BOOK REVIEWS

KRISTALLE UND GESTEINE (ein Lehrbuch der Kristallkunde und allgemeinen Mineralogie), by PENNTI ESKOLA, Wien, Springer-Verlag, 1946, 396+viii pp., 461 figs. Price about $11.00. First published (1939) in Finnish as *Kiteet ja kivet;* German translation by Martha Romer.

Here is a book that should be in the hands of every teacher of mineralogy. Of all books designed for an elementary course, this one is written from the most modern point of view. The treatment is sufficiently advanced to challenge and stimulate the intelligence of a college student, but without such rigorous prerequisites as vector analysis or physical chemistry.

The first section, *Crystal geometry* (76 pp.), is fairly conventional. The treatment of space lattices is good, and the fundamental subject of space-groups is given more than the usual cursory statement, although their relation to relative importance of surface forms is not mentioned. The crystal classes are logically discussed beginning with the triclinic.

Section II, *Crystal physics* (80 pp.), is modelled partly after Niggli's textbook.[1] Vectorial properties are given in terms of ellipsoids. Discussion of mechanical properties, although a little more extended than that in English texts, is still not commensurate with their importance in modern petrologic investigations. Crystal optics is treated at length in the manner of Tschermak-Becke, and Dana-Ford.[2] *X*-Ray methods are sufficiently covered in ten pages, and radioactivity is mentioned.

Eskola's treatment of *Crystal Chemistry* (80 pp.—enlarged from the Finnish edition) is his major contribution to mineralogy texts. Although it is of necessity based on original literature more than the other sections, it follows Evans' text[3] rather closely. Types of bonding are described from the standpoint of electron structure of the atoms. Ionic radii, polarization, and coordination are followed by a detailed discussion of crystal structures according to the classification of Evans. The eleven-page summary of *Geochemistry* might be read with profit by most geologists. Subject headings are: *Composition of the crust of the earth, Camouflage of the trace elements and their occurrence as independent compounds, Distribution and movement of the principal elements in the crust of the earth, Distribution of the elements in the concentric shells of the earth, Abundance of the elements, Origin of free oxygen in the atmosphere, and The Kuhn-Rittmann hypothesis of the origin of the earth from solar matter.*

As Eskola points out in the foreword, only a quarter of the book is devoted to "rocks." Under the heading *Physical chemistry of crystals. Rocks:* (70 pp.), he really presents "kinetic crystal chemistry." Elementary discussion of phase diagrams is followed by a review of processes of crystallization in igneous rocks; pegmatites are treated at length and related to hydrothermal solutions. A few pages are devoted to crystallization of chemical sediments. The section is weighted in favor of Eskola's principal interest, metamorphism, by a discussion only slightly condensed from his presentation in "Entstehung der Gesteine."[4] Throughout the section he attempts to discuss the subject as an application of mineralogy, and to this extent it prepares for, rather than replaces, a course in petrology.

[1] Niggli, Paul, Lehrbuch der Mineralogie, 8th ed., Pt. 1, Berlin (1926).

[2] Becke, F., Tschermak's Lehrbuch der Mineralogie, 8th ed., Wien (1921); Ford, W. E., Dana's Textbook of Mineralogy, 4th ed., N. Y. (1933).

[3] Evans, R. C., Crystal Chemistry, Cambridge (1939).

[4] Barth, T. F. W., Correns, C. W., and Eskola, Pennti, Die Entstehung der Gesteine Berlin (1939).

In the final section (75 pp.) the common minerals are described on the basis of the combined chemical and structural classification of Strunz.[5] The discussion by groups is more interesting and helpful to the student than is the usual formal listing by species. Phase diagrams, structure drawings, and graphs and orientation diagrams of optical properties, are given for a few important cases.

If the book suffers at all it is in illustrations. Some of the diagrams are very good, such as the integrated series on the properties of the crystal classes. The scarcity of photographs may well have been dictated by economy. It is regrettable, however, that a drawing should be as noticeably in error as figure 303*a*, which purports to develop a body-centered lattice from close (square) packed layers.

It is fitting that one so eminently qualified and highly honored should publish an elementary text at the time that he is retiring from active teaching. His departure from tradition and convention in this text might well be followed by other authors, to the better training of all geologists in one of the fundamental branches of their science.

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ROCK ALTERATION AS A GUIDE TO ORE--EAST TINTIC DISTRICT, UTAH. By T. S. LOVERING.

The first of the Monograph Series in Economic Geology is Rock Alteration as a Guide to Ore—East Tintic District, Utah, by T. S. Lovering, in collaboration with 11 other members of the U. S. Geological Survey. The choice of this study as the initial monograph publication is an auspicious one, for not only does the paper bid fair to become a classic description of the geology and mineralogy of an important active mining district, but also it outlines fundamental methods for the recognition, recording, and interpretation of wall rock alteration genetically related to ore deposits. The technique of detailed delineation of different zones of country rock alteration as clues to the presence of hidden ore promises to be of considerable value as an additional ore finding tool. As yet the method is in its teens, for too few geologists are acquainted with its requirements to allow its present widespread application. Furthermore its use requires considerable petrographic knowledge, especially of an unspectacular, humdrum group of clay minerals with whose optical characteristics all too few petrographers are familiar. Dr. Lovering is to be congratulated not merely on the geological quality of his product but also on his wise inclusion of mineralogical data that will assist others in the adoption of this device. Certainly the monograph will do much to advance the mapping of rock alteration zones in the examination of ore deposits and districts.

In the East Tintic District five definite stages of hydrothermal wall rock alteration can be recognized: (1) the early barren stage, (2) the mid barren stage, (3) the late barren stage, (4) the early productive stage, and (5) the productive (ore) stage. In stage one dolomitization of Paleozoic limestone and chloritization of the lower part of an Oligocene volcanic series were diagnostic changes. Stage two is characterized by "argillic" alteration products—endellite, beidellite, halloysite, kaolinite, dickite, and allophane. Minerals of the late barren stage are barite, pyrite, sparse chlorite, and SiO_2 as jasperoid in the sediments and quartz, allophane, barite, pyrite, and calcite in the lavas.

The introduction of potassium and the crystallization of clear quartz in open spaces characterize the early productive stage. In general during this period, earlier formed clay

[5] Strunz, Hugo, Mineralogische Tabellen, Leipzig (1941).

minerals were converted to sericite. During the last, or ore stage, pyrite and other sulfides were formed. In contrast to the often assumed idea that wall rock alteration and ore deposition proceed simultaneously, Lovering assigns the individual alteration zones to chemically ". . . differing solutions whose periods of activity have been separated by appreciable time intervals." The mineralogy of the zones changes outward in all directions from centers of hydrothermal activity. Outermost minerals are also the oldest; i.e., subsequent stages of alteration become increasingly restricted to the vicinity of solution conduits.

Superimposed on this complex sequential hydrothermal assemblage is a variety of supergene alteration products, including kaolinite, halloysite, jarosite, alunite, and allophane derived from acid sulfate waters, and montmorillonite, beidellite, endellite, allophane, gibbsite, and calcite formed from alkaline solutions. Recognition of different kinds of altered wall rock is facilitated by types of limonite whose diagnostic appearance depends upon the parent mineral—pyrite, biotite, chlorite, epidote, or magnetite.

The zones of alteration are related to the structure and lithology of the district by means of a series of maps and diagrammatic sections. An impressive frontispiece consists of a sectioned isometric block diagram in four colors showing relation of alteration to structure and ore in the North Lily fissure zone. The general mineral paragenesis is discussed in interesting detail, and the geochemistry of the alteration is summarized graphically from 37 new chemical analyses of fresh and altered rocks.

Lovering is careful to point out that the recognition of an altered zone is no sinecure for the presence of ore but states, "Knowledge of the space relations of altered zones and the stages represented in an area of favorable structure, and the position of the various stages in the sequence of hydrothermal events that culminated in ore deposition, gives a reasonably secure basis for estimating the chance of finding an ore body."

Successful application of the technique requires the integration of careful field mapping with detailed petrographic study—an exacting blend of the demarcation of regional features with the recognition of microscopic minutiae. Thus the attention of mineralogists and petrographers as well as that of economic and mining geologists may profitably be directed to this succinct summary of satisfying results obtained from a complex endeavor. In the 64 pages, 12 figures, and 5 plates contained in the paper-bound volume the author has competently formulated basic principles for the construction and utilization of a new weapon in the war on the diminution of ore reserves. The monograph may be obtained from M. M. Leighton, Business Manager, *Economic Geology*, Urbana, Illinois, for $1.50 to subscribers of *Economic Geology*, $1.00 to student subscribers of that journal, and $2.50 to non-subscribers.

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INTERNAL STRUCTURE OF GRANITIC PEGMATITES. By E. N. Cameron, R. H. Jahns, A. H. McNair and L. R. Page.

As has been the case with many other geological inquiries, the study of pegmatites and their constitutents has passed in time through various phases, which have been distinguished one from another by changes in technique, by changes in approach and objectives, and especially by changes in emphasis on different aspects of the general problem. Early studies were concerned with pegmatites as sources of unusual mineral species and of fine crystals. A second phase, which began in the late 1800's and culminated in the early 1920's with the work of Landes, Schaller, Hess, and others, was marked by detailed attention to the sequence of mineral formation, focussed particularly on the less common and more intriguing mineral components. The third aspect, initiated just before World War II, found *geological* methods applied to pegmatite investigation in the first systematic attempt to

decipher rules of their internal structure that might assist in finding and prospecting for mineable concentrations of pegmatite minerals. This phase has now been climaxed by the publication of Monograph 2 of the Economic Geology series—Internal Structure of Granitic Pegmatites. To Professor A. M. Bateman and his coworkers of the editorial staff of *Economic Geology* are due the universal congratulations and thanks of geological students for producing, in quick succession, two "smash hits" in the Monograph series. The same sentiments should likewise be extended to the authors, not only for their obviously painstaking compilation of the results of "68 man years of work in the pegmatite districts of New England, the Southeastern States, South Dakota, Idaho, Montana, Wyoming, Colorado, and New Mexico," but also for their definitive distillation of this gargantuan mass of diverse data.

The carefully organized Monograph of 115 pages is prolifically illustrated with 79 figures, including 7 collotype plates and 19 fold-in figures in the rear. Most of these are excellent and pertinent, and relatively few departures from the drafting quality appear throughout. The Monograph may be purchased from M. M. Leighton, Business Manager, *Economic Geology*, Urbana, Illinois, at a cost of $2.50 to subscribers of *Economic Geology*, $1.75 to student subscribers, and $4.00 to non-subscribers.

The introductory part of the work furnishes a background for the more specialized section by discussing some of the general features of granitic pegmatites, including distribution, age, relations to parent batholiths and to wall rocks, size, and shape. The largest single section is devoted, of course, to pegmatite structural units and describes first the zone types—border, wall, intermediate, and core with a detailed statement on the sequential petrology of zones. It is here, perhaps, that the single most significant contribution is presented—that despite individual and district variants, zoned granitic pegmatites show a relatively consistent petrological progression from walls to center, which is in accord with the demands of the theory of fractional crystallization of magmas. Thus this progression can be advanced as a powerful argument for the rather widely accepted theory, which is also favored by the authors ". . . that zones have developed from the walls inward, essentially by fractional crystallization and incomplete reaction in a restricted system."

The secondary units, which are fracture fillings and replacement bodies, are next described in interesting detail. However, the nadir of the work is revealed in the section devoted to the origin of these units (pp. 105–106). Here the authors content themselves with merely a weak-kneed rehash of the ideas advanced by previous pegmatite specialists. An adequate summary of the various hypotheses is disappointingly omitted. This is in direct contrast to the previous part on the origin of zones, in which the different theories are carefully weighed and a favorite is advanced. Surely considerable careful thought and much cogent argument have been expended on the genesis of secondary pegmatite units, and it is regrettable that the writers chose not to include a judicious inquiry into this aspect of the work and to present an equitable opinion. The reviewer believes, as do other workers in pegmatites, that this is one of the most fascinating and fruitful phases of the investigation and is now well removed beyond the bounds of mere specious speculation.

The Monograph concludes with a discussion of the practical applications of structural mapping of pegmatites and with a tag-along appendix on symbols suggested as suitable for depicting pegmatite units on maps, etc. The bibliography contains 121 entries. A most unfortunate omission of the study is any reference to the work of Scharizer (*Zeits. Kryst.*, **13**, 449–473, 1887), who not only at that early date specifically introduced the term, "zone" for pegmatite units ("Ich belege diese Mineralassociationen mit den Namen 'Zonen,' weil in der Natur in gewisser Hinsicht thatsächlich eine zonenartige Anordnung Platz greift . . ."), but also ascribed their development to magmatic differentiation in a closed system (". . . man im Pegmatitgranit von Schüttenhoffen sicherlich nicht das Werk zeitlich

getrennter Bildungsepochen, wie etwa bei den Zonen der Erzgänge, vor sich hat, sondern diese Scheidung der Gesteinsbestandtheile in die drei angeführten typischen Associationen ist durch eine allmähliche und continuirliche Differenzirung eines ursprünglich einheitlichen Magmas bewerkstelligt worden"). Scharizer's pioneer and classic studies have long failed to receive the recognition they so richly merit. The Monograph might also have justly mentioned the work of Vlassov (*C.R. Dokl. Acad. Sci. U.R.S.S.* **41**(9), 384–387, 1943 and 53(9), 831–834, 1946) who has contributed significantly to the knowledge of internal pegmatite structure.

The publication marks a milestone in pegmatite study, and, indeed, some might wonder as to what remains for worthwhile future work. However, we are probably even now entering into the fourth phase of pegmatite investigations—that of correlating mineralogy, structure, and paragenesis with the geology of entire pegmatite districts. The summaries and definitions contained in this monograph are prerequisite to satisfactory essays along those lines in the future.

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AN INTRODUCTION TO CRYSTALLOGRAPHY. By F. C. Phillips, pp. ix+302, 500 illustrations. Longmans Green and Company, New York, Price $6.50.

This is a very readable introduction to crystallography. The book is divided into two parts. Part I deals with the external symmetry of crystals and covers, in order, the fundamental laws of crystallography, methods of projection, drawing of crystals, a general survey of the crystal systems, goniometry, the thirty-two crystal classes, parallel growth and twinning, and the mathematical calculations of goniometry. The usage of the terms "diad," "triad," "tetrad," and "hexad" axes will seem strange to many American crystallographers. The Weiss parameters, considered by many teachers of elementary crystallography to be very helpful to students in visualizing the orientation of crystal planes in space, are not included in this presentation. The discussion of projection and the drawing of crystals will be very useful. The chapter on goniometry is good, but it deals only with the one-circle method. Two-circle methods are dismissed in one sentence elsewhere in the book. The reviewer is greatly pleased with the treatment of the thirty-two crystal classes and the chapter on parallel growths and composite crystals. The chapter entitled "some mathematical relationships" will be greatly appreciated by students.

Part II, the symmetry of the internal arrangement, fills a need for an elementary presentation of the results of space group theory. The student who masters this section will be considerably helped in the study of x-ray crystallography. In this treatment of the crystal classes and of the space groups, the Hermann-Mauguin symbols are used. An appendix contains a brief discussion of the Schoenflies' symbols, which are introduced in order to enable the student to read papers employing that notation. The final chapter in the book concerns crystal habit and provides an introduction to the subject of morphological analysis developed by Professor Donnay.

The book is designed for mineralogists, chemists, physicists, and others. The illustrative examples include about 100 minerals and approximately 75 chemical substances. A human touch is added to this book by the inclusion of short biographical sketches of the lives of twenty-one crystallographers. The reviewer warmly recommends this book as a college text.

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