten Wissenschaften. The book is divided into two parts: the first and larger portion deals with the methods generally applicable in the analysis of silicate rocks; the second part outlines specific applications and modifications for the analysis of minerals such as albite, anorthite, beryl, biotite, hornblende, muscovite, etc.

The procedures are clearly written and are in general agreement with those given in standard texts such as Hillebrand's Bulletin 700 published by the U. S. Geological Survey. The presentation reflects the attitude of a good professor in his classroom. Usually a paragraph on general considerations opens the discussion, then follow in logical order a brief outline of the principles of the method and finally the exact directions for an analysis. Procedures are outlined for the determination of both the major and minor constituents of silicate rocks. Very few references and supporting data are given. However, the existence of tri- and quadrivalent titanium in certain minerals has been demonstrated.

The absence of a subject index somewhat detracts from the usefulness of the book, but this omission is partly excusable because it is a short book and contains a fairly complete table of contents.

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THE BARKER INDEX OF CRYSTALS: A METHOD FOR THE IDENTIFICATION OF CRYSTALLINE SUBSTANCES, BY M. W. PORTER AND R. C. SPILLER. Volume 1, Tetragonal, Hexagonal, Trigonal, and Orthorhombic Systems. Part 1, Introduction and Tables, x+250 pp., 74 figures. Part 2, Crystal Descriptions, x+1,027 pp. Cambridge. W. Heffer and Sons, Ltd., 1951. Prices. Part 1 30s; Part 2 £4 10s. Part 1 and 2, £6.

This volume, which is an index to most of the known tetragonal, hexagonal and trigonal, and orthorhombic substances, is essentially a treatise on determinative morphological crystallography as initiated by Dr. T. V. Barker, who died in 1931. It is an attempt to set down rules for dealing with crystal geometry "which will enable two independent crystallographers who have measured crystals of the same substance to choose the same set of angles for identification" and, thus, to quickly and easily identify the substance by its crystallography. The rules were formulated by Barker and have been applied by the authors and others to the substances given in Groth's *Chemische Krystallographie* and in a few other sources.

The statement of rules governing the choice of unit form (setting) and orientation is lucid and straightforward. The unit plane which is selected is that which gives the greatest number of simple planes, these being {001}, {100}, {010}, {110}, {101}, {011}, and {111}. In the hexagonal system 4-index symbols, 2 may enter into the indices of simplest planes. In cases where two or more different unit planes give the same number of simple planes, rules are set forth to eliminate all except one. Since the method is concerned with the identification of substances by their crystal form, it may not be too important that the

unit thus chosen can conceivably differ from the structural unit. The effects of glide planes, screw axes, and lattice centering upon the occurrence of simple planes is ignored; but oftentimes the selection of a unit which gives the largest number of simple planes does yield the structural unit, so the disadvantage is not too serious.

An elementary explanation of the Barker Index for non-crystallographers by L. W. Codd introduces Part 1 of Volume I. This treatment is fairly rigorous and probably useful to beginning students of geometrical crystallography. It discusses: interfacial angles; spherical, stereographic, and gnomonic projections (the spherical projections which he uses are not too spherical—but serve their purpose very well); and zonal relationships. A heavy emphasis on zones seems to spring from a reluctance to leave one-circle goniometry, the principal argument being the advantage of being able to identify symmetries (highly doubtful!). Since one setting for many crystals is frequently all that can be made, zones and zonal relationships are actually better studied by measuring on a two-circle goniometer and plotting on a Wulff stereographic net.

Aside from the fact that there probably can be no short cut to an understanding of crystallography, such as Mr. Codd attempts, several non rigorous approaches leave much to be desired. For example, he shows the determination of zone symbols by the usual cross multiplication of indices of two faces in the zone, but in the cross multiplication he uses as indices of the two faces *hkl* and *pqr*. This should prove rather confusing to the beginner. The indexing of faces by use of the stereographic projection is not at all convincing. Too often the word *setting*, meaning unit, is ambiguously used to refer to orientation or to unit and orientation. It would be less confusing to restrict *setting* to the position of mounting of a crystal for measurement and to use the rigorous terms *unit* and *orientation* where they apply. Dr. Hey, in his later treatment, has been more precise in his use of *setting*. On page 78, however, he uses *setting* in the sense of *unit*, but in Part 2, page viii, *setting* carries the connotation of combined *unit* and *orientation*.

Codd describes seven crystal systems, but he follows the British custom of recognizing a trigonal system which contains seven crystal classes, of which two must be hexagonal while the other five may be hexagonal or rhombohedral. Hey recognizes this ambiguity, but uses the *trigonal system* in spite of its non rigorous character.

Pages 68 to 119 of Part 1 are AN INTRODUCTION TO THE BARKER INDEX by Dr. M. H. Hey. His writing is very clear, rigorous, and in fine style. This section makes no pretense of being an introduction to goniometry, but it would certainly be of considerable value to the beginner in crystallography. He emphasizes that the Barker Index reduces the 32 crystal classes to 11 centrosymmetric Laue groups by assuming the existence of a center of symmetry in all cases. In the tegragonal, hexagonal, and trigonal systems he notes the existence of *restricted* and *free* Laue groups based upon the presence or absence, respectively, of vertical planes of symmetry. In the *restricted* classes the choice of orientation is fixed, but there is freedom of choice of orientation in the free classes. Hey states that *orientation problems only arise in the orthorhombic, monoclinic, and anorthic systems*, but his *free* classes present some problems as well.

The critical angle for orthorhombic, tetragonal, hexagonal and trigonal substances in the Barker Index is the angle *cr* (001∧101). In the orthorhombic system there are two additional angles. The first, *am* (100∧110), must be less than 45° but closer to 45° than *cr* or the third angle *bq* (010∧011). These angles are in cyclic order. In case the angles cannot be measured because a plane or planes are missing, they may be calculated according to given procedures or by methods which are available to any crystallographer. Isometric substances are not included in the Index, since they do not have distinctive angles.

Once the classification angle or angles are known, it is a simple matter to refer to the determinative tables where *cr* values are listed according to increasing magnitude. The

subsidiary angles and, or the physical properties are then sufficient to narrow the choice from the range of possibilities to the correct species.

Hey has done a real service in his excellent treatment of *goniometry under the microscope and from photographs.*

The experienced crystallographer will be able to proceed with the Index with not more than a half hour study. He will find useful the *multiple tangent* tables; the *determinative geometrical* tables based on increasing angle *cr;* the *determinative optical* tables where uniaxial substances are listed according to increasing ω and orthorhombic substances are listed according to increasing β (beta is improperly called the ('mean') index in one section); and the determinative tables based on *increasing specific gravity* and on *increasing melting points.* The Alphabetical List of ENGLISH CHEMICAL AND MINERALOGICAL NAMES, plus the ALPHABETICAL LIST OF GERMAN CHEMICAL NAMES AS USED BY GROTH complete Part 1. All of these tables and lists are cross indexed with the thorough summaries of the properties of the substances, which are given in Part 2.

Part 2 is composed of three different sections devoted to tetragonal, hexagonal and trigonal, and orthorhombic substances. Within each section the substances are listed in the order given by Groth. Each substance is named and chemically defined and is given a reference number (there are 401 tetragonal, 434 hexagonal and trigonal, and 2,156 orthorhombic entries). References to Groth and other chemical works are made. The classification angles are listed, and the transformation formula—Barker to Groth—is given. Critical crystal forms are noted; the form indices are based on the Barker unit and orientation; the form letters are those of Groth for cross reference purposes.

A condensed description of the substance as given by Groth follows. (Ambiguity arises here, however, for the form indices are not those of Barker but of Groth.) The crystal class of the substance is given both with Hermann-Mauguin and with Schoenflies symbols. The habit, physical, and optical properties are summarized. Transformation formulae—Groth to Barker and others—are given. The description closes with the x-ray spacings where they are known of the three most intense lines as given by *ASTM.*

These two parts of volume 1 represent a prodigious amount of work on the part of the disciples of Barker's approach to determinative crystal geometry. That other approaches might serve as well is of little moment. The fact is that through this work the authors have raised geometrical crystallography from the realm of the abstract to a position of unique value as a determinative tool. No longer can crystallography be considered an adjunct of mineralogy, alone. This work must go a long way toward convincing the chemical profession and others that crystallography is a tool without which they cannot afford to continue. The mineralogist may find Part 1 of this volume sufficient for determinative purposes, since the *New Dana System of Mineralogy,* Volume I and II, supply most of the information that is in Part 2. It would seem, however, that the cross references involved in Parts 1 and 2 would make the purchase of both highly desirable.

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PRINCIPLES OF GEOCHEMISTRY BY BRIAN MASON, 276 pp., 42 figures, 39 tables. John Wiley and Sons, Inc. 1952. $5.00.

Here at last is the book that fulfills adequately the long-felt need for a *textbook* in geochemistry, written by a student of one of the pioneers and outstanding figures in the field, V. M. Goldschmidt. Although another recent book, *Geochemistry* by Rankama and Sahama, is more encyclopedic in scope and offers more detailed information on the occurrence and distribution of the individual elements, *Principles of Geochemistry* by Brian Mason of Indiana University, reaches the happy intermediate level, considerably above

that of an elementary treatise and somewhat below that of a source book. Not only has the author succeeded in distilling down the enormous vatfull of geochemical data available from the literature, but he has likewise been able to instill in his product a flavor that will undoubtedly be palatable to the majority of users.

The plan of the work has obviously been carefully fashioned. After a short introduction dealing with definition, history and references, Chapter two discusses the relations of the earth to the universe. Here are assembled brief accounts of the most recent ideas on the nature, age and origin of the universe, nature and origin of the solar system (emphasizing the version of von Weizsäcker), the compositions of the universe, sun, planets and meteorites, and finally, cosmic abundance and origin of the elements.

The structure and composition of the earth are the subjects of Chapter three, in which seismic, density and temperature data are reviewed, structural conclusions summarized, various earth models are critically examined and the zones of the earth—atmosphere, biosphere, hydrosphere, crust, mantle and core are chemically described. The chapter concludes with sections on the primary geochemical differentiation of the earth, geochemical classification of the elements and an interesting and well-constructed bit on the pregeological history of the earth.

Chapter four, Some thermodynamics and crystal chemistry, is in part a diversion from the general theme of the book. Most of it is chemistry and basic crystallography which the author deems necessary for a complete understanding of geochemical concepts. If the book is used as a text, this section may be of value to students whose backgrounds in collateral fields is incomplete. Magmatism and igneous rocks, Chapter five, considers the nature and composition of magmas, the crystal chemistry of the common rock minerals, crystallization of silicate melts, their minor and volatile elements and the relation between ore deposition and the magmatic cycle. It is interesting to speculate why the author, in choosing his species lists of the groups of common minerals, included such a rare example as johannsenite under the pyroxenes and omitted the more widespread hastingsite under amphiboles. In some groups the relations between "species" are not clearly indicated nor the complete isomorphism in series indicated. The discussion of pegmatites, when one considers the wealth of recent literature, is elementary, and it is most unfortunate that the author assists in perpetuating the notion that some mineralogically simple pegmatites have formed by differential fusion.

Sedimentation and sedimentary rocks are treated in Chapter six under such subtopics as composition, physico-chemical factors, pH, redox potential, colloids and products of sedimentation. Next follow three chapters (7, 8, 9) describing successively the hydrosphere, atmosphere and biosphere, each as to nature and composition and development. In the last of the three are sections on coal and petroleum as well as trace elements in biogenic deposits.

In Chapter ten, on Metamorphism and metamorphic rocks, the author considers chemical and mineral composition, mineral stability, thermodynamics and kinetics of metamorphism, metamorphic phase rule, facies, metasomatism and ultra metamorphism. It is gratifying to note that the author deemphasizes the role of ionic migration through solids as an important factor in large-scale rock transformations. The final chapter, The geochemical cycle, is a succinct summation.

Minor typographical and grammatical defects are at a minimum and there appear to be few significant omissions or misstatements. The organization is coherent, the presentation is cogent and the topography is clear. Line drawings are completely legible, but their number probably could have been increased. Each chapter is followed by an excellent selected bibliography which includes " . . . comprehensive texts, significant recent papers (especially those in journals not usually referred to by geologists), and review articles with comprehensive bibliographies." Fortunately Russian sources have not been neglected,

and the reviewer was pleased to note a description, one of the few in English, of Vernadsky's terms, clarke and concentration clarke (pp. 42–43).

To all students of geochemistry, whether their interest stems from the preficial or the sufficial roots of the name, this book is completely recommended as a highly readable and useable integrated account of the physical and chemical history of our planet.

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REPORT OF THE COMMITTEE ON THE MEASUREMENT OF GEOLOGIC TIME, 1950–51. Division of Geology and Geography, National Academy of Sciences—National Research Council. Publication 212, 140 pp., 1952. Mimeographed, $1.00.

The 1950–51 report of the Committee on the Measurement of Geologic Time, prepared under the direction of John P. Marble, Chairman, includes the following reports: (1) Summary report of the Committee on the Measurement of Geologic Time for 1950–51 by J. P. Marble; (2) Annotated Bibliography of Articles Related to the Measurement of Geologic Time, compiled by J. P. Marble (nearly 400 entries); (3) Abstracts of Papers delivered at the Symposium on the Measurement of Geologic Time, *Am. Geophys. Un.*, April 30 and May 2, 1951 (Articles published *in toto Trans. Am. Geophys. Un.* 33(2), 150–203, 1952); (4) Extracts from the Preliminary Report of the Committee on the Measurement of Geological Time in India, 1947–1950; and (5) Natural Variations in Isotopic Ratios of the Chemical Elements (A Report to the Commission on Atomic Weights, International Union of Chemistry, September, 1951) by J. P. Marble.

As in previous years this report will again be welcomed by geologists and mineralogists as a source book offering an integrated discussion and summation of world wide progress and results in geological age determination studies.

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THE FORMATION OF MINERAL DEPOSITS, by Alan M. Bateman. John Wiley & Sons, Inc., New York. 371 pp. 1951. $5.50.

The Formation of Mineral Deposits is a partly reconstituted, streamlined version of Part I (Principles and Processes) of Bateman's well known larger textbook, *Economic Mineral Deposits*, " . . . written," as the dust jacket states, "in language as non-technical as possible . . . ." Some of the illustrations are new; others are repeated from the more advanced book. The organizational patterns of the two works are very similar. Chapter subjects in the new book include: materials of mineral deposits, history of their study, their relation to igneous activity, mineralizing solutions, magmatic processes, contact-metasomatism, hydrothermal processes, sedimentary, weathering and ground water processes, metamorphic processes, controls of mineral localization, exploration and mineral resources. Despite its general title the book is concerned mainly with mineral deposits of *economic significance* and is not primarily a textbook on mineral paragenesis. The book has a well-considered scope, and every effort has been made to provide background information for the discussion of the more advanced ideas presented. Despite the author's statement that "A knowledge of mineralogy is not prerequisite," it is difficult to believe that average readers without a command of basic mineralogy and geology can assimilate the work completely. Nevertheless it goes farther than any other available book toward accomplishing its aim, namely "to serve general readers interested in mineral substances, and scientists, engineers, industrialists, and others who deal with the mining profession and business, as well as students who desire collateral reading in other courses or in a brief course in mineral deposits." For these the book can be recommended most strongly.

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EINFÜHRUNG IN DIE KRISTALLOPTIK BY EBERHARD BUCHWALD. Sammlung Göschen, Band 619, Walter de Gruyter & Co. 4th edition. 138 pages, 121 text figures. 1952. DM 2.40.

Professor Buchwald's (Jena) simplified introduction to the optical properties of crystals is one of a long series of small (4″×6″) books published as the Göschen collection, a series apparently similar to the College Outline Series published by Barnes and Noble. Following a brief introduction and a short discussion of crystallography, the book is divided into four parts. The first part is titled "Double refraction and polarization," containing in addition discussions of optical surfaces, index of refraction, and conical refraction. "Interference phenomena in polarized light," both parallel and convergent, comprises the second part. The third part contains a discussion of "crystals showing optical rotation and absorption." In an attempt to explain further the observations of the first three parts, the fourth part contains a discussion of the behavior of light in the crystal structure; it is entitled "Lattice optics of the visible spectrum."

Not only is the organization foreign to most texts on optical mineralogy, although nonetheless logical, but the subject content is different and refreshing. The book is concerned solely with the theories and proofs of the theories on the behavior of light in crystals; no consideration is given to optical mineralogy or to the microscope. The discussion is most clear and understandable for such an abbreviated treatment of a complex subject, although some American readers will find the German somewhat difficult.

From past reviews of earlier editions in the *Centralblatt*, this book apparently has been popular with students, for whom it is written. It contains much clarifying and additional material to that found in texts on optical mineralogy. Also from past reviews, it appears that this edition represents little change from the third edition, but considerable change from the first two editions, which contained less discussion of anisotropic crystals and of the electromagnetic wave theory, and more treatment of the effects of physical variables, such as temperature, on the optical constants.

The book is well printed on good paper, and has paper covers. It is most useful for its discussion, albeit too brief, of the electromagnetic wave theory, proofs of laws of optical crystallography, and of the behavior of light in the crystal structure.

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GIANTS OF GEOLOGY BY CARROLL LANE FENTON AND MILDRED ADAMS FENTON. Doubleday & Company, Inc., Garden City, New York. 1952. Price $3.50.

Geology as an organized body of scientific information is less than 200 years old. However people have been making observations of geological phenomena for more than 2,000 years. The history of Geology is naturally closely associated with the men who have worked in this field and Giants of Geology introduces us briefly to some of these early observers. As early as 585 B.C. Thales of Miletus was studying the Nile delta and the deposition of silt by the famous Meander River. The celebrated philosopher Aristotle (born 384 B.C.) made observations on the stars and the earth. Pliny, who perished in the eruption of Mount Vesuvius in the year 79 A.D., wrote Natural History in which he describes earthquakes, and comments on the occurrences of gold, silver, and iron.

Many workers in the early history of Geology were greatly influenced and often hampered by narrow theological concepts which extend down to recent times and are especially evident in the fields of Evolution and Paleontology. There were fierce conflicts concerning the nature of fossils and some of the explanations that were given to account for these organisms are absurd and grotesque. The great artist, Leonardo da Vinci (1452–1519) gave one of the first correct explanations of the occurrences of fossils in rocks.

Nicolaus Steno, born at Copenhagen in 1638, was greatly puzzled when he found solid shells enclosed in solid rock. He correctly assumed that these shells had once belonged to

living animals but larger bones and teeth he thought must have belonged to elephants which Hannibal used in his war against Rome in 218 B.C.

Geological thinking has often been dominated by strong personalities. This may retard the growth of a young science just as fixed ideas always do but fortunately there have always been dissenters in Geology who refuse to accept the dictates even of so-called authorities.

Abraham Gottlob Werner was one of these strong characters. He was born in 1749 and spent much of his life around Leipzig. Werner did not travel extensively and he apparently read very little yet he produced a booklet of 28 pages in which he undertook to tell the complete story of the earth. Werner attracted many enthusiastic students who roamed widely in search of illustrations of the master's ideas. James Hutton was one of the rebels who attacked Werner's system with great success. Hutton believed that the face of the earth has undergone many changes and thus he is in agreement with modern geological thought. Hutton's great work was entitled "Theory of the Earth, With Proofs and Illustrations."

Charles Lyell's famous work, the Principles of Geology, was a sensation and helped greatly to establish geology as a sound and very reasonable science. He traveled widely and observed keenly and was always searching for new material. He visited Canada and the United States in 1841 and gave a famous series of lectures in Boston. The Principles grew with each successive edition. One of these editions contains fifteen chapters on Darwin's Origin of Species. Lyell accepted the main conclusions of Darwin with enthusiasm. He died in 1875, a greatly respected man, and his friends asked that he be buried in Westminster Abbey.

Giants of Geology thus carries the story of geology down through many famous persons into recent times. The foibles of the great are mentioned and we see many of them as fine, friendly characters who believed in the great science of geology and many of these men were inspiring teachers. They have enriched the subject of geology and have helped many people to enjoy the earth upon which we live.

Giants of Geology is written with a light touch but, after all, geologists have their lighter moments. The book should interest the general reader and students of geology will find it a valuable store of information on the history of their subject.,

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METEORITE COLLECTIONS IN HUNGARY. (MAGYARORSZÁG METEORITGYÜJTEMÉNYEI) by Tokody (László) and Dudich née Vendl (Mária). Budapest (1951).

This book of 102 pages is mainly a list in Hungarian and English of the meteorites in the National Museum of Natural History in Budapest. The list is in duplicate, the falls being arranged first alphabetically by locality of fall; and again according to the classification of Prior. There is no descriptive matter except the weight of each specimen but the total weight of each fall is not indicated.

According to a very brief introduction the first meteorite was acquired in 1815. At present 484 localities are represented by 1295 specimens. There are pieces of all falls (12 stones and 4 irons) that had fallen in Hungary before 1918. There are only 45 falls in the collection dated later than 1900 and the latest fall noted was of 1931.

Three much smaller collections of meteorites in other Hungarian institutions are also listed in the same way.

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