BOOK REVIEWS

PROCEEDINGS OF THE IMA-IAGOD MEETINGS '70 IMA VOLUME, edited by *Y. Takeuchi*, Special Paper No. 1, Mineralogical Society of Japan (1971), 301 pages, 43 papers, 48 abstracts, proceedings of seventh meeting, $24.00 (Asahi Evening News, CPO Box 555, Tokyo, Japan).

This IMA volume is one of three which cover the joint proceedings of the Seventh General Meeting of the International Mineralogical Association (IMA) and the Third General Meeting of the International Association of the Genesis of Ore Deposits (IAGOD) which were held in Tokyo, Japan, in 1970. The other two records are the Joint Symposium volume and the IAGOD volume.

Papers presented at two symposia : "Progress of Cosmic Mineralogy" and "Mechanism of Growth and Phase Transition of Minerals", as well as those delivered in an Open General Session of the IMA meetings are published in this volume. All papers and abstracts are in English.

The symposium "Progress of Cosmic Mineralogy" was introduced by D.P. Grigoriev who presented the first of three papers in which he outlined the progress and trends for this "new branch of science". The two remaining papers and two abstracts were concerned with the study of Apollo 11 and 12 lunar material. Edwin Roedder's paper on the crystallization of lunar glasses is followed by a study (I. Kushiro, Y. Nakamura & S. Akimoto) on the petrology and mineralogy of Apollo 12 crystalline rocks. E.F. Stumpfl & F.G.F. Gibb, in an abstract, outlined the basic differences in ore-mineralogy between Apollo 11 and 12 material and presented some electron microprobe data. The remaining abstract (R.G.J. Strens & B.J. Wood) gives the results of experimental studies on the crystallization of silica and olivine-normative glasses which represent the extremes of the composition range reported for the crystalline and vesicular Apollo 11 rocks.

The second symposium "Mechanism of Growth and Phase Transition of Minerals" consists of eighteen papers and an introduction by R. Kern. The most extensively treated subjects are transformation and crystal morphology.

Transformations of sheet silicates and clays are discussed in four papers. G.W. Brindley discusses dehydroxylation of diotahedral hydrous layer silicates, Y. Takeuchi & N. Haga covers slip mechanisms of octahedral sheets and polytypic changes of micas, V. Frank-Kamenetzky, N. Kotov, E. Goilo & G. Klotchtova gave a paper on structural transformations of some clay minerals under pressure in hydrothermal conditions, and thermal transformations of montmorillonites in acid clays were investigated by H. Takeshi & Y. Uno. Papers on transformations in pyrrhotite (H. Nakazawa & N. Morimoto) and in germanate feldspar (N. Kinomura, S. Ueda, M. Shimada, S. Kume & M. Loizumi) are also included.

Orientated crystal growth was the subject of five papers : sphalerite in chalcopyrite (Y. Aoki) ; $NaNO_3$ and $LiNO_3$ on carbonates (J. Iniquez, F. Arrese, M.T. Martin Patino & Julio Rodriguez) ; native gold crystals (N.V. Petrovskaya$_1$; some silicate minerals under high pressure (H. Takubo, S. Kume & M. Koizumi), and the growth condition of a natural diamond (H. Komatsu & A.R. Lang).

Three papers deal more specifically with nucleation : galena and phlogopite (I. Sunagawa & Y. Endo), crystallization in glass (S. Kakitani) and cadmium iodide (S. Kitazawa, I. Sunagawa & Y. Endo). Two papers on mineral syntheses were also included, one on idocrase (J. Ito & J.E. Arem), the other on quartz and clay mineral formation at low temperatures (H. Harder).

Two abstracts round out this symposium, one on dislocation structures in garnets (H. Carstens) and the other on the syntheses and structures of alkaline earth metasilicates and metagermanates (C.T. Previtt & R.D. Shannon).

The General Session, the third section of this volume, contains nineteen papers which cover a variety of topics including descriptive mineralogy, structural and textural features in minerals, crystal chemistry and phase relations, and paragenesis.

Six papers are devoted to descriptions of minerals from specific occurrences. One describes a new mineral, bideauxite (S.A. Williams) ; the remaining five include studies of pyroxenes from the Cottian Alps (A. Mottana), jadeite from Omi-Kotaki, Japan (K. Chihara), livingstonite (T. Watanabe, A. Kato & T. Suzuki), betechtinite (T. Matsukuma) and dioctahedral chlorite (N. Fujii, T. Omori & T. Fujunki) from the Matsuo, Furutobe and Shinyo Mines, respectively, in Japan. X-ray diffraction was used to study the clay mineralogy of Dinantian limestones residues (J. Thorez & P. Bourquignon), and with electron microscopy to study copper silicate minerals (M.C. Van Oosterwyck-Gastuche & Ch. Gregoire). A soft x-ray study of olivine was described by Y. Kuroda & Y. Iguchi.

Three papers deal with structural and textural features in minerals; microtextures of schiller feldspars (G. Shibuya), microstructures, reflectivity and microhardness of sphalerites and galenas (Dino di Corbertaldo & Adriana Vaghetti) and cleavage in pyrite (A.N. Mariano & R.M. Beger).

Crystal chemistry is the subject of two papers : a classification of the spinel group from ultra-basic rocks (M. Zhelyazkova-Panayotova) and ideal solid solutions of alkali earth elements in silicates (J. Roux, M. Volfinger, M. Lagache, J.T. Iiyama, G. Sabatier & J. Wyart). Blue-remaining covellite and its relation to phases in the sulphur-rich portion of the copper-sulphur system at low temperatures were examined by G.H. Moh, while phase relationships between secondary minerals associated with Permian volcanic rocks were investigated by B. Nashar & A.C. Purvis.

The three remaining papers in the General Session include an examination of differentiation and metasomatism within a Carboniferous spilite — keratophyre suite (R.D. Morton & D.G.W. Smith), a study of authigenic minerals in spilitic basalts (M. Shimazu), and a paper by D.J. Schneer which attemps to correlate crystal form with lattice type, space-group and chemical composition.

Some of the abstracts at the end of this volume would have been welcomed by the reader as full texts in the General Session. However, the reluctance of some authors to publish in symposium volumes is generally recognized. They prefer instead to try for a wider circulation through current journals and, as a result, the editor of a symposium volume such as this IMA issue is often not able to include the more select papers.

This IMA volume suffers the same, perhaps unavoidable, shortcomings of its predecessors. Seventeen months separates its publication from the deadline (December 1969) for abstracts submitted for the meetings. One is immediately aware of this problem from papers given in the first symposium. The data presented are from collected on Apollo 11 and 12 missions and the Apollo 12 work is referred to as "preliminary". This appears when work on Apollo 14 material has already been published elsewhere.

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"RATIO CORRELATION, A Manual for Students of Petrology and Geochemistry", by *Felix Chayes*. University of Chicago Press, (1971), i-viii ; 1-99pp. $6.00 cloth, $2.25 paper.

Most petrologists and geochemists manipulate percentage (or ppm) data, looking for significant associations. Frequently such manipulations require the calculation of ratios such as MgO/(MgO + FeO), K/Rb, etc. ; frequently scatter diagrams are plotted ; frequently norms are calculated. This book is concerned with the algebraic consequences of such manipulations, and the algebraic (artificial, spurious) correlations they engender and which impede the discernment of true relationships.

Chapter 1 presents a survey of the general algebraic characters of geochemical variables, including closure restraints, their generation of illusory ratio correlations and the concept of the expected *null value correlation* (generated by the transformation of the parent variables) as the appropriate model for statistical testing of measured correlations. A curious lapse occurs on p. 8, line 1, where the author erroneously (see *Reference*, p. 545) includes reciprocals and ratios among *linear combinations* of the parent variable vector [**X**] : this mistake also occurs in other places in the book. A closing note which explains the algebraic expansion of a ratio as a power series is seriously marred by the introduction of a deviation δ nowhere defined : since this symbol is of considerable significance later the reader must divine its meaning. Incidentally the last paragraph of p. 7 is surely out of sequence.

In Chapter 2 the K.R. Pearson general equation for the (approximate) null correlation of ratios derived from uncorrelated variables is present and its implications examined. Various interesting consequences are derived including the following : (a) that the coefficient of variation of a ratio C is the square root of the sum of squares of the coefficients of variation of numerator and denominator $\sqrt{(C_1^2 + C_2^2)}$ (for uncorrelated variables) ; (b) that the formation of ratios from closed variables (proportions) nullifies the closure constraint ; (c) that correlation of X_1/X_2 with X_1, when X_1 and X_2 have strong positive correlation (e.g. K/Rb with K) may be either positive or negative.

Chapter 3 extends the discussion to correlation between ratios where one or both denominators are the sum of two variables, including the case of correlations in ternary diagrams.

Application of the results of these two chapters requires further development for variables which are proportions forming a closed array. This begins in Chapter 4, starting with a summary of Chayes' well-known earlier paper (*J. Geophys. Res.*, **65,** 4185-4193, 1960). It continues in Chapter 5 and 6, where the estimation of the means and variances of the hypothetical (and perhaps illusory) uncorrelated open variables is tackled, leading to an empirical procedure for estimating closure-generated covariances suitable for cases involving at least four variables.

Chapter 7 extends the preceding discussion of correlation to regression and to reduced major axis analysis.

In Chapter 8 an attempt is made to free geochemical variables from closure-generated correlation for construction of variation diagrams of the Niggli type. The algebraic implications are clearly developed. Adequate tests of the procedure can seldom be realised, so its usefulness remains uncertain. The book closes with an analysis (Chapter 9) of Harker diagrams directed to the same ends, with an exploration of the implications of negative variances in the open variables on which the oxide variables are theoretically based. These two chapters may nevertheless lead researchers to one of the aims of the book, which is to "stop talking a great deal of nonsense about petrographic variation diagrams" (p. viii).

The typescript is generally clear and free from errors (N_i in line 7, p. 77 should be N_1) but in some places (e.g. p. 63) the abundant algebraic statements could have been more elegantly spaced. There is no index but this is hardly a drawback.

Readers of Dr. Chayes' articles have come to admire his writing, which combines terse and rigorous analysis with incisive, but idiomatic, prose. The latter survives in this book, but is too much subordinated to the analytical discussion for this slim volume to serve as a text book. It will be an extremely useful "prerequisite for... careers of research in geochemistry" (p. viii) — and for that matter in biology, psychology and other fields where numerical data must be interpreted. But it is too restricted in scope and didactic presentation, in spite of numerous examples for the reader to evaluate, to constitute a course text. It will most serve scientists with some statistical background and

who already follow Chayes' contributions to mathematical petrography. Non-petrographers will find the first seven chapters more valuable than the last two.

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Reference

The International Dictionary of Applied Mathematics, 1960. Van Nostrand Co. Inc. Princeton, U.S.A., pp. 1-1173.

COBALT : AN INDUSTRY ANALYSIS by *James C. Burrows*, Heath Lexington Books, Massachusetts, xiv, 218 pp., (1971), $25.00 US.

The book is based on a study originally performed by the author for Charles River Associates Incorporated, under contract to the General Services Administration of the U.S. Government. The book is the first in a series of studies of the minerals industries by Charles River Associates, performed under the G.S.A. contract The text may be broadly divided into two parts : (i) A quantitative and descriptive part — Chapter 1, Introduction ; Chapter 2, Primary Production of Cobalt ; Chapter 4, Secondary Recovery and Stocks of Cobalt ; Chapter 5, Government Policy ; Chapter 6, Structure of the Cobalt Industry ; Chapter 7, Price History, and (ii) An econometric analytical part — Chapter 3, Consumption of Cobalt ; Chapter 8, Price Determination in the Cobalt Market.

The strength of the book lies in the latter two chapters. In Chapter 3, econometric estimates of the demand for cobalt in nine end uses are developed. The author leads in with an explanation of techniques and derivation of formulae and places much effort in examining the results obtained from the regression analyses. Similarly in Chapter 8, the author presents a well-reasoned set of hypotheses and analyzes the mathematical fits of the price analysis. The presentation of the data in the Chapter is considerably enhanced by the graphs and references to them.

The qualitative and industry analysis parts of the book, which form an important basis for the mathematical treatment, display some weakness. A lack of close familiarity with the industry will be discerned by the minerals specialist. The author attempts to make up this lack of familiarity by drawing extensively on reference sources and by detailed annotation of sources. However, the text all too often is a series of extracts from sources and tends to indicate insufficient direct industry follow-up and interviewing [1].

Having developed the consumption and price models the author states (on page 180) that "simulation of the above model (price) to yield forecasts of the cobalt market are beyond the scope of the analysis of this book". The book ends rather abruptly on this note. The econometrician may be satisfied that a detailed analysis had been performed and the market performance understood. The minerals specialist may remain somewhat unconvinced by the exercise. Having spotted some weaknesses in the industry analysis, and possibly having had some problems with the econometric analysis, the minerals

[1] Examples of this may be cited as follows : The stripping ratio is not an adequate proof of the extent of capital intensivity of a mining operation (page 18). A 1965 reference is cited which makes general reference to the Torco process and open pit mining by Rhokana Corporation, and an unidentified (in time and place) tonnage of cobalt bearing ore is mentioned (page 28). "Cobalt production by Inco, Falconbridge, and Sherrit-Gordon is apparently strictly a by-product of nickel production" — is a rather vague phrase (page 30). The author, in discussing the limited data available on the cobalt bearing ores in Canada, does not make it clear whether he checked primary sources of data and whether the data was limited to him or within the Companies concerned. He concludes that the limited data available "illustrates the relative unimportance (to the Canadian producers) of cobalt production". (page 31). There is no attempt made at analyzing the Communist production and trends.

specialist will tend to look for an econometric forecast accompanied by a reasoned analysis, as a test of insight of the market. The minerals specialist will share with the author the problem of forecasting technological changes and the impact of lateritic nickel development (to cite two) but will tend to seek an interpretation of these uncertainties within a reasoned range of probability.

The book is a contribution to the field of Mineral Economics in that a very thorough attempt has been made in examining the trends in a particular mineral commodity. The reasoning of the hypotheses on pricing strategy are particularly interesting. A less expensive publication would be quite acceptable and would undoubtedly receive a broader readership. It could be noted that the original studies in this series are available to the public from the Clearinghouse for Federal Scientific and Technical Information, U.S. Dept. of Commerce, at a considerably lower cost than the list price for this book.

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INTRODUCTORY PETROGRAPHY OF FOSSILS by *Alan Stanley Horowitz* and *Paul Edwin Potter*, Springer-Verlag, New-York, Heidelberg, Berlin, (1971), 96 pages, 100 pl., 28 fig., $28.40 US.

This book is directed at the sedimentary petrologists and stratigraphers who encounter fossils, not as biological entities, but as shells and bits contributing to the composition of sedimentary carbonate rocks. In deference to their avowed audience, the authors have avoided the excessive use of paleontological terminology and systematics, and have identified and described a great variety of fossil forms and structures as simply as possible. This approach also saves the professional paleontologist the labour of referring to dusty tomes for the classification of obscure, unfamiliar taxa. This book is thus doubly useful to layman and professional alike.

The volume is divided into two main portions — 94 pages of text, and 100 black and white plates. The text comprises the first three chapters: Introduction; Getting started in Carbonate Petrography: Methodology and Applications; and Identification of Biotic Constituents. The Introduction — of one page — needs no comment; the second chapter, however, provides an excellent discussion on the historical development of carbonate petrography from Henry Sorby, founder of carbonate petrography in 1851, to the latest contributions of Folk, and Friedman. Chapter 2 also includes an annotated list of the foundation papers in the fields of limestone carbonates. These references are arranged chronologically, a departure from the usual alphabetical order, but one which allows the reader to find quickly and easily the most recent reference in his field of interest. Textural components, framework, grains, and classification of carbonate rocks are briefly reviewed, along with an outline of the models and cycles associated with carbonate deposition. Although the topics mentioned above are treated briefly, the reader is guided by numerous cited references to the most recent literature on each subject, and to the plates of Chapter 4 which illustrate the textural components and framework grains. Dolomites and dolomitic textures are deliberately excluded from this discussion of carbonate petrography.

The third chapter provides reference material for the identification of numerous fossil groups that occur in limestones. Key identification characteristics are outlined for 18 major fossil groups from tintinnines, radiolarians, and foraminifers to vertebrates, wood, faecal pellets, and calcareous algae. The format for discussion of each fossil group is — Skeletal architecture, Skeletal microstructure, Distribution, and Comparisons. "Skeletal architecture" comprises the salient calcareous morphology of the group, gross shape and the usual forms taken by skeletal particles derived from the particular fossil group. Few of the fossil groups are illustrated, but the reader is referred to a selection of the most recent texts or references that provide comprehensive treatment, with illus-

trations, of the group. Detailed microstructure and mineralogy of each fossil group are discussed under the heading "Skeletal microstructure". This section provides considerable optical and mineralogical data on the fossil groups that is not readily available in any other single reference. References are provided to more comprehensive microstructural treatments of each group, and in addition, an annotated list of the major microfacies monographs is appended at the end of the chapter.

The topic — "Distribution — summarizes the known stratigraphic range and geographic distribution of the fossil group. This topic receives comparatively brief treatment and serves only to "round out" the general geological setting of the fossil group. The final topic — "Comparisons" — offers a valuable guide to the identification of fossil fragments by briefly describing similarities and differences of fossil groups that might be confused. Many fossil groups closely resemble each other in microstructure and only with experience or precisely worded explanations can one hope to distinguish between them.

The final chapter is an excellent collection of 280 black and white photographs of 200 thin sections. The first 63 plates illstrate the fossil groups discussed in the text; the remaining are selections from carbonate rocks of various ages. The authors note that the plates represent the best from some 1000 photomicrographs of about 400 thin sections. The photographs are of very fine quality, resolution is high, contrast is uniformly good, and the magnifications (from 20x to 100x) such that the carbonate fossil fragments are easily viewed. All the features of each fossil group discussed in the text are clearly illustrated. The photographs alone make this text a valuable contribution to the study of fossil fragments in carbonate rocks.

A few final photographs included at the end of this chapter are titled "pleasant potpourri", "good goulash", "satisfactory succotash", and "savory stew". These were obviously intended for the limestone gourmet, but they provide food for thought to anyone interested in carbonate petrography.

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MOON ROCKS AND MINERALS by *Alfred A. Levinson* and *S. Ross Taylor*, Pergamon Press Inc., New York, (1971), 222 pages. $11.50 US.

This book has condensed and simplified the scientific results of the investigation of the lunar samples returned by the Apollo 11 astronauts, previously published in three volumes as "Proceedings of the Apollo 11 Lunar Science Conference," a 2500 page supplement of the journal Geochemica et Cosmochimica Acta.

The book is divided into 9 chapters, with 8 color plates, 111 figures or photos, 33 tables, a glossary of over 200 scientific terms, a guide for converting units to British-U.S. units, and a list of the chemical elements and their symbols.

Four broad subject areas of NASA research as covered in the *Proceedings* are discussed: Mineralogy and Petrology, Chemical and Isotope Analysis, Bioscience and Organic Geochemistry, and Physical Properties and Measurements. The emphasis by the authors on an *understanding* of the Apollo II rocks is evident throughout the book with discussions on such topics as the significance of no biologic, organic matter in the moon samples, the textures of the rocks as compared to terrestrial rocks, and the importance of these rocks in unfolding lunar history and origin.

This book is an invaluable reference source for the professional, students, rock and mineral collectors, and all those interested in lunar exploration, and a necessary and welcomed addition to every municipal, institutional and technical library.

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