BOOK REVIEWS

IGNEOUS AND METAMORPHIC PETROLOGY, BY FRANCIS J. TURNER AND JEAN VERHOOGEN. McGraw-Hill Book Company, New York. 602 pp., 92 fig., 1951. $9.00.

Once in a while in every field of scientific specialization there is published a work which not only mirrors the complete development of its field but also is so fundamental that it immediately becomes part of that development and serves as solid substance for future expansion. Such a book is *Igneous and Metamorphic Petrology*, in the field of petrogenesis. The book is too advanced for beginning students but is intended, in the authors' words, " . . . for the use of advanced students, research workers and teachers . . . ." To these it may well become indispensable, for it is eminently successful in attaining its goal of presenting " . . . a unified general impression of the origin and evolution of rocks that are generally believed to have crystallized, or to have been profoundly modified, at high temperatures and at pressures such as prevail from the earth's surface to a depth of 15 or 20 km."

The book may be considered as consisting of three parts. The first part contains an introductory chapter and another on principles of chemical equilibrium as applied to rocks. Thereafter follows the section devoted to igneous rocks, and last is the part dealing with metamorphic rocks. The portion on igneous rocks begins with chapters on characteristics and classification, variations in rock associations, crystallization of igneous minerals and crystallization of basaltic and granitic magmas. These are followed by description of the various natural rock associations: (1) the oceanic olivine-basalt—trachyte volcanic association, (2) volcanic associations of nonorogenic continental regions—those with alkaline affinities and the flood basalt—quartz diabase type, (3) volcanic associations of orogenic regions, (4) basic and ultrabasic plutonic associations, (5) granite, granodiorite plutonic association, and (6) pegmatites, lamprophyres and nepheline syenites. Under each group are discussed occurrence based on excellent, well-studied examples, distribution, chemistry, general mineralogy and hypotheses of origin, including a judicial critical review in which the ideas on genesis are examined in the light of *both* field and laboratory evidence. The final chapter on igneous petrology is a succinct summation entitled, "Environment, origin, and evolution of magmas."

In the part dealing with metamorphic petrology the subjects are: scope, classification, chemical principles, correlation of mineral assemblages and metamorphic environment, facies characteristics, special fabric features and the interrelation of metamorphism, magma and orogeny. The facies classification is Turner's modification of Eskola's work (*Geol. Soc. Am., Mem.* **30,** 1948). As is stated in the preface, " . . . Chaps. 15 to 21, dealing with metamorphism, constitute a reduced revised version of *Memoir* **30** . . . ."

The treatment of the individual igneous rock types as parts of a petrologic association is in general an excellent technique for presenting data on occurrence and genesis. Many rock types, however, appear in more than one major association, and thus their descriptions are somewhat decentralized. There are other minor points with which a reader might find fault. Some of the districts cited as examples for igneous rock associations are treated at undue length (Pliocene volcanic association of Eastern Otago, New Zealand—nearly 10 pages!) whereas for some other associations few or no examples are specifically described. On the other hand, the section on the nepheline syenite rocks is in proportion to the quantitative importance of this type, and, on the whole, an equitable balance is maintained between amount of descriptive material and relative abundance of the rock.

Some readers will look in vain for such topics as myrmekite, deuteric processes in general (deuteric is not even listed in the index), the formation of dumortierite with boron metasomatism, agpaitic sequence of crystallization, auto-injection structures, alumina

metasomatism, pegmatite-aplite relations and phenocrysts of the non-marginal plutonic type. Others will no doubt wonder why the authors have insisted on contributing toward perpetuation of many varietal, local, and other minor rock names (e.g., crinanite, atlantite, keratophyre, mangerite, mikenite, allivalite), the mere restatement of which, despite some attached definitions, gives tacit approval to their continued usage.

The line drawings (there are no plates) and tables are uniformly excellent; 41 figures have been repeated from *Memoir* **30**. Typographical errors seem to be at a minimum; a conspicuous example is the topic heading on p. 425. However, the index does not seem to match the text in quality. Some headings do not appear at all (latite, monzonite) and others have been incompletely cited (for dacite pp. 319 and 330 should also be listed). This materially detracts from the value of the book as a reference work. Many of the physical-chemical principles involved are discussed in extensive mathematical equations and formulae; fortunately an adequate understanding and appreciation of the book are not necessarily hinged on a complete comprehension of the complex mathematical notation.

These minor criticisms should not in any way minimize the over-all importance of the work. It will undoubtedly receive a well-deserved and enthusiastic welcome by "hard rock" petrologists everywhere as the outstanding new book in petrogenesis.

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TABLES FOR MICROSCOPIC IDENTIFICATION OF ORE MINERALS, by W. Uytenbogaardt. Princeton University Press, Princeton, N. J. 242 pp., 1951. $5.00.

Tables for Microscopic Identification of Ore Minerals is another welcome addition to the small group of books dealing with the study and identification of opaque and semiopaque minerals in polished section, mainly under vertically incident light (mineralography, mineragraphy, ore microscopy, Erzmikroskopie). The compiler of the Tables, W. Uytenbogaardt, at the Department of Mineralogy of Stockholm University, follows, in several respects, the work of his distinguished compatriot in the field of ore microscopy, Van der Veen. The first part of the book consists of two lists. List I is an arrangement of the ore minerals in order of increasing polishing hardness (following Van der Veen's technique for comparing the relative hardness of adjacent mineral grains) together with their compositions, % reflectivities (mainly data by Folinsbee) and their optical grouping (I=isotropic, W=weakly anisotropic, D=distinctly anisotropic and S=strongly anisotropic.) In List II the minerals are arranged by increasing % reflectivity, and other data given here are their composition, isotropism-anisotropism and relative grinding hardnesses as compared with those of galena, chalcopyrite, and pyrite. Together these two lists cover about 15 pages. Both give the pages in the subsequent table in which the complete mineral descriptions occur.

Most of the book is made up of a single table in which the minerals are listed by increasing "resistance to polish" (H), as compared to the three standard reference minerals noted above: galena, chalcopyrite and pyrite. For each mineral species much detailed and modern information is presented under the headings: chemistry, crystallography, Talmadge hardness, reflectivity, color, etch tests and miscellaneous. The most valuable information in the entire book is collected in the "miscellaneous" column. Here are notes on polish quality, cleavage, twinning, intergrowths and associations.

The book closes with a list of superfluous mineral names, a bibliography of 441 entries and an index.

The chief virtue of the work is that the author has gathered under one cover and carefully systematized much miscellaneous information and many widely scattered data on ore minerals that have emerged in the literature since the publication in 1940 of Short's,

U. S. Geological Survey, Bulletin **914,** The Identification of the Ore Minerals. One table alone, however, arranged on the basis of the often unobservable property of relative hardness, does not fufill the promise of the title of the book. Using this book and only this book the beginning worker in ore microscopy would indeed be hard pressed to identify ore minerals on the basis of characteristics obtained by means of the standard techniques. The book is a valuable supplement to Short's tables but cannot be considered as supplanting them, even though much of their information is outdated.

What is now needed in ore microscopy is a textbook in English that would encompass not only the *mineralogy* of ore minerals, including preparation of polished sections, optical theory of opaque minerals, mineral identification techniques, data and tables, etc., but also the *petrography* of ore minerals wherein could be found descriptions and examples of textures and microstructural features, their classification and genesis.

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BULLETIN 3, GEOLOGICAL SURVEY OF GREAT BRITAIN, His Majesty's Stationery Office, *London,* **1951.** 71 pp., 3 plates. Price 4s.6d postpaid ($0.80).

This *Bulletin* is published as a partial record of the work of the Atomic Energy Division of the Geological Survey of Great Britain. It contains four papers:

1. "On thucolite and related hydrocarbon-uraninite complexes, with a note on the origin of the Witwatersrand gold ores," by C. F. Davidson and S. H. V. Bowie. This is the first technical description of the uranium-bearing Rand ores in which both uraninite and a coal-like hydrocarbon, "thucolite," occur, the latter having been formed through polymerization of hydrocarbon gases by means of radioactive radiations. Since the uraninite is clearly of hydrothermal origin and of the same period of mineralization as the gold, its presence is a forceful argument for the hydrothermal origin of these deposits, a thesis long and eloquently advocated by Graton but generally rejected by the Rand mining geologists.
2. "Notes on the photoluminescence of minerals," by J. E. T. Horne, contains a succinct outline on the mechanisms of luminescence, discussions of intrinsic and impurity-activated phosphors, brief developments of some geological applications of luminescence and three appendices: I, an alphabetical list of luminescent minerals with short notes on the species; II(i), an alphabetical list of the fluorescent uranium minerals; and II(ii), a classification of uranium minerals under type of fluorescence or absence of fluorescence.
3. "The chemical determination of uranium, with special reference to its occurrence as a minor constituent of minerals and rocks," by C. O. Harvey. Here are discussed the ferrocyanide method, the peroxide method and uranyl nitrate extraction via ethyl ether. The techniques for uranium determination in siliceous rocks, monazite and other types of material are described.
4. "Autoradiographic techniques in geological research," by S. H. V. Bowie are deescribed under the headings alpha-particle autoradiography, beta-particle autoradiography, exposure, processing, examination and interpretation and quantitative measurements.

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DIE FESTIGKEITSERSCHEINUNGEN DER KRISTALLE, by H. Tertsch. vii+ 310 pages, 219 text figures. Springer-Verlag, Vienna, 1949. Price, $9.60.

There is a great deal of information in the literature on determination of strength, deformation, working and properties of polycrystalline aggregates, but comparatively

little on single crystals. This is true partly because much information is developed on such materials, especially metals, in the course of processes of fabrication and in experiments on methods of fabrication. Also, it is generally easier to study and describe the properties and behavior of a polycrystalline aggregate that acts as a more or less isotropic medium than a single crystal whose properties and response to stress vary, sometimes quite considerably, with crystallographic direction.

These and other considerations led Tertsch to attempt a synthesis, from the point of view of the mineralogist, of the strength-properties, deformation, etc., of single crystals. He has drawn his material in part from his many years of experience in this field and in part from the literature in mineralogy bearing on this subject. (There are 317 references at the end of the text.) Many of the examples and references are metallurgical. Tertsch assumes that the reader of this volume will have an adequate knowledge of crystallography, including an understanding of the twinning laws of the various crystal systems.

The book consists almost entirely of the description of methods of measuring, expressing, and recording four properties of crystals; (1) cleavage, (2) plasticity, (3) hardness, and (4) impact and pressure figures.

Cleavage is classified as impact-, pressure-, and tension-. Methods are described for measuring and expressing each kind quantitatively. This section closes with a theoretical discussion of cleavage and the cleavage process.

The longest and most complicated section (124 pp.) is that on crystal plasticity. The subject is clearly treated and well illustrated. There is more emphasis on mineral crystals than in other treatments of the subject, but even here a large proportion of examples are drawn from metallurgy. About two-fifths of the illustrations in this section are theoretical diagrams; the other three-fifths are almost equally divided between minerals and metals, the latter taken largely from the works of E. Schmid and his co-workers. An interesting feature on the section on crystal plasticity is a table in which translation elements and/or twin glide elements are tabulated for 85 minerals. This should be very useful for anyone interested in the deformation of minerals and rocks, and especially for those who are undertaking experimental work in this field. So far as the writer is aware this is the largest such compilation ever made. Schmid and Boas[1] give a similar table, but only 15 metal crystals are listed. The section ends with a 29-page theoretical discussion of crystal plasticity.

In the section on hardness twelve different methods of measuring this property are described and the effect of temperature on measurements by various methods is discussed. There are some interesting and instructive tabulations:

(1) The 1500 plus well-defined mineral species are grouped according to hardness, the number being given for each half division of the Mohs scale, and the number in each group that contain combined water. There are approximately 100–200 minerals for each half division between 2 and 6 inclusive, with a maximum of 187 with a hardness of 3. There are no hydrous minerals harder than 6.5.

(2) A similar tabulation is made for minerals containing each of 27 important elements.

(3) A chart shows ionic radii of 64 elements on one side and the maximum hardness of minerals containing each on the other side. In the theoretical discussion at the end of this section there is a further treatment of the relation between hardness and the periodic arrangement of the elements.

In the section on impact and pressure figures the relation of these phenomena to crystal symmetry is pointed out and methods for their production and study are outlined.

The book is bound in paper, but is well put together and is printed on a very good grade paper on which half tones as well as line drawings reproduce nicely. It is the most complete,

[1] Plasticity of Crystals, by E. Schmid and W. Boas (Trans. by L. H. Tripp), F. A. Hughes & Company, London, 1950. Pp. 85.

authoritative and up-to-date treatment of the strength, deformation, and related properties of single crystals of minerals. As such, it is a useful and beneficial compendium not only for those who are working with the deformation of minerals and rocks in Nature or in the laboratory, but also for those who have a broader interest in the physical properties of minerals.

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MINERALOGY (AN INTRODUCTION TO THE STUDY OF MINERALS AND CRYSTALS), BY E. H. KRAUS, W. F. HUNT, AND L. S. RAMSDELL, 4th Edition, 664 plus vii pages, 735 illustrations, McGraw-Hill Book Co., 1951. Price $8.00.

This is the fourth, revised edition of one of the most widely used textbooks for the teaching of elementary mineralogy in American colleges and universities. Considering the large number of copies sold since it was first published in 1920, and that it is an elementary textbook in a competitive field, the question arises as to the reason for its marked success. This reviewer believes that its success is due to the degree to which it fulfills the requirement as stated by Whitehead[2] that "A student should not be taught more than he can think about. Selection is the essence of teaching." This text presents the basic principles for an elementary course in mineralogy. The selection of the information and data to be included has been uniformly excellent. In addition to the normal topics included in the usual instruction in elementary mineralogy, there are chapters on qualitative blowpipe methods, optical mineralogy, crystal structure and x-ray analysis, gemstones, and what is commonly termed mineral economics. All of the special chapters do not have to be included in an elementary course. The selection from this group of topics will depend on the interests of the students, time, and facilities available.

All sections of this book have been revised—some more than others. The illustrations in this edition are much improved over those in earlier editions. A number of illustrations have been omitted and new ones added. Many of those previously used have been reproduced in a much larger size which greatly enhances their value.

The section on "Descriptive Mineralogy" has been radically changed. The arrangement of the species is now based on the classification used in the 7th Edition of *Dana's System of Mineralogy* and on *Strunz's Mineralogische Tabellen*. This is a very desirable change. With the exception of the usage of analcite for analcime, the recommendations of the Mineralogical Society of America's nomenclature committee (1936) have been accepted. *Orthite* has been changed to *allanite* in this edition. The following mineral species have been added to the text (*a*) in large print: aegirite, alabandite, amblygonite, brucite, cordierite, glaucophane, kernite, and prehnite; (*b*) in fine print: annabergite, antlerite, calaverite, covellite, cristobalite, diaspore, dumortierite, erythrite, greenockite, jadeite, microlite, millerite, montmorillonite, nephrite, niter, oligoclase variety—sunstone or aventurine, pentlandite, sylvite, tridymite, triphylite, vermiculite, vivianite, and wurtzite. The list of occurrences for brucite should have included Gabbs, Nevada. Considering the wide distribution of the clay minerals montmorillonite and hydromica (illite group), their description is inadequate.

The chapter on crystal structure and x-ray analysis has been rewritten and is both informative and stimulating. It serves to introduce the student to the phenomenological approach to the solid state. The chapters on gemstones and on the classification of the minerals according to the chemical elements have almost a new set of illustrations, in

[2] General Education in a Free Society. Report of the Harvard Committee. Harvard Univ. Press, 1945, p. 63.

keeping with the many changes in these fields in recent years. A selected bibliography of 57 entries has been added.

The determinative tables have been expanded to include the new species added to the text.

This reviewer believes that this fourth edition of Kraus-Hunt-Ramsdell will maintain for this textbook its fine reputation in the field of teaching elementary mineralogy and that it will gain for it many new friends.

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DIE FELDSPAT-QUARZ-REAKTIONSGEFÜGE DER GRANITE UND GNEISE UND IHRE GENETISCHE BEDEUTUNG BY F. K. DRESCHER-KADEN (1948). Springer-Verlag, Berlin/Göttingen/Heidelberg. xi+259 pp., 210 text figs. Price DM 39.00.

This book is the first of a series to be devoted to monographic treatises on very limited subjects. This series is entitled *Mineralogie und Petrographie in Einzeldarstellungen*, and is under the editorship of F. K. Drescher-Kaden and O. H. Erdmannsdörffer.

The book is organized into four parts. The first part is introductory, and is concerned with the geometrical pitfalls in textural interpretation, classification of reaction textures, a blast at dry diffusion, and nomenclature. The second part contains chapters on myrmekite and its genesis, on graphic granite and granophyre—treated as a single phenomenon—and *its* genesis with generalizations on metasomatism, and on feldspathization of quartz. In each case, some of the older works are adequately reviewed. The third part of the book contains chapters on the space problem of crystalloblasts, the textural relations between crystalloblasts and groundmass, and saussuritization of feldspars. The final section is devoted to a contrast of *truly* igneous and granitic textures, and to a discussion of the source of the substance of aplite and pegmatite dikes. An incomplete summary of the literature is arranged according to year.

Since the book is concerned with the origins of granitic textures, it is in the midst of a lively controversy; the theories will meet approval or disapproval according to the reader's likes. Whether one agrees or disagrees—as do I—with Drescher-Kaden, he deserves full credit for many fertile ideas, only a few of which are considered in this review. Although his conclusions seem to be based too largely on assumption, his book is an important and useful contribution. The excellent descriptions add a wealth of useful information, much serious and sensible doubt is cast on the dogmas of textural interpretation (see also, Niggli, *Schweiz. Min. u. Pet. Mitt.*, Bd. **30,** p. 500, 1950) and the discussion is lively and unusually thought provoking. I wish to urge its reading as exceptionally worthwhile to both magmatist and granitizationist.

Descher-Kaden prefaces his descriptions with the opinion that all granites have a metasomatic origin—and this is a basic assumption in all of his arguments. Although recognizing the described textures to be late stage phenomena produced by the alteration of an earlier fabric, he considers them proof that the entire rock had a metasomatic origin. The crystalloblastic nature of these textures is compared with a *truly* igneous texture (volcanic porphyry), and is argued as proof that granites cannot have crystallized from a melt. It would seem more likely that the crystalloblastic character of many granitic rocks is an expression of a different environment from that of volcanic rocks, an environment more favorable to retention of volatile constituents of the magma and to the presence of exotic hydrothermal solutions, either of which would serve to alter an originally igneous texture into a crystalloblastic one.

A process of "cyclic metamorphism and rheomorphism" is advanced as an integrated

explanation of the several textures described. Although vaguely stated, this hypothesis may be abstracted as follows: metasomatic introduction of potash feldspar during the formation of myrmekite (excellent evidence is presented for the conclusion that potash feldspar is the youngest of the three minerals of myremekite texture) releases soda and lime for granitization of quartz-rich metamorphic rocks; the latter reaction supplies silica to the metasomatizing solutions for use in the formation of myremekite-quartz and of the quartz in graphic granite and granophyre; silica that replaces potash feldspar in the graphic granite reaction releases potash for the formation of the potash feldspar associated with myrmekite and for the sericitization of plagioclase. The hypothesis is too vaguely stated to allow fair criticism. It is surprising that Drescher-Kaden should attribute sericitization of plagioclase to metasomatic solutions. He contends that *all* potash for sericitization of plagioclase is introduced from external sources, overlooking the common presence of sufficient potash feldspar in solid solution to account for the total volume of sericite in a plagioclase crystal.

Noting a common lack of evidence for a channel along which metasomatic solutions were introduced into a partly replaced crystal, the idea of "wet-diffusion" through the structure of the crystal, via structural defects called "intertrunclare" ("lineage" of M. J. Buerger), is advanced and is termed "endeleptonisch." The American literature on this idea is apparently not known to Drescher-Kaden. The idea is intriguing and deserves careful consideration. Its use by Drescher-Kaden seems to be subjective; thus, sericite inclusions in quartz are interpreted in the usual way as inclusions of an older mineral whereas sericite in adjoining plagioclase crystals is interpreted as having been introduced—in light of the endeleptonisch hypothesis. Neither conclusion seems likely as a general rule.

The complete lack of descriptions of field occurrences to supplement and to clarify the microscopic data is unfortunate. To cite an isolated example, the formation of "trains" of liquid inclusions in quartz glyphs in graphic granite is argued for textural reasons—not very convincingly—to precede deformation (disaggregation) of the same glyph (p. 137). Tuttle's (*Jour. Geol.*, 1949, p. 331) careful study of these planes of liquid inclusions, in which field data play a critical part, renders Drescher-Kaden's conclusion very unlikely.

The descriptions of the textures are accurate, unusually detailed, and carefully documented with the numerous drawings and photographs, and, in the case of myrmekite, they are indeed a classic of this kind of study. Many of these illustrations and descriptions —cited as proof of one thing or another—are open to various interpretations. Several of the illustrations contradict Drescher-Kaden's conclusions. For example, photographs cited as showing evidence of auto-catharsis are, in this case, as good textural evidence against the process as one could ever expect to find.

The book is printed on two weights and surfaces of paper; this seems to be a common postwar practice of German publishers. In many instances, letters have failed to register. The covers are paper, and the binding is insecure.

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