BOOK REVIEWS

INTRODUCTION TO THE SPACE GROUPS, by P. TERPSTRA. 160 pages. J. B. Wolters, Uitgevers Maatschappij, Oude Boteringestraat 24, Groningen, Netherlands. (1955). Price (unbound) $4.00.

The title of this fascinating book is a bit misleading. Indeed, it would scarcely be comprehensible to one having no previous acquaintance with space groups. The purpose of the book may be suggested by quoting its opening lines:

"THERE ALREADY EXIST A GREAT NUMBER OF WRITTEN RECORDS about space groups. And then one book would still be lacking?

"Such is indeed the case since the year 1950, when Niggli's articles about his matrix method were published."

The reference is to Paul Niggli's *Die vollständige und eindeutige Kennzeichnung der Raumsysteme durch Charaktertafeln*, I, *Acta Cryst.*, **2**, 263–270 (1949); and II, *Acta Cryst.*, **3**, 429–433, (1950), extended by Alfred Niggli and Paul Niggli in *Raumgruppensymmetrie und Berechnungsmethoden der Kristallstrukturlehre, Zeits. für angew. Math. & Physik, (ZAMP)* **2**, 217–232; 311–327 (1951). The opening sentence of the English abstract of the first of these articles reads: "Space groups can be given a novel representation by means of tables of characters having the form of square matrices." In the first article the application of such a scheme to space groups of primitive lattice in the trimetric systems only is set forth and in the second extended "to space groups with face- or body-centered translation groups and to those of the tetragonal, hexagonal and cubic systems." Professor Ewald (*Acta Cryst.*, 1953, **6**, 226) referred to these papers in the following words: "Niggli's urge for unifying, condensing and classifying knowledge so as to make it applicable to ever wider fields stands out in his papers on 'Charaktertafeln' (1950–51) in which a method is developed for symbolizing each space group so as to make any further reference to tables unnecessary." Niggli (1950, p. 433) planned to present his tables in a separate work which he did not live to finish.

In the ensuing five years Niggli's scheme has found little application but Professor Terpstra is convinced of its usefulness. He states (p. 44) "The application of these matrices may be compared with the procedures of an experienced calculator who, for example, uses logarithms without reference to the theory of logarithms." And on page 75 he says "The value of these matrices for this kind of space problem is, at the very least, as great as that of the advantages which are offered by the stereographic projection method in elementary geometrical crystallometry. Perhaps one is inclined to put the method of the matrices as superior in this comparison, because the geometry of the space groups is much more difficult than that of the geometrical crystallography, although the matrices are much more easily handled than stereographic projections."

Professor Terpstra's book lacks a table of contents and the nine chapters have no titles. It begins with a two page "Apology" the opening lines of which have been quoted above and ends with a two page "Summary" in which the gist of each chapter is set forth in a few sentences. The first three chapters review certain aspects of crystal symmetry, space lattices and Hermann-Mauguin symbols needed for the following development. Some previous familiarity with these matters will be required of the reader. In the fourth chapter a few necessary theorems and conventions are explained. The term *"form of points"* is introduced and a usage recommended by Niggli & Niggli (1951, p. 218–22) explained as follows: "Thus the form comprising all points equivalent to the point x, y, z, is represented by the symbol $<xyz>$. In the same way the symbol $<[uvw]>$ represents the assemblage of edges equivalent to the edge $[uvw]$ and the symbol $<(hkl)>$ has the corresponding function for the face (hkl)."

In chapter V Niggli's "tables of characters" are introduced. They depend on choice of origin in a symmetry center or "potential" symmetry center and are best adapted to the characterization of space groups D_{2h}^{1-16} and their subgroups. From these tables or matrices it is possible to determine directly the character and position of the symmetry elements and coordinates of points in a "general" position as well as information on subgroups, special positions, change in *H-M* symbol with orientation, extinctions and so on. By means of some simple auxiliary devices the same can be done with a single matrix for space groups with a primitive lattice in the classes C_{2v}, D_2, C_{2h}, etc. The matrices are very compact and can be set up for each space group from the *H-M* symbol. Many examples were pictured by Niggli (1949). The information to which they provide the key is usually given in tables requiring a page or more for each space group.

In chapter VI the extension of the scheme to orthorhombic space groups with centered lattices is explained. This requires the use of "matrix" and "by-matrix." Though somewhat cumbersome these devices yield the same information as the single matrix for the simple space groups and in addition give a clue to the alternative *H-M* symbols which may be applied to such groups. Terpstra does not take up the extension to space groups of the tetragonal, hexagonal and cubic systems, very briefly set forth by Niggli (1950).

The last three chapters give the application of Niggli's approach to structure factors, to Fourier summations for electron density and to vector sets. With the aid of an "algorithm" (p. 76) and a scheme for its application (p. 82) taken from Niggli and Niggli (1951, 313–314) the structure factor and electron density equations can be derived from the matrix for each space group in the form most convenient for computation. In the application to vector sets the author introduces the "Harker-matrix" (p. 131) from which the array of Harker sections (M. J. Buerger, *Acta Cryst.*, **3**, 465, 1950) may be seen.

Every application of the matrices is illustrated with specific examples which are worked out with great care. There are innumerable references to the *International Tables for X-ray Crystallography* and many illuminating comments thereon as well as on Donnay and Nowacki's *Crystal Data*. There is an abundance of excellent drawings, and repetition, even of figures, is not shunned where it may help understanding. The author shows his concern by such statements as "The reader is now asked to finish the incomplete scheme above" (p. 132) and "Does the reader understand this clearly?" (p. 98). The book is best read with a copy of the *International Tables* and pencil and paper at hand.

There is a general index of less than two pages and an incomplete list of references to space groups. The typography is excellent and there are very few misprints.

Professor Terpstra is one of the few masters of classical crystallography with a keen understanding of some of the latest developments, even to the vector sets of Buerger and the statistical material in Donnay and Nowacki's *Crystal Data*. Possibly this leads him to the statement (p. 14) that "the examination of a crystal usually starts with crystallometric determinations and afterwards comes the study by means of *x*-rays, from which can be obtained data concerning the crystal structure." Unfortunately there are few American crystallographers who proceed in this way. Had they been indoctrinated by Professor Terpstra it might be otherwise. Though his latest book will hardly serve as a textbook on space groups it can be recommended to all students and teachers of geometrical crystallography as valuable collateral reading.

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MICROSCOPIC PETROGRAPHY, by E. WM. HEINRICH. Pages xiii+296, 1956. McGraw-Hill Book Co., Inc., New York. Price $6.50.

This book is intended as a beginning to intermediate text for microscopic rock study; however, it will serve as a fine reference for workers in most geological and related fields.

The author attempts to bring our older petrographic descriptions up-to-date in 257 pages allotted as follows; igneous 84, sedimentary 71, and metamorphic 102. The treatment of each of these three rock types is equally well executed. The classification is simple and suitable for both field and laboratory work. The author has succeeded in presenting a vast amount of information, and the book is in general accurate, authoritative, well organized, and practical.

A short chapter on methods of microscopic study offers very useful material, much relatively new, on thin section preparation and micrometric analysis. It is pointed out that few petrologists today prepare their own thin sections, the work "being carried out by trained preparators." The student, however, should not be led to believe that a thin section professionally prepared is necessarily a section properly prepared. All too frequently preparations are accepted without question, and no check made for possible errors in labelling or orientation. A brief explanation of how to check thin sections should be included in our modern texts.

This book is illustrated by 132 photomicrographs in which the general rock fabric is clear, but higher magnifications are needed to bring out details, especially for the beginner. Most illustrations should have had their magnifications doubled. Some should have sacrificed larger scale features to secure magnifications of 50 or 100 times. Many will be of little value to the beginner. The student wants to see more clearly what is meant by trachytic texture, quartz overgrowth, and hornfelsic texture; but, unfortunately, the illustrations offered are of little help.

Only about 20 pen-and-ink sketches have been used; many more should have been included. For the beginner they are superior in most respects to photomicrographs. Furthermore, they are more economical.

The weakest sections of the book are those on textures and structures of rocks. This material needs further development, reorganization, and expansion. Loosely and vaguely defined terms are numerous and help to promote nothing but improper usage and corruption. Petrographic terminology certainly needs no assistance along these lines. From page 23 the student is likely to conclude that an overgrowth is the same as a reaction rim, or that radial clusters are also spherulitic. Relict texture is an example of a very poorly defined term. On page 24 the author implies that aplitic and saccharoidal textures are to be distinguished from mosaic texture. The manner of distinction, however, is not stated, and it is very doubtful if the beginner will readily discover it from the illustrations cited. The terms poikilitic and poikiloblastic seem adequately defined, but they are used very inconsistently in the chapter on metamorphic rocks.

The difficulty lies in the brevity of definitions. Further qualification and finer distinction are necessary. In many instances one must refer to several places in the book before he can obtain a complete picture. Zoning in minerals is mentioned in many parts of the book, but there is not a single striking illustration of this important structure. A totally inadequate description of zoning is given on page 22, and the beginner will be at a loss to understand the differences between various types of zoning. The chemical significance and petrological importance of this seemingly simple feature merit considerable attention.

There has been surprisingly little change in our petrography books over the half century since Rosenbusch. Although these works enable the student to describe and classify rocks, they fail completely to demonstrate the reason for obtaining such information.

Heinrich and other writers point out that petrography is a geological research tool, not an end in itself. If we are to succeed in getting this idea across to the student, we must catch him from the beginning. He must understand that rock study embraces two complementary operations; one is data-gathering and the other is interpretation. With the first the student has little trouble, and here our books on petrography are most useful. But the first operation, which can never be truly divorced from the second, is of little value without the second; and to bring this point home to the student, we must require him to make these

two operations right from the start. Special emphasis must be placed upon interpretation to counteract the natural tendency to drift toward the notably easier, passive act of description.

Such a statement as "A xenocryst is an included foreign grain or crystal" is not adequate. The student wants to know how to recognize a xenocryst and how to distinguish it from a phenocryst. To say that certain features are autoclastic and others cataclastic is useless unless the criteria for such distinction are given.

It is true that much on the interpretive side can be handled by the instructor, but it is also true that much valuable class time can be saved if the textbook covers general principles of interpretation.

A new textbook, an "interpretive petrography," would be an extremely worthwhile contribution. Several chapters of Harker's *Metamorphism* are suggestive. Preparing such a text would be complicated due mainly to differences in interpretation of rock features. Though no simple task, the various ideas should be presented, with supporting evidence where possible, enabling the student to become acquainted with these differences of opinion from the beginning. The problems should be disclosed, not suppressed.

The need for integrating microscopic work with field relations is paramount, and the student must learn how futile is an attempt to solve geologic problems with thin sections alone. Obviously it is impossible to include all relevant field material in such a text, but a sufficient number of examples could be given to illustrate the type of information needed in a variety of problems.

A few statements as to the importance of textural and structural features and the need for working out mineral sequences is inadequate and does not durably impress the student. If the main value of petrography lies in an understanding of the mineral associations, textures, and structures of rocks, then our texts must be revamped and built around these features with interpretation as a main objective. If the scope of petrography has changed in the past few few decades, then there is great need for a new type of textbook in this field.

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GEOCHEMIE, by A. A. SAUKOV. 311 pp. 40 tables, 21 figures. VEB Verlag Technik, Berlin (East Zone), Germany. 1953.

This is a German translation from the Russian by R. Sallum and Tatjana von Schenk and edited by Professor F. Leutwein of Freiburg. The preface indicates that the original is intended as a short introduction to the study of geochemistry in Soviet colleges and universities. However, there will doubtless be many who will take issue with the evaluation that "the work not only exceeds such a framework but also the presently known international literature in this field."

The introduction defines geochemistry, its scope and techniques. In chapter 1 is presented a short history of the development of geochemical ideas, emphasizing the role of Russian scientists. Chapter 2 is an elementary discussion of the periodic table of elements, of atomic structure, and of the geochemical classification of elements. The structure of earth is dealt with in the long chapter 3, under such topics as chemical composition of the crust, genesis and composition of meteorites, hypotheses of origin of interior shells, the atmosphere, and the hydrosphere. The next chapters deal successively with the relation of mineral structure and composition, the migration of elements, and the association of elements in the crust. Chapters 7 to 9 are concerned with magmatic, hydrothermal, and supergene processes respectively. In the last chapter the geochemistry of single elements is described, with but three examples, H, Fe, and Hg.

The book is a disappointment in scope and in detail. One might overlook the abject, self-depreciatory preface that the German publishers use as a *raison d'etre* for the appear-

ance of this translation; after all, they may well be in a position resembling that of Tennyson's immortal brigade. But it is difficult to forgive their superiors, who, having in their resources the classic efforts of Fersman and Vernadsky, have palmed off a substitute. The book cannot hold a candle to Geochemistry by Rankama and Sahama as a reference work, or to Principles of Geochemistry by Brian Mason as a textbook, neither of which is listed in the references.

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AN INDEX OF MINERAL SPECIES AND VARIETIES ARRANGED CHEMICALLY, by Max H. Hey. British Museum (Natural History), Cromwell Road, London, S. W. 7, England. Second, revised edition. 728+xxiv pages, 1955, £3.

The first edition of this work, which was reviewed in the *American Mineralogist*, **36,** 634 (1951) has been exhausted for some time, owing to the great demand for the book and the limited impression. It is gratifying, therefore, to see that Dr. Hey and his assistants, who cheerfully again undertook the painstaking drudgery of compilation, checking, and cross checking, have once more successfully concluded their lucubration. Although not of immediate scientific fruit to them, the results are so highly useful to all mineralogists that the entire profession is in their debt. *Dios se los pagará!*

In the new edition has been incorporated all material coming to the notice of the author up to March 1955. This has led to a considerable expansion of the book, which, however, retains its original format—a first index by chemical groups in which each entry is assigned a decimal number, and a second alphabetical list.

In this edition a pronouncing index of accepted mineral names covering 65 pages has been added, a courageous attempt to reduce chaos to mere disorder. For some individuals pronunciation of mineral tongue twisters is usually based on "Whom did you hear it from the loudest the first time?" There is little room for dogma in pronunciation of mineral names, for, after all, orthoëpy is an art.

Doubtless this edition too will head the mineralogical "best seller" list. It is an indispensable reference tool and the first edition, now well thumbed, has saved this reviewer many hours of tedious checking. It is still deplorable, however, that the book makes not the slightest effort to reduce the number of varietal and trivial names, by indicating the proper substitute of a chemical adjectival modifier (Schaller system), a usage now widely practiced. Weeds grow more abundantly than flowers; "Off with their heads."

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LA PROSPECTION DE L'URANIUM. Presidency of the Council, Commissariat for Atomic Energy. With a preface by Marcel Roubault. 62 pp., 13 figures, 1 black and white plate, 2 colored plates. In French. Masson et Cie, Editeurs, 120 Boulevard Saint-Germain, Paris—6e, France. Paper bound. 1955. 450 fr.

This is an attractive and well organized example of a manual designed to acquaint laymen with basic information prerequisite to prospecting for uranium. And it ranks high in quality for brochures of this type, which have been issued by several countries (e.g., U. S. A., Canada, Brazil, England, Australia and New Zealand) and by several states in the United States (e.g., Georgia, Virginia, Texas, Colorado, Utah, Washington, Oregon, and California).

The slim volume has four chapters: I. General prospecting methods, including a summary of fundamental geological data and general principles common to all types of pros-

pecting. II. Details of prospecting for uranium. III. Summary description of the principal minerals containing uranium, including primary and secondary minerals and a table of the principal uranium and thorium-bearing minerals. IV. Detection of uranium minerals with the aid of the Geiger-Müller counter—description and utilization of apparatus, interpretation of radioactive measurements, preparation of a radioactive-count map, and other physical and chemical detection methods. V. Essential characteristics of uranium deposits.

The two colored plates (II and III) of six figures each, depicting well crystallized autunite, torbernite, renardite, curite, billietite, beta-uranophane, uranophane, kasolite, and parsonite, are the finest colored reproductions of secondary uranium minerals seen by the reviewer, and alone are worth the cost of the booklet.

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GEOLOGY OF SOUTHERN CALIFORNIA. Bulletin 170, California Division of Mines. With 103 contributors, edited by R. H. Jahns. 878 pp., 441 text figures, 95 maps. Boxed, measuring 13×9½×4 inches, weighing 10 lbs. 1954. $12.00.

This gigantic symposium rapidly became a best seller; in fact it is already out of print and can no longer be purchased. It consists of ten chapters, bound separately, five geologic guides for selected field trips, also separately bound, and 34 map sheets. The chapters are:

I. General features, 3 sections.
II. Geology of the natural provinces, 10 sections.
III. Historical geology, 8 sections.
IV. Structural features, 7 sections.
V. Geomorphology, 9 sections.
VI. Hydrology, 3 sections.
VII. Mineralogy and Petrology, 8 sections.
VIII. Mineral deposits and mineral industry, 7 sections.
IX. Oil and gas, 4 sections.
X. Engineering aspects of Geology, 3 sections.

Of particular interest to members and fellows of the Mineralogical Society are Chapters VII and VIII. The various sections in Chapter VII include: 1. Minerals in southern California by Joseph Murdoch and Robert W. Webb. 2. Problems of the metamorphic and igneous rocks of the Mojave desert by Thane H. McCulloh. 3. The batholith of southern California by Esper S. Larsen, Jr. 4. Miocene volcanism in coastal southern California by John S. Shelton. 5. Pegmatites of southern California by Richard H. Jahns. 6. Contact metamorphism in southern California by Ian Campbell. 7. Contact metamorphism at Crestmore, California by C. Wayne Burnham. 8. Anorthosite complex of the western San Gabriel Mountains, southern California by Donald V. Higgs. Chapter VIII deals with salines, the Mountain Pass rare-earth deposits, tungsten, base metal and iron deposits, gold and silver mining districts, and nonmetallic substances.

The work represents the enormous combined effort of many people, efficiently organized by Jahns. It is one of the most valuable and complete regional geological studies to appear in many years, and in many ways sets an enviable standard of excellence for such studies, which will be difficult to exceed or even match. Possessors of copies may count themselves fortunate.

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