BOOK REVIEWS

PETROGRAPHIC MODAL ANALYSIS, by FELIX CHAYES, xii+113 pages, John Wiley and Sons, Inc. New York, 1956. Price $5.50.

This book is a forceful reminder that classic petrography is not yet static, despite the diluting influence of other, more recent, analytical tools. It is a particularly welcome addition to the field of quantitative petrography, which has always been a weak link and neglected partner. Felix Chayes, of the Geophysical Laboratory, has set about to improve this state of affairs, and, as far as this reviewer is concerned, has succeeded admirably.

It is a small book, measured by the space it requires on a library shelf; its quality, however, is inversely proportional to its size. Modal analysis of rock thin sections has long been in need of a thorough overhaul and the author of this book is preeminently qualified to do the job. Over a period of about ten years Chayes has worked almost exclusively on modal analysis problems and has successfully set them up in a logical statistical framework. Some of his work has already appeared in print, but this book contains much that is new and not heretofore published.

Organization of the material into book form was stimulated by a graduate seminar which the author was invited to give at the California Institute of Technology in 1955. For their indirect help in inspiring Chayes to publish his work the sponsors of this seminar are to be congratulated.

In the Introduction the author lists the principal problems of modal analysis as

1) the equivalence of areal and volumetric proportions
2) the reproducibility of estimates of areal proportions
3) the sampling efficiency of thin sections.

Chap. 1 is concerned with the geometrical basis of modal analysis, the contrast between bias and consistence, and the fundamental Delesse relation between area and volume. Much petrographic underbrush is tidied up here.

Chap. 2 is the first rational discussion known to this reviewer of modal analysis of banded rocks. It is clearly shown that "the consistence of estimates of volumetric proportions based on areal measurements is not in any way influenced by the presence (or absence) of orientation. What *is* affected by orientation is the random analytical error." Chayes demonstrates how this error can be kept to a minimum.

Chap. 3, on methods of measurement, includes Chayes' own contribution to the instrumentation of modal analysis, an inexpensive point counter combining both speed and efficiency, which has worked a minor revolution in quantitative petrography.

Chapters 4, 5, and 6, on the reproducibility of thin-section analysis, identification and tabulation conventions, summarize investigations already in print. One fairly comprehensive test by five operators, each measuring five sections cut from the same specimen, analyzes the error arising between operators and between sections, with a remainder which is purely a counting or reproducibility error.

Chapters 7 and 8, on the relation of grain size to measurement area, are at the heart of modal analysis problems. On their evaluation depends our estimate of analytical error, or the uncertainty between the thin section analysis and the true modal composition of the parent rock.

Chapter 9 gives a practical solution to the difficult problem of reducing grain size to quantitative terms. An impressive series of measurements is described as a test of the method proposed by the author. Through an oversight, the caption for Table 9.1 (p. 74) is incomplete. The additional statement—1C/25 mm—is needed here.

In Chapter 10 we find the distilled product of all that has gone before. With a means of evaluating grain size, how many thin sections need be measured to keep analytical error below some predetermined level? For a given measurement area per section a plan for modal analysis can now be set up which takes care of the grain size problem and at the same time keeps within the desired limits of analytical error.

Chapter 11 deals with the troublesome problem of overestimation of areas of very fine-grained constituents, or the so-called Holmes effect. This is a function of thin-section thickness, and no practical solution is available at present.

There are two appendices—one listing useful statistical references, the other outlining one of the calculations used in Chapter 2.

Although the present reviewer is not qualified to pass judgment on the merits of various statistical approaches which might be useful in modal analysis, he is confident from personal knowledge that Chayes has explored the possibilities very thoroughly with colleagues expert in statistical analysis. The result is a mature, consistent, presentation for which every petrographer should be grateful.

Insofar as a review is expected to contain at least some adverse comment, this one must be considered a failure. Chayes' book, unlike other petrographic texts, has neither predecessor nor competitor, so that there is nothing to compare it with. The reader who is totally uninformed in statistical matters will undoubtedly complain about this aspect of the work, but this is scarcely the fault of the author, as all investigations in quantitative petrography demand statistical treatment.

The book is well planned and edited, and attractive in format. Chayes' distinctive prose style, to the point, in places entertaining, will be familiar to readers already acquainted with his work. The book deserves a prominent place on every petrographer's bookshelf.

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THE BARKER INDEX OF CRYSTALS: A METHOD FOR THE IDENTIFICATION OF CRYSTALLINE SUBSTANCES, by M. W. PORTER and R. C. SPILLER. Volume II, Monoclinic System. Bound separately in three parts, each 7.5×10 in. Part 1, Introduction and Tables, v+383 pp., 43 figures. Part 2, Crystal Descriptions, viii+760 pp. Part 3, viii +686 pp. Cambridge. W. Heffer and Sons, Ltd., 1956. Price £10, for the three parts.

In the first volume of this monumental work, the elegant method of T. V. Barker (1930) for identifying a crystal from its interfacial angles is explained in detail, and determinative tables are given for the tetragonal, hexagonal, trigonal, and orthorhombic systems. With Volume II, the "Barker Index ' is extended to the monoclinic system; this is to be followed, sometime in the future, by a volume for the triclinic system.

The comprehensive reviews of Volume I, by J. D. H. Donnay (1952) and C. W. Wolfe (1952), make unnecessary here any detailed discussion of the general scope of the work, and the history and mechanics of the Barker method. I wish to add my voice to those of Professors Donnay and Wolfe in praising the authors and their collaborators for their herculean efforts.

Part 1 of Volume II contains a detailed discussion (47 pp., 43 fig.), by M. H. Hey, of the rules for the Barker method appropriate to the monoclinic system. A treatment is included on the operations of measurement, projection, and indexing, especially as applicable to monoclinic crystals. Nineteen examples of difficult crystals, having under- or overdevelopment of faces, are worked out for the reader.

Some 3500 monoclinic crystals, constituting 52% of the measured crystals, are treated in Volume II. Tables are given in Part 1 listing the substances according to their classification angles, according to the sequence in which they are described in Parts 2 and 3, in

alphabetical order of their chemical and mineralogical names, and in alphabetical order of the Groth chemical names. Tables of refractive indices, densities, and melting points are also given. Barker's table of multiple tangents is reprinted.

Parts 2 and 3, constituting roughly five-sixths of the volume, contain the crystal descriptions. These descriptions follow essentially the same scheme as that used in Volume I.

A "Brief Directions for Using the Barker Index, Volumes I and II," and a "Corrigenda and Addenda" for both volumes, have been bound into Part 1, Volume II. The number of errors listed is surprisingly small, attesting to the great care with which this work was put together. A leaflet intended for insertion in Volume I is included with Volume II. This gives brief directions for the use of the Index, and the corrigenda and addenda to Volume I.

It is obvious that the authors and the publishers have given to the present volume the same meticulous attention to detail that they lavished on the first volume of the Index, and consequently have produced the same excellent results.

As was pointed out by Donnay, the Barker Index contains a vast amount of data on compounds for which there are no x-ray results. Because of this it will be very useful to all those who work with crystals, however they designate their profession and regardless of the techniques they use to study crystals.

References

Barker, T. V. (1930), Systematic Crystallography (Thomas Murby and Co., London).
Donnay, J. D. H. (1952), *Nature*, **169**, 851–852.
Wolfe, C. W. (1952), *Am. Mineral.*, **37**, 875–877.

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ARIZONA'S METEORITE CRATER, PAST-PRESENT-FUTURE. H. H. Nininger. 232 pages, 47 plates. Published by the author; American Meteorite Museum, Sedona, Arizona. 1957. Price $3.75.

This book reviews the exploration as well as the studies and controversies about this crater. The writer's life has been closely connected with this meteorite crater and he has collected and examined much material from there. It was an appropriate undertaking for this author to record his studies and conclusions about the Arizona Crater in a book for the general public as well as for those who are professionally interested in meteorites.

The book is divided into two parts. Part one deals with the Discovery and Exploration. Part two contains chapters with headings such as: A New Approach, Condensation Products, Impactite, Observations on Diamonds, and Future of Crater. There are other sections such as references to plates, bibliography and index.

Under the heading "A New Approach" the author begins to mention his observations and findings. In this section there are some headings which should be listed in the Table of Contents. Such topics as, "Problems of the Northeastern Rim Concentration," "The Swarm Theory," "The Formation of the Crater," and "Shale Balls" are important parts of this book and are somewhat lost when included under the heading, "A New Approach."

Nininger in 1939 planned a field survey for fragments which were "too small to attract attention" of the early collectors. This work showed no meteoritic material existed farther than 2½ miles from the crater rim. He found an elongated area stretching southwest from the crater rim which contained "twisted and gnarled forms," of meteoritic iron.

In 1948 a magnetometer survey was made with east and west traverses crossing the foot of the southern rim and also across the northern rim. He describes these, ". . . several local anomalies were encountered and in each case a five foot interval grid established that the seat of the disturbance was extremely concentrated and at no great depth."

The author found 6,000 specimens on the outer slopes at the northeast rim; the largest two pieces weighed 17 and 15 pounds. The average weight of the specimens collected was approximately 4 ounces. Nininger's field studies showed the irons found near the crater were thermally altered and lacked a Widmanstattan pattern.

Nininger observed distinctive differences in some irons from the crater and assumed a group of several meteorites fell at the time the crater was formed. In 1952 this author published "Out of the Sky," in which he discussed the idea of a compact swarm of meteorites falling and defined a compact swarm as made up of members not all of which have a common origin. In the earlier book he said, ". . . Evidence of the composite nature of the swarm has been recently found in the form of several atypical irons."

In the last book the author says, ". . . Our studies . . . have shown positive evidence that more than one mass arrived from space but we can not find evidence to support the idea of a sufficient number to be termed a swarm." Nininger further states, ". . . There seems to be no reason why all members should conform to a single pattern of structure and the Canyon Diablo meteorites do show a considerable range of structure within a single large mass and a corresponding range between the individual small masses." ". . . one would hardly be justified in calling the colliding mass a swarm; a group or a system, yes, but not a swarm."

The author devotes 53 pages to "Condensation Products," "Small Pellets" and "Impactite." These are contributions to our knowledge about this crater that he has made. The metallic pellets are widely scattered on the outer slope of the crater rim. These are scattered a mile to the southwest of the crest of the rim and an equal distance to the northeast.

An analysis of the metal shows nearly 2.4 times as much nickel and about 4 times as much cobalt as occurs in the Canyon Diablo meteorites. Thus, he argues that these cannot be strippings from the meteorite and assumes they are condensation products from a vapor cloud of atoms, each element segregating and uniting with microdroplets of the same kind in the vapor cloud.

Nininger measured the quantities of spheroids or pellets in 60 locations within $1\frac{1}{2}$ miles of the crater. He estimated between 4,000 and 8,000 tons of these existed in the upper 4 inches of soil within a $2\frac{1}{2}$ mile zone of the crater.

Nininger found small meteorite fragments which he called Sluglets. These resemble miniature meteorites and after their oxide film was removed the metal was found to contain 6.5% nickel and 0.38% Co. Since the chemical composition is very similar to the composition of the Canyon Diablo meteorites these obviously are not condensation products.

Vesicular siliceous glassy objects, called Impactite, were found at other meteorite craters by investigators but Nininger was the first to find such objects at the Arizona crater. He estimates the quantity of impactite in certain areas would be between 50 and 162 pounds per square yard.

Nininger says that diamonds, "carbonado bearing inclusions," in the Canyon Diablo samples may be expected in a frequency of 1 to every 32 square inches of finished surface. He also says the findings of diamonds was limited to irons that showed evidence of being heated above 760° C. and asks if diamonds formed on impact with the ground.

The reviewer believes that this book should have contained a discussion of the geology of the crater and a labeled cross section of the rocks exposed. The book could have been improved if it had been more critically edited. In places it is difficult to follow the author's thinking.

Nininger concludes the book with two chapters, one on the Future of the Crater in which he pleads for it to be made into a National Monument or a Park and in the other chapter, he makes 28 suggestions for future research at the crater.

This is the best of the Nininger books. It gives the general public interesting facts about the celebrated Arizona meterorite crater.

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SEDIMENTARY ROCKS, 2nd Edition, by F. J. PETTIJOHN. 718 pages, 40 plates, 173 figures, 119 tables. Harper and Brothers, New York. Professional Edition, $12.00. Text Edition, $9.00.

The first edition of *Sedimentary Rocks* by Professor Pettijohn, which was reviewed in *The American Mineralogist*, **34**, 764–765, 1949, has been so favorably received, both as a reference and text book, that the enlarged and revised second edition, strengthened in many respects, is doubly assured of maintaining its position as the outstanding English source book on sedimentary petrology.

Although the general format of the book remains unchanged, the work has been completely rewritten and considerably expanded (718 vs. 526 pp.). Of the figures 77 are new, and the 40 excellent collotype plates include over 100 illustrations. Essentially new material is contained in sections dealing with geochemical evolution of sediments, their depositional environments, and the representation of their vector properties. Descriptions both of rock types and sedimentary processes are quantitative in treatment. References, profuse and pertinent, are collected as classified bibliographies at the ends of chapters and at other appropriate places. The book in every way is an excellent account, concisely written, both of the descriptive petrography and the genetic petrology of sedimentary rocks. For those few readers not acquainted with the scope of the work, the list of chapters is as follows: 1. Introduction. 2. Textures. 3. Composition of Sedimentary Rocks. 4. Structures. 5. Classification and Nomenclature. 6. Gravels, Conglomerates, and Breccias. 7. Sandstones. 8. Shales, Argillites, and Siltstones. 9. Limestones and Dolomites. 10. Nonclastic Sediments (Excluding Limestones). 11. Provenance (And Mineral Stability). 12. Dispersal. 13. Depositional Environments. 14. Lithification and Diagenesis. 15. Historical Geology of Sediments.

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METEORITES IN THE COLLECTIONS OF YALE UNIVERSITY, POSTILLA NO. 27, Yale Peabody Museum, Kurt Servos. Published September 28, 1956.

This catalog lists 404 meteorites and 17 thin sections of stony meteorites as well as some tektites and impactite. The catalog contains no synonyms nor references to the literature. Apparently the Peabody Museum has the largest meteorite collection of any university in this country.

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ROCKS AND MINERALS, by RICHARD M. PEARL. Barnes and Noble, Inc., New York, 1956. x+275 pages, 35 figures, 12 colored plates. Price $1.95.

This paper-bound book is No. 260 of the Everyday Handbook Series, whose purpose is to summarize popular subjects for students and laymen. Although different in scope and purpose, *Rocks and Minerals* contains much material revised from the earlier (1955) *How to Know the Minerals and Rocks* (review by Earl Ingerson, *Am. Mineralogist*, **40**, p. 1147). The text under review has been more carefully prepared, edited, and illustrated (especially the line drawings of crystals) than the earlier book.

The color plates depicting fluorescence of minerals are improperly arranged. As the

plates are now arranged, there are three separated pictures with different titles for one specimen of scheelite. "Fluorescent Minerals" and "Minerals in Ultraviolet Light" should be paired for comparison. Franklinite is apparently labeled as fluorescent in one plate.

All errors have not been eliminated. On page 51, line 18 should read "the unit cell of halite consists of 4 ions each of Na and Cl," rather than "14 Na and 13 Cl."

In the discussion of jade on page 137 there is no mention made of Meso-American jade and its occurrence in Guatemala (Foshag, W. F., *Am. Mineral.*, **40**, p. 1062).

On page 173, line 12, the impression is given that the Kokomo meteorite was recovered from a well, whereas it was uncovered in digging for a well at a depth of two feet.

"Florite" for "fluorite" in Figure 1 and "1877" for "1837" on page 47, line 7, are the only two typographical errors noted.

Apart from these and a few other technically debatable points, *Rocks and Minerals* will provide hours of entertaining and profitable reading for amateur collectors and laymen. Simple tests, properties, classifications, and origins of minerals and rocks are woven together with threads of interesting and odd facts about the mineral kingdom. Gems, meteorites, radioactive and fluorescent minerals are given special attention. A rather brief glossary is appended. Two final chapters on collections and magazines and books should be useful to the new friends of rocks and minerals which this book should win.

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GEOLOGÍA DE LAS CUENCAS SEDIMENTARIAS DE VENEZUELA Y DE SUS CAMPOS PETROLÍFEROS, by G. A. YOUNG, A. BELLIZZIA, H. H. RENZ, F. W. JOHNSON, R. H. ROBIE, AND J. MAS VALL. Repub. Venez, Minist. Minas e Hidrocarb., Dir. Geol., Bol. Geol., Special Publication No. 2, 140 pp., Caracas, 1956.

For each of the four basins of Venezuela a concise description of the stratigraphy is given and an account of the structure and tectonics for the better known ones; also, a discussion of the development of the petroleum industry, or the petroleum possibilities, where there is actual or potential production of oil.

The fourteen principal oil fields of the country are briefly described, with maps, sections, and stratigraphic charts.

A short supplementary section outlines the methods of exploration and development that have been employed in the Venezuelan oil fields.

EARL INGERSON

HOW TO PROSPECT FOR URANIUM, by HUBERT LLOYD BARNES, x+117 p., 8 tables 5 figures, 6 appendixes. Dover Publications, Inc., New York, 1956. Paper bound, price $1.00.

The avowed intent is to provide guidance for the intelligent layman interested in uranium prospecting. As such, the book is as successful as the two sources from which it is derived essentially verbatim, namely, the well-known Government publications, "Prospecting for Uranium" and "Prospecting with a Counter." Handily, the book combines these two useful publications within one cover.

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