BOOK REVIEWS

THE EARTH: AN INTRODUCTION TO PHYSICAL GEOLOGY. By JOHN VERHOOGEN, FRANCIS J. TURNER, LIONEL E. WEISS, CLYDE WAHRHAFTIG, AND WILLIAM S. FYFE. Holt, Rinehart and Winston, Inc., New York, 1970. 748 pages $13.

It is gratifying to see a comprehensive introductory book dealing with the geological and geophysical aspects of the earth that is relatively uncompromised in the use of chemistry, mathematics, and physics. The expressed purpose of the book is "to present a summary of what is known of the constitution of the earth and of the processes that have shaped its evolution" to "second- and third-year students in American universities" who possess strong backgrounds in the physical sciences. The major considerations of this review are chapters 2, 5, 6, and 10, which cover mineralogy, thermodynamics, and petrology; however, we consider them in the context of the book as a whole.

Chapter 2, entitled "Minerals," is 100 pages in length and is divided into three major sections; crystallography, chemical mineralogy, and physical mineralogy. The chapter is well illustrated with 99 figures. The crystallography section makes liberal use of vectors, matrices, and group theory. This is especially convenient from the standpoint of the development of a large amount of material in a small amount of space and is an appropriate approach for those who will continue on in the field of structural mineralogy. This section of the chapter will be rough going for most readers, and is, perhaps, more difficult than necessary. The presence of a significant number of technical errors will require that caution be exercised by instructors assigning this chapter as background reading. Many of these errors will presumably be taken care of in later printings. The authors suggest that portions of the book may possibly be used for specific courses (for example, mineralogy) at the second—and third—year level. We conclude that it is not satisfactory for that purpose. Although the authors point out that material in specific chapters would have to be supplemented, we believe that other books or combinations of them would still be required for a comprehensive mineralogy course at the level of rigor to which the authors are addressing themselves.

Although authoritative and refreshing in its use of petrologic examples, the authors' treatment of thermodynamics (Chapter 5) is too brief (22 pages) and superficial. Fortunately, further coverage is contained in the following chapter on igneous phenomena and products, and a lengthy list of general references, to which the motivated student can turn, dealing extensively with chemical thermodynamics, is given at the end of Chapter 5. It is unlikely that many instructors would assign this section to students whose prime area of interest is in mineralogy and petrology and would prefer, instead, to have them go to any of several excellent texts introducing the subject of thermodynamics and its geological applications. On the other hand, this chapter would provide a substantial background for students whose interests are in the other disciplines of earth science for which thermodynamics is not so critical a cornerstone.

The chapter on igneous phenomena and products (6) considers, first, volcanism and the origin of magma based upon experimental studies and second, igneous rocks, their classification and origin. The remainder of the chapter is devoted to a discussion of petrographic provinces. This is the strongest section of the chapter; however, in our opinion there are serious omissions. One glaring area of neglect, for example, is the discussion of layered intrusions to which the names Skaergaard, Stillwater, and Bushveld are synonymous. None of these is discussed.

The chapter on metamorphism (10), a condensation of Turner's book, includes an excellent, comprehensive description of a contact metamorphic locality in California and discussions of the classical metamorphic localities in Japan, New Zealand, and Scotland.

However, American students will find reference to New England metamorphic localities disappointingly lacking. The value of this chapter in providing a strong foundation in metamorphic petrology for science-oriented students is somewhat compromised by the failure of the authors to introduce the AKFM projection and by the superficial treatment of petrogenetic grids. In this single chapter some topics are covered extensively—perhaps to the point of being overdone considering the purpose of the text—while others are mentioned only in passing or are neglected entirely.

We puzzle, as do the authors, for what the book could best be used. We believe one of the best potential uses of this book would be for beginning graduate students in geoscience whose undergraduate degrees are in chemistry, mathematics, or physics. A course using this book might substitute for several that those students might otherwise have to take. However, the book has several problems that partly negate this potential use. It is not well referenced and the treatment is not uniform. Advanced students finding their appetites whetted for the quantitative aspects of geology, almost certainly will want to go to some of the original references but will find this a frustrating task. The authors state that for reasons of clarity many references have been omitted. The effect, however, has been to reduce the value of the book to the people for whom it was intended.

In summary, although the book is not technically perfect, many students and researchers will almost certainly want this volume in their libraries for quick reference to fields with which they are unfamiliar. We congratulate the authors on a refreshing approach to an introductory geology text that removes in part the stigma of geology as a non-quantitative science.

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DANA'S MANUAL OF MINERALOGY, 18th ed. By C. S. Hurlbut, Jr. John Wiley and Sons, Inc., New York, 1971. 579 pages. $14.95.

Updating of introductory mineralogy textbooks has been badly needed, only in part because changes have been taking place in the science itself, particularly with respect to increasing emphasis on applications to geological problems. Of greater importance is the tendency for undergraudate students entering mineralogy courses to be increasingly well prepared in cognate areas, especially chemistry. Students are capable of handling more complex concepts and of relating traditional mineralogical subjects to other disciplines Dana's Manual of Mineralogy is a widely used and popular introductory textbook. The general format remains unchanged, with major chapters on crystallography (123 pp.), physical mineralogy (46 pp.), chemical mineralogy (47 pp.), descriptive mineralogy (263 pp.), occurrence and association of minerals (22 pp.), and determinative mineralogy (47 pp.). There are some welcome changes and revisions within these subdivisions, which result in improvement over the 17th edition [*Amer. Mineral.* 56, 750–751]

The chapter on crystallography now contains an introduction to space groups, and the section on X-ray crystallography (22 pp.) including a description of single-crystal methods, is nicely done. The overall emphasis is still on morphological and descriptive crystallography, with some 55 pages devoted to the crystal systems and classes. Unfortunately, the description of lattices and the general nature of translational periodicity are much underplayed. A familarity with these concepts is necessary to the understanding of many structural and chemical properties of minerals, and should be treated at length in introductory texts. Crystal growth is touched on, but defects and other deviations from translational periodicity are not considered, beyond a strictly descriptive treatment of twinning.

The chapter on physical mineralogy contains a well written section on optical crystal-

lography (30 pp.). There is a growing tendency to introduce this subject in elementary mineralogy courses, and the text and accompanying diagrams are excellent for this purpose. There is little change in the coverage of other physical properties however, although some chemical and structural significance is attached to color.

The chemical mineralogy section is principally devoted to an introduction to elementary concepts of crystal chemistry, with a concise discussion of ionic bonding. Other concepts such as solid solution and polymorphism are only briefly described, with little discussion of their relation to crystal chemical or pressure-temperature-composition variables. There is still a section on blowpipe analysis, but it is not extensive. Etch, microchemical, and spectroscopic-analytical methods are mentioned, but there are no descriptions of other methods in common use such as X-ray fluorescence and electron microprobe analysis.

The mineral descriptions have been changed slightly with the addition of some new data, including *d*-values and optical properties. Some major mineral groups are introduced with sections on their general crystal chemistry; the description of the phyllosilicates is particularly well done. Many mineral system descriptions, especially feldspars, lack simple phase diagrams, and many aspects of crystal chemistry, structure, and properties are too little related to environmental parameters such as time, pressure, temperature, and composition. Some attempt at the latter is made in the chapter on occurrence and association of minerals through a description of the common rock types. The determinative tables for mineral identification are excellent and should continue to be most useful in those introductory courses where emphasis is placed on hand specimen identification.

This latest edition continues in the tradition of its predecessors in presenting a thorough coverage of a very introductory level of mineralogy. The changes are generally consistent with trends toward a more crystal chemical approach, but the overall emphasis remains with the more classical descriptive aspects of mineralogy. For those students not having preparation in university-level introductory chemistry or other cognates, such as junior-college-level students, this textbook might be a satisfactory one. For the increasing number of students with such a background or the facility to obtain it, this text would be inappropriate, however.

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THE GROWTH OF SINGLE CRYSTALS. By R. A. Laudise. Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1971. ix, 352 pages $14.50.

There are several very good books on the art and science of crystal growth. This book which could be subtitled, "The Practical Crystal Grower," has the advantage of being in English, of being up-to-date, and of having the coherence of a single author who has a proven record as a practicing crystal grower. Dr. Laudise's book also reflects his very close association with his many Bell Telephone Laboratory colleagues who have all made significant contributions to both the theory and practice of growing a variety of crystals whose ultimate characterization has often been in a device. If you want in one package a basic introduction to the various techniques of crystal growth, to the pertinent fundamentals for appraising and understanding the strengths and limitations of each method, to the necessary equipment and where to get it, to the various methods of characterization, and to the more useful literature of the field, then include this book in your library. For those few academic institutions who have a course in crystal growth in their curriculum, this book would be a most useful text.

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TEXTBOOK OF LITHOLOGY. By KERN C. JACKSON. McGraw-Hill Book Company, New York, New York, 1970. 484 pages. $16.00.

Teaching a beginning petrology course has become a challenge as modern developments in several diverse fields of geochemistry and geophysics have tended to supplant the more classical (or old-fashioned, however one views it!) approaches to study of rocks, *e.g.*, petrography and field mapping. Classical and modern subject matter can and should have a balance in the introductory course, without sacrificing the fun and excitement too. In my opinion, the introductory textbooks which have appeared during this period of revolutionary growth in petrology have not met the challenge and have fallen short of the purpose for which they were written. The balance, professional sophistication and logic, and the illustrations of texts published 30–50 years ago have not been matched in the modern generation of books. On the latter point, we find, for example, two texts, ostensibly for a beginning petrology course, presenting textural terminology and rock classification without a single effective illustration of a rock—on any scale! On the positive side, however, several good to excellent books have appeared in the past decade covering various facets of the broader discipline of petrology. One solution to the "textbook gap" has, therefore, been to employ more than one of these good books to achieve some degree of balance in an introductory course.

Textbook of Lithology by Kern C. Jackson of the University of Arkansas is designed to lay "a foundation for observation of geological detail in the undergraduate curriculum." The unusual title was "expressly selected to emphasize the nature of the laboratory study . . . based on megascopic examination of samples." The book is not designed to be comprehensive and omits topics that may be found in an introductory course. Field relations and modes of occurrence of rocks are not covered, except for a few photographs of outcrops. Microscopic petrography is touched lightly in the form of many nice photomicrographs. An introductory discussion of phase relations in crystal-liquid systems is presented, but without mention of petrologic application or significance, as a 40 page appendix.

The book is divided into two parts: "In chapters 1 to 4 the classical concepts of rock genesis are developed" to parallel classroom lectures on the genesis of the major rock types. "Chapters 5 to 7 are designed for use in the laboratory in conjunction with the detailed study of specimens." Following an introductory chapter on the physical and chemical nature of the earth, Chapter 2 deals with magmatic processes. Although fairly comprehensive, there is no mention of viscosity, stoping is said to be a *cause* of ascent of magma and, of the several hypothesized origins of andesite presented over the years, only one, involving mixing of granitic and gabbroic magmas, is presented. Chemical variations accompanying partial melting and crystal fraction are demonstrated in tabular form. Chapter 3 is a well organized treatment of factors involved in the formation of sedimentary rocks; the enigma of primary dolomite is considered and the novel suggestion made that Precambrian dolomites are a byproduct of granitization of vast greenstone terraines. Chapter 4, which includes a ten page statement on granitization, presents the detailed facies terminology of both Turner and Hietanen. This, together with several tables setting out mineral assemblages and reactions for a variety of chemical rock types, seems too involved on an introductory level. Triangular diagrams are not utilized.

The next 3 chapters are the real heart and strength of Jackson's text. They consist of a detailed and largely illustrated catalog of rock nomenclature, textures, and mineralogy—the latter broken down into major and accessory (or clastic and cementing) minerals, color, habit, inclusions, and alteration. This catalog is not only a great help in identifying minerals in hand specimens, but it also implicitly stresses the importance and value of

careful detailed observations and exposes the beginning student to the systematics of petrography. I feel, however, that more could have been said, or greater emphasis made, regarding the geologic significance of the cataloged textures and structures. A confusing feature of these chapters is the layout and typography of the headings, which break into 6 ranks. Regarding metamorphic fabric, it is noted (p. 414) that "accurate description of features is more important than terminology" yet the following pages *name* 6 types of cleavage, 5 types of planar structures, and 6 types of lineation!

Overall, the text is well written and lucid. Ambiguous and opaque statements are not apparent; neither are typographical or editorial errors. Regrettably, there are two dozen photographs which are seriously out of focus, or have very poor contrast, or don't show what the caption claims, or are simply unimportant. When students are screaming—and rightfully so—about the exorbitant price of textbooks, surely they ought to get their money's worth in the most costly item.

Whether the text achieves its stated objectives will depend, ultimately, on the individual student and how assiduously he takes advantage of Professor Jackson's coaching. But, certainly, this text is the best introduction to the study of rocks which has appeared in the last decade.

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SALT DEPOSITS: THEIR ORIGIN AND COMPOSITION. By O. Braitsch. Translated by P. J. Burek and A. E. M. Nairn. Springer-Verlag, New York, 1971. 297 pages. $19.80.

This book, which is a translation of *Entstehung und Stoffbestand der Salzlagerstätten* (1962), is the most comprehensive work on the mineralogy and geochemistry of evaporites in the English language. It brings together the results of the classic works of Van't Hoff, Jänecke, and Boeke, the important researches of Kurnakov and his school, and the investigations of equilibrium conditions by D'Ans, Autenrieth and Braune, Kühn, Herrmann, and many others. After a thorough discussion of stability conditions of evaporite minerals, Braitsch develops a series of physico-chemical models and then compares them with natural salt sequences. The natural sequences discussed in greatest detail are the German Zechstein and the Tertiary salt deposits of the Upper Rhine valley. Braitsch was one of the few authors to discuss the importance and the results of a *dynamic* rather than the static system for the formation of evaporites. In each section he was as careful to point out the unsolved problems as he was to present the facts as they are known.

The translation of the text by Burek and Nairn is, in general, excellent. This book, however, is not an easy one to read. First, the subject is very complex, which necessitates a certain amount of repetition, and second, the translation is awkward in places owing to the complexity of the original text.

The list of over 350 references to the worldwide literature of evaporites is one of the major assets of the book, and the translators have added many new references to papers published as recently as 1968.

Because of the rapidly growing interest in evaporites and in rocks related to the evaporite environment, this book is essential reading for those interested in sedimentary and geochemical processes in addition to the specialist in evaporites.

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PRINCIPLES AND PRACTIVE OF X-RAY SPECTROMETRIC ANALYSIS. By EUGENE P. BERTIN. Plenum Publishing Corporation, New York, New York, 1970. 679 pages. $37.50.

As stated in the author's preface, this book is intended primarily for students and technicians who are not content simply to operate the X-ray secondary emission (fluorescence) spectrometer, but who want to understand the method and instrument. The book is not only successful in this respect, but it will also prove most useful to those who teach courses in X-ray spectrometric analysis. It is obviously difficult to write a "practical" textbook in a field in which instrumentation and technique change is rapidly as in X-ray spectrometry, but by emphasising the principles of the method as well as standard techniques, this difficulty has largely been overcome. Many students will welcome the emphasis on descriptive rather mathematical terms. It should be mentioned, however, that mathematical equations are included where necessary.

The first two chapters are devoted to an elementary but certainly adequate discussion of the origin and nature of continuous and characteristic spectra, primary and secondary excitation, fluorescence yield, absorption, scatter, and diffraction. Chapters 3 to 9 provide a detailed description of the X-ray spectrometer, its components, and their operation including a useful discussion of the scope, advantages, and limitations of the method. The detailed sections on excitation, dispersion (flat crystal dispersion is emphasized), detection, and measurement assemble a wealth of information much of which often lies buried in manufacturer's manuals and technical reports, or is transmitted by word-of-mouth. Since the book was written, several new analyser crystals have been developed and the potential analyst would be well advised to keep abreast of developments in this field. The chatper on pulse-height analysis includes a 6-page section on non-dispersive analysis. The great strides made in recent years in the development of semiconductor detectors have made the energy dispersion X-ray analyser competitive in many respects with the wave length dispersion spectrometer. It seems safe to predict that the energy dispersion X-ray analyser will replace the wavelength dispersion spectrometer in many applications within the next few years. For this reason, an extended discussion of energy dispersion techniques and principles would have enhanced the value of this book.

Chapters 10 to 15 deal comprehensively with the important topics of qualitative, semiquantitative, and quantitative analysis. Standard analytical techniques and correction procedures are described in detail. A short listing of available computer programs for data reduction would have been useful. All the various sources of error that beset a quantitative analysis are discussed and ways to avoid (or at least evaluate and correct for) systematic errors are outlined. Analytical precision and accuracy are discussed at length. Chapters 16 and 17 are devoted to specimen preparation and presentation and as such are of considerable practical importance. The remaining chapters describe unconventional modes of operation which are in large part of only limited value to geochemists. Although XRF is not the preferred method of analysis for most minor and trace elements, it is still widely used. The absence of a chapter devoted to this subject detracts somewhat from the value of the book.

The appendixes contain tables of wavelengths of spectral lines and absorption edges, excitation potentials, and mass absorption coefficients. Frazer's (1967) extensive compilation of mass absorption coefficients are not mentioned. As befits a book of this type, the bibliography is extensive (up to 1968). The book is well written, well organized, remarkably free of typographical errors, and contains an adequate index.

The author's stated objectives have certainly been fulfilled in this generously illustrated, comprehensive textbook. I highly recommend it to all those involved in X-ray spectrometric

analysis. It is unfortunate, however, that it appears to be priced out of the range of the majority of its potential users.

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REUNION HISPANO-BELGA DE MINERALES DELA ARCILLA. J. M. Serratosa, ed. Consejo Superior de Inves tigaciones Cientificas, Madrid, 1970. 233 p., $10. [from C.S.I.C. at Vitrubio, 16, Madrid-6, Spain].

This volume presents the papers from an international meeting sponsored jointly by the Socieda Espanola de Arcillas and the Groupe Belge des Argiles, held in Madrid 1–3 June, 1970. In addition to a general section, 26 of the papers were organized into two symposia on the interaction of water and clay, and organic complexes of silicates. Languages are English, French, and Spanish.

William T. Holser

COAL AND COAL-BEARING STRATA. Duncan Murchison and T. Stanley Westoll, eds. American Elsevier Publishing Co., Inc., New York, 1968. 418 p., $28.50.

Although this volume is based on some of the papers presented at the 13th Inter-University Geological Congress held at the University of Newcastle upon Tyne, January 4–7, 1965, the editors have assembled it as an integrated series of review papers. The chapters each summarize an important aspect of coal petrology, of which the four chapters comprising the section on geochemistry and metamorphism will be of particular interest to mineralogists and geochemists. On the whole the book is a modern introduction to the subject of coal that will be very useful to those in peripheral specialities. Discussion of particular deposits is limited to those of Germany and South Africa.

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PRINCIPLES OF LITHOGENESIS, Volume 3. By N. M. Strakhov. Edited by J. E. Hemingway and S. E. Tomkieff; translated by J. Paul Fitzsimmons. Plenum Publishing Corporation, New York, 1970. 577 p., $35.00.

This third volume of Acadamician Strakhov's monumental treatise on sedimentation, originally published in Russian in 1962, presents a comprehensive analysis of marine and continental sedimentation in arid zones. The treatment begins with terrigenous clastic sediments and progresses through chemical sediments deposited from waters of increasing salinity.

Part one of this three part book covers deposition in basins of low salinity and stresses the important chemical influences of groundwater discharging into continental basins.

Surprisingly, a sixty page section accents the importance of Cu-Pb-Zn deposits (referred to as the "arid triad") which are sedimentary in origin, not directly associated with hydrothermal or igneous activity, and whose geographic distribution suggests formation in arid zones. Following an initial admission that the sources of Cu-Pb-Zn can be determined only rarely, there is a fascinating, if categorical, presentation of the processes of distribution and deposition of these elements in sedimentary environments. One misses, however, a foundation of chemical information for evaluating the theories.

A chapter on phosphates and carbonates treats the mechanism of dolomite formation at length but omits many perplexing problems of carbonate stability such as the apparent lack of equilibrium, common in modern environments, between particulate carbonates and host solutions.

Although many sedimentary deposits in arid regions have little organic matter, a factor which tends to inhibit reducing reactions during diagenesis, a case is made for large

bituminous and oil shale sequences forming in basins of arid regions where the salinity is essentially the same as normal sea water.

In part two, deposition from more saline solutions is discussed. Evaporites are forming today predominantly in continental lakes while most ancient deposits are interpreted as products of deposition from saline gulfs or lagoons which were connected with the sea.

Modern evaporite basins form a complex array of hydrochemical types and the conditions controlling brine metamorphism are presented along with a classification which, in its simplest form, recognizes three major brine types: carbonate, sulfate and chloride. Processes of formation are explained following a presentation of the basic physiochemical laws and empirical solubility data for salt systems.

Part three is a description of ancient evaporite deposits, their composition (including trace elements), structure and classification. There are lengthy descriptions of specific deposits from many parts of the earth. Treatment extends from the origin of local deposits to the distribution of major deposits in space and time in relation to changing climatic and tectonic belts.

An intriguing problem of interpretation is the relationship between rates of subsidence and rates of accumulation in evaporite basins. Strakhov concludes that complete development (in the sense of including the more soluble chloride phases) of evaporites could have occurred only in depressions which suddenly subsided very rapidly. Thus, evaporites provide a record of episodes of relatively rapid subsidence, a conclusion which many will dispute.

Sedimentation in the arid zone is treated in broad perspective and the volume is well-organized although lacking an index. Regional relationships are described fully but there is little petrographic information. The interpretive portions tend to be categorical and in places there is a sprinkling of 'indisputablies' and 'undoubtedlies' attached to statements which seem insufficiently supported or even outrageous. However, this translation exposes in English a wealth of information from the Russian literature and is a substantial and stimulating contribution of interest to more than the evaporite specialist.

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CRYSTAL DEFECTS AND CRYSTALLINE INTERFACES. By W. BOLLMANN. Springer-Verlag New York Inc., New York, 1970. 254 pages. $27.00.

Atomistic understanding of crystal structures are a fundamentally important aspects in various branches of earth and material sciences, since deformation, diffusion, alteration, recrystallization, and dynamic processes taking place in crystals are in many cases initiated at the crystalline interfaces, yet not much has been understood quantitatively and atomistically. We have at present atomistic explanation for twin boundaries in terms of geometrical fitting of atom positions (such as Bragg's explanation of the aragonite twin boundary) and for small-angle grain boundaries (such as polygonization walls) in terms of dislocation arrays and networks. The former explanation can be applied only for twin boundaries, and the latter, which was developed by F. C. Frank in 1950 and is the only mathematical treatment we have, can be applied only for special cases in which rotation angle θ is small and two joining grains are the same kind. Neither can be applied for general crystalline interfaces or for phase boundaries, which are naturally far more complicated than twin- or small-angle grain boundaries. It is not too much to say that we have been almost innocent about the atomistic configurations of general crystalline interfaces or the boundaries between different phases, in spite of the fact that a vast amount of observations has been accumulated through various methods of direct observation of crystal defects.

Dr. Bollmann has been working on this difficult problem since 1961, and has developed a new mathematical theory to analyse the structures of general crystalline interfaces. His theory is based essentially on Frank's basic work on small-angle grain boundaries, and is called the O-lattice theory. He has published several papers on his theory and its application in several scientific journals and symposia, but these are known only among a limited circle. This book is published with the intention of presenting his general geometrical theory as a whole for the first time. The so-called O-lattice is constructed by superimposing two crystal lattices through the operation of translation and rotation of one lattice against the other and finding the best fits of lattice points. The structures of crystalline interfaces can be constructed from the O-lattice. The theory treats the O-lattice mathematically by matrix calculation procedure. As can be seen from this procedure, the O-lattice is directly related with Moiré patterns, which therefore can be considered as visual representation of the O-lattice. Although energy is not involved in the theory, which is based purely on geometrical analysis, theoretical prediction of the structures of crystalline interfaces agrees well with the experimental observation of actual interfaces.

The book consists of 14 chapters, 3 appendices, and a set of Moiré models. Chapters 1 to 9 describe briefly general aspects of crystal structures, some special structures, point defects, geometric basis of individual dislocations, interaction between dislocations, partial dislocations, and dualistic representation of dislocation reactions. These more or less introductory chapters give clear understandings of basic concepts of the theory to those who are not very familiar with dislocation theory. Only the essence of dislocation theory is described, and the description is very clear and simple. In Chapters 10 and 11, both theoretical and experimental understandings on the dislocation structures of subgrain boundaries which we had before the appearance of the O-lattice theory are explained. These chapters are mainly based on the Frank's formula. Chapters 12, 13 and 14 are the core of this book, in which the O-lattice theory and its application to the actual examples are presented. Chapter 12 presents general geometric theory of crystalline interfaces, *e.g.* mathematical derivation of the O-lattice. Chapter 13 describes a few examples of the application of the theory, the most interesting is its application to an optimum phase boundary between monoclinic and triclinic lamellae observed in moonstone. The analysis seems to be reasonable. Other examples, mainly of metals, are also presented in this chapter. However, it was the reviewer's impression that the book would be improved by including more actual examples of the application of the theory. This is perhaps due to the fact that the theory is in its initial stage of application. In chapter 13, the linear O-lattice theory is extended to non-linear problems thus generalizing the theory. In appendices, matrix calculation procedure, which is important in mathematical treatment of the O-lattice theory, is described for convenience of mineralogists and metallurgists who are not familiar with the subject. Explanation of Moiré models and a brief note on the literatures of direct observation of crystal defects are also included in the appendices. The most useful supplement to the book is a set of Moiré models, printed on transparent sheet papers, with which readers may enjoy themselves seeing how various Moiré patterns (or O-lattices) can be produced by slight rotation or translation of one lattice against the other. In fact, the idea of O-lattice theory was originated from observations made on Moiré models and the subsequent formulation of these observations in mathematical terms.

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GEOCHEMICAL FACIES ANALYSIS. (METHODS IN GEOCHEMISTRY AND GEOPHYSICS, Vol. II.) By WERNER ERNST. Elsevier Pub. Co., Amsterdam/London/New York. 152 pp., 34 illust., 18 tables. $9.50.

This little book brings together a variety of topics in the geochemistry of sediments that may be useful in determining the environment of sedimentation, provenance of detritus, or specific diagenetic conditions. It starts with a brief summary of the terminology and ideas of facies and their analysis, and goes on to elaborate on the ways in which various elements are incorporated into sediments as functions of environment, climate, tectonism, provenance, etc. Much of this is an abbreviated treatment of principles of sedimentation and sedimentary petrology with emphasis on the distribution of chemical elements. A short section on methodology, including sampling, is followed by the longest part of the book on results of geochemical facies analyses, divided into a long section on recognition of hydrofacies (treating salinity, oxygen, and temperature facies), and short sections on litho- and bio- facies. The emphasis is on how to tell such things as the salinity or temperature from the abundance of certain elements. For example, boron is treated in some detail as a salinity indicator.

Most of the topics are not covered in great detail and the book may be most useful as a guide to the literature (though the bibliography is by no means comprehensive) and as an indicator of how some problems may be tackled. The field is still in its infancy and its future will depend on much more work along the lines that Victor Goldschmidt laid out more than 50 years ago, that is, how crystal chemistry and mineralogy may be related to elemental composition. In the case of sediments the all-important equilibrium or non-equilibrium relations between aqueous solutions and minerals together with an understanding of kinetics of transformations, neither of which are emphasized in this book, will be an important part of our understanding of how certain elements may be useful as diagnostic indicators of specific facies.

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