

## BOOK REVIEWS

CRYSTAL CHEMICAL CLASSIFICATION OF MINERALS. Volumes 1 and 2. By A. S. Povarennykh. Translated by J. E. S. Bradley. Plenum Press, New York and London, 1972. 766 pages. \$40.00.

Taxonomic mineralogy once was a forefront science. In fact, it was through mineralogy and the classification of naturally occurring crystals in the 18th and early 19th Centuries that inorganic chemistry, quantitative chemical analysis, and crystallography were nourished and early developed. Today, the wheel has turned 180°, and mineralogy is nourished from physical chemistry, inorganic chemistry, and solid state physics.

The classification of minerals has been an unbroken pursuit ever since the Greeks discovered the geometrical relationships among the facets of the regular and semi-regular polyhedra. Mineral taxonomies effectively reflected the extent of technology and knowledge of their time. Most revolutionary, perhaps, is the evolution of mineralogical systematology based on crystal structure. Imagine the anguish felt by the great Charles Palache, the last scion of morphological crystallographers who saw order and system in angle tables, when he recognized the years of painstaking effort being progressively superceded by the more penetrating and general classification based on crystal structure!

We appear to be entering another Renaissance in classification (and retrieval) of inorganic materials. As yet, there is no rational or *natural* classification of crystal structures. There is a growing sentiment that such a classification will be topological and geometrical, with a shift away from arrangement according to anionic groups. The key will be classification based on structure type.

Professor Povarennykh's two volume set is a modern and relatively rational arrangement of mineral taxa which reveals his competence at understanding crystal structure—the core information toward complete knowledge of a mineral species. This is the main feature of the work, which distinguishes it from the other systems of mineralogy. Its relative thoroughness at the level of crystal structure, however, does not render the other familiar systems obsolete. Rather, this work *supplements* other systems. *The Systems of Mineralogy (of Dana)* contain a wealth of information on physical properties and locations, difficult to find elsewhere. Povarennykh's work emphasizes crystal structure and its utility in mineral classification; locations and analytical data are absent. Over 1400 references are presented, to be sure a small fraction of the total research effort in mineralogy, but these are up to date and refer to the structure analyses.

Some 185 pages are devoted to a general outline of the basic "laws" of mineral chemistry including a penetrating survey of the history of mineralogical research, with emphasis on Russian studies. Page 89 begins with statements concerning a rational classification of minerals. Povarennykh richly utilizes his own nomenclature throughout the volumes, but the names with IMA approval fortunately appear first. For example, thomsenolite,  $\text{Na}[\text{Ca}(\text{H}_2\text{O})\text{AlF}_6]_2$

is followed by nacalchyalbite (= na-calc-hy-al-fl-ite). An index of prefixes and suffixes is included and we are invited to utilize these tongue-twisters. (Fortunately, we are spared a name for tourmaline!) It is questionable whether such a nomenclature will enlighten us. After all, there are only some 3000 good species at most and the trivial names serve adequately. Quite different is the problem of nomenclature which faces organic chemists, where some 10<sup>6</sup> compounds are known. However, Vitamin B<sub>2</sub> or riboflavin is still used in preference to 7,8-dimethyl-10-(2,3,4,5-tetrahydroxyamyl) isoalloxazine. The key, of course, is the structure. I submit that it is probably easier to recall the structure than the formal nomenclature! Or one can retrieve the compound through the formula  $\text{C}_{17}\text{H}_{20}\text{N}_4\text{O}_6$  with the assistance of a key index. Now imagine the problem of a similar nomenclature applied to three-dimensional structures like minerals. A rational classification based on the absence of geometrical and topological ground rules? Don't you believe it, Dr.!

Putting Professor Povarennykh's nomenclature aside does not diminish the books' importance, nor minimize the attention his Herculean effort so richly deserves. The minerals are arranged according to groups in a quasi-Linnéan fashion: subclass-division-subdivision-group. They are arranged with some choice on the part of the author in many instances—but the emphasis is on the principal cluster which makes up the structural motif. Each entry is followed by space group, cell parameters, comments on the structure (often with a figure), and brief comments on chemistry and physical properties.

This two-volume set is a boon to the crystal chemist and structure analyst. It is the closest work to any we have on the modern classification and interpretation of mineral chemistry. The layout is attractive and the figures are decipherable, but it is a pity that the publisher didn't put the care into rinsing out many small errors and slips of the typewriter. There are numerous errors in the figure legends. Did these appear in the original manuscript? If so, why weren't they caught? Professor Povarennykh's painstaking efforts deserve more.

Professor Povarennykh has certainly engaged in this task out of love, not for money: competent structure analysts and crystal chemists command only a small select audience in the mineralogical community. Perhaps this work will act as an inspiration, for it is becoming clear that the mineralogy of the future will necessarily commence at the level of understanding crystal structure and chemical bonding.

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CRYSTAL DATA. DETERMINATIVE TABLES. Third Edition, Volumes I and II. Edited by J. D. H. Donnay and Helen M. Ondik. Section Editors: Sten Samson (Intermetallic), H. M. Ondik (Inorganic), Mary E. Mrose (Mineral), Olga Kennard (Organic), M. V. King (Protein). U. S. Dept. of Commerce, National Bureau of

Standards, and Joint Committee on Powder Diffraction Standards, 1973. \$30.00 for Volume I (x + 872 pages); \$50.00 for Volume II (x + 1857 pages).

This extremely valuable compilation contains over 24,000 entries as compared with the approximately 13,000 entries of the 1963 edition. The 24,000 entries are grouped together as a set of determinative Tables which comprise almost 90 percent of the volumes. The subdivisions deal with anorthic (triclinic) crystals, monoclinic, orthorhombic, tetragonal, hexagonal and rhombohedral, and cubic crystals. Within these sections the crystals are arranged in order of increasing cell-edge ratios, namely the ratio  $a/b$  for the anorthic, monoclinic, and orthorhombic sections, and the ratio  $c/a$  for tetragonal, hexagonal, and rhombohedral crystals. Cubic crystals are ordered in terms of increasing values of the cell edge  $a$ . Consequently, if the conventional unit cell has been determined for a substance, its cell-edge ratio (or length in the case of cubic crystals) may be sought in the appropriate section and, thanks to the thoroughness of Professor Donnay and co-workers, will likely be found, provided someone has previously published a report on this same crystalline material. Several references to prior work will then be given as well as the previously published cell edges, space group, unit cell contents, and, if available, measured and calculated density ( $D_m$  and  $D_x$ ). In all cases, the compilers have recalculated  $D_x$  using the original data but with the  $C^{12}$  unified scale of atomic weights. They point out (p. 5) that use of these latter may cause discrepancies between the previously and newly calculated densities, "for instance, for the transuranium elements."

The INORGANIC FORMULA INDEX (initial entries: Ac, AcBr<sub>3</sub>, AcCl<sub>3</sub> . . .), INORGANIC NAME INDEX (initial entries: Actinium, Actinium bromide, Actinium chloride . . .) and MINERAL NAME INDEX (Abernathyite, Abukumalite, Acanthite . . .) together comprise almost 10 percent of this volume and provide the cell-edge ratio that enables one to locate a compound or mineral within the determinative tables. Volume I similarly contains a FORMULA INDEX, ORGANIC NAME INDEX, and MINERAL NAME INDEX, this latter containing over 105 mineral names.

This work is a gold mine of information for mineralogists, ceramists, metallurgists, and organic and inorganic chemists. Many entries even correct errors in original works.

We are indebted to the General Editors, J. D. H. Donnay and Helen Ondik, and their co-workers for this service to our science. No science library should be without this volume.

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THE INTERPRETATION OF GEOLOGICAL PHASE DIAGRAMS. By Ernest G. Ehlers. W. H. Freeman and Co., San Francisco, 1972. viii + 280 pages. \$12.50.

This book "is intended for supplementary use in graduate and undergraduate courses in petrology and for reference use." (p. vii). The goal is to bridge the gap between petrology texts and the phase-equilibrium data in the literature. On the whole, this goal is attained. While every in-

structor will have certain objections—some of my own will emerge shortly—there simply is no other text available that starts at a beginner's level and advances so far into the nuts and bolts of phase diagrams. Professor Ehlers is at his best guiding the student through the intricacies of a phase diagram; the descriptions are straightforward and usually well-keyed to the figures. There are 251 figures—many showing sequential changes within a given system—and a conscientious editor has managed to keep most of them on the same or facing page with the discussion, so there is a minimum of page flipping as one follows the description of a course of crystallization. Parts I thought were especially good are the discussion of subtraction *vs* reaction curves (pp. 35–37); the use of vectors to determine the nature of an invariant point (pp. 38–41); the discussion of distributary reaction points (pp. 57–62); and the treatment of isobaric  $T$ - $X$  sections through the  $P$ - $T$  diagram of the NaAlSiO<sub>4</sub>-SiO<sub>2</sub> system (pp. 116–125). It is unfortunate that there is not more emphasis on sections versus projections of phase diagrams, for these are sources of much confusion for students.

My three biggest objections to the book are its treatment of the Phase Rule, the careless drafting of a number of the figures, and the introduction to Chapter 10 (Systems Involving Changes in Oxidation State). The Phase Rule is presented axiomatically in Chapter 1, and the student can obtain little insight into its meaning. In the absence of a formal derivation, there should at least be a reference to such a derivation and some qualitative description pointing out that the variance is simply the difference between the total number of possible variables and the total number of restrictions on those variables. One can then distinguish between those restrictions imposed by the conditions of equilibrium (which of course lead to the classical Gibbsian statement of the Phase Rule) and any additional restrictions imposed on the system externally—constant temperature, pressure, or  $P_{H_2O}$  for example. If the number of additional restrictions is  $r$ , then the most general form of the Phase Rule is  $f = c - p + 2 - r$ . The great advantage of this expression is that it encompasses the various "modifications" of the Phase Rule: I find that students are much less likely to become confused if they learn one Phase Rule and how to evaluate  $r$ . In particular, this approach obviates any need to invoke that abomination, the "Condensed Phase Rule," which Ehlers tells us (p. 8) applies to systems under atmospheric pressure. True, the "Condensed Phase Rule" usually gives the numerically correct variance, but it is not rigorously applicable in this case, and students find it far more meaningful to observe that the restriction to a constant pressure increases  $r$  by 1. Not the least of the objections to the "Condensed Phase Rule" lies in the lack of agreement as to what a condensed system is—Ricci (1966, p. 63) and many workers in sulfide systems require that a condensed system be vapor-saturated; most other authorities consider the vapor-saturation surface only to be the *limit* of a condensed system.

I hesitate to attack the figures in this book because on the whole they are most helpful, but a distressing number have been so carelessly drafted that they end up being thermodynamically impossible. The most flagrant example of this is in Figure 8 (p. 19) illustrating maximum and minimum

melting in binary systems with complete solid solution. The liquidus and solidus are not mutually tangent at the extremum, nor is the tangent to either parallel to the composition axis as it must be. In Figures 5, 106, 107, 108, 109, 110, showing the congruent melting of binary compounds, the liquidus does not have a horizontal tangent at the composition of each compound. Figure 88—a pseudobinary through a ternary system—contains an impossible maximum on the liquidus for phase  $A_2B$ : as it stands, the pseudobinary implies that certain liquids can become enriched in  $A_2B$  while precipitating phase  $A_2B$ ! Figures 94 and 118 (inset) are impossible (for first-order phase transitions); they violate the Morey-Schreinemakers Rule. In Figure 135, a  $P$ - $T$  diagram for  $MgSiO_3$ , the forsterite liquidus at low pressure is inexplicably drawn with a negative slope. Figure 139B is incorrectly drawn in the region of non-binary melting. Figure 139D, originally published with dashed lines as a hypothetical diagram for plagioclase at 30 kbar, is redrawn with solid lines and appears to be as valid as Figures 139 A-C which are experimentally determined. Some of these errors are contained in the original published figures, but that does not excuse the author from either correcting them or at least pointing them out. Composition axes on most diagrams are not specified; apparently they are in weight percent unless otherwise labeled, but this convention is nowhere stated explicitly.

Much of the introduction to Chapter 10 is appalling. The student who depends on it to learn about redox phase diagrams will be confused at best and misled at worst. Page 210: "Whether the assemblage does or does not vary with oxygen pressure depends on the vapor pressure of the phases themselves." This astounding statement is amplified; we are led to believe that phases with high vapor pressure will react with oxygen in the surrounding atmosphere whereas those with low vapor pressure will not. The latter is stated to be ". . . certainly a non-equilibrium situation . . .". Now, there may well be cases where the *rate* of a redox reaction is dependent on the vapor pressure of a phase, but *whether* a phase will oxidize (or reduce) in a given atmosphere depends, of course, on the free energy of the redox reaction. Perhaps Ehlers means "dissociation pressure" rather than "vapor pressure".

Nor is that the end; on page 211 we read "If experimentation were being conducted in a furnace in which an  $O_2$ -containing gas were flowing over the sample, a cation,  $R$ , of variable oxidation state, would reach a particular equilibrium ratio between its oxidation states  $R^{2+}$  and  $R^{3+}$ . If the partial pressure of oxygen were changed, then the ratio would change as well." This is not generally true—one need only think of magnetite, which (at sufficiently low temperatures or high pressures to prohibit cation deficiency) maintains an essentially fixed ratio of  $Fe^{2+}$  to  $Fe^{3+}$  over many orders of magnitude of  $P_{O_2}$ . (The ratio may, in fact, vary slightly, but not enough to be detected by standard chemical analysis.) Then, in a discussion of controlled atmosphere by gas mixing (p. 211): "The very nice aspect of this type of atmosphere control is that if some oxygen is taken up or released by the solid or liquid phases the gas will quickly react to return to its original equilibrium state: *therefore there is no need for a constant source of new gas.*" (Emphasis added.) This is pure bunk—as is

well-known, the gas-mixing method precisely depends on a constant source of new gas.

I strongly urge that any instructor who assigns this chapter should order each student to obliterate the last paragraph on page 210 through the first half of page 211!

There are relatively few typographical errors, and most are unlikely to cause confusion. However, on line 14, page 31 "invariant" is used where "univariant" is meant.

Finally, I feel compelled to lament a philosophy that has led to a book covering so much of the geometry of phase diagrams and so little of the theory behind them. I applaud Ehlers' evident desire to begin at a low level—to assume little prior knowledge other than chemistry and mineralogy—but surely there could have been added one or more chapters or appendices outlining the relationship between phase diagrams and free-energy surfaces, the derivation of the Phase Rule, and the like. Students who are forced to learn this much about phase diagrams without really understanding them should feel cheated.

I suspect many undergraduate and beginning graduate students will consider this book a godsend. Their instructors, being more aware of its shortcomings, will be less enthusiastic, but most will probably decide that it is still the best book available on the subject.

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FOURIER METHODS IN CRYSTALLOGRAPHY. By G. N. Ramachandran and R. Srinivasan. Wiley-Interscience, New York, 1970. xiii + 259 pages. \$15.95.

This book is concerned with recent developments in Fourier syntheses useful in the early stages of crystal structure determination, and the contents are thus more specialized than the broad title would suggest; the standard electron density and Patterson Fourier syntheses are treated relatively briefly, structure refinement not at all, and of course crystallography comprises much more than structure determination. Primarily this is a collation of research papers from the Madras school, and as such it will be found valuable by researchers in the structure determination field. The treatment is mainly theoretical, with few details of experimental and computational problems, but there are also useful summaries of recent papers in which new methods were used and assessed. There are also rather complete references at the end of each chapter, by no means limited to Indian work, but including references to journals which would not ordinarily be seen by the Western reader.

The first 120 pages introduce and assess new syntheses which have proved useful in completing the determination of structures of which a part is known, usually the positions of heavy atoms or groups. Whereas for an electron density synthesis the Fourier coefficients are  $F(hkl)$ , and for a Patterson,  $|F|^2$  the authors derive, by ingenious use of the convolution-multiplication duality, the result to be expected from syntheses whose coefficients are, for example,  $|F|$ , or  $1/F$ , or  $\exp i\phi$ . These results are then used to predict the properties of syntheses with compound coefficients such as  $|F_N|^2 F_p$ ,  $|F_N|^2/F_p$ , and  $|F_N| \exp i\phi_p$ , the so-called

$\alpha$ -,  $\beta$ - and  $\gamma$ '-syntheses. Here  $N$  refers to the whole unit cell, of which a part  $P$  is known. The usual heavy-atom synthesis is an example of  $\gamma'$ , but the  $\beta$ -synthesis has been proved a superior tool.

In the second half, general treatments of isomorphous replacement and anomalous dispersion data are followed by accounts of new Fourier syntheses, akin to the  $\alpha$ -,  $\beta$ - and  $\gamma$ '-syntheses, which may be used for such data. Anomalous dispersion of neutrons is briefly treated.

The authors write in excellent, clear English, and develop the complex ideas in steps which are easy to follow. It is usual for reviewers to attest their industry and competence by spotting errors, and indeed there are some misprints and slight mistakes, but not so many as one might expect in so mathematical a work. There are missing  $H$ 's on page 73, and one might quarrel with the signs in equations on pages 9, 54, and 73, and with the definition of  $\psi$  as a negative angle on pages 170 and 171, but these are minor matters. The work is well produced, the type-face clear, the captions bold, the diagrams adequate. It might have been possible for diagrams which had to be compared with one another to appear on facing pages; often a page had to be turned back and forth to compare details of Fourier syntheses.

The examples in this work are not mineralogical: perhaps if structural mineralogists read this book and apply the methods there might be some to include in a future edition. The sections on isomorphous replacement and anomalous dispersion will be valuable to those teaching structure determination courses, but largely this is a book for researchers. It is fully worthy to join the previous excellent volumes in this series.

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**EPITAXY DATA OF INORGANIC AND ORGANIC CRYSTALS.** By M. Gebhardt and A. Neuhaus. Volume 8 of Group III: CRYSTAL AND SOLID STATE PHYSICS; In, Landolt-Borstein: *Numerical Data and Functional Relationships in Science and Technology*, New Series. Editor-in-Chief, E. H. Hellwege. Springer-Verlag, Berlin-Heidelberg-New York, 1972. vii + 186 pages.

Epitaxy is a curious but widespread phenomenon whereby one crystalline phase growing upon another takes up a preferred orientation with respect to the substrate. Epitaxy is a template effect and might even be extended to include the regular attachment of molecules at the active sites of enzymes; it summarizes what happens across the interface between two phases. The characteristic is that there is an increase in dimensionality—the structure of a two-dimensional surface is shown by its three-dimensional effects—the mutual orientation of the two phases which meet at that surface. Properties of the surface other than those of the bulk crystal structures enter into the problem. For example, adsorbed surface layers are, in many cases, important in promoting or retarding good ori-

entation. Moreover, many epitaxial effects take place even upon glass.

In these tables, calculations of the percentage misfit (how much the two lattices which meet may be out of exact register) are made for one direction only, although the surfaces concerned are two-dimensionally periodic. This approach may make epitaxy seem simple, whereas it is actually complex; there is no problem, however complex, which, when properly regarded, does not become even more complex.

For example, suppose that one strongly ionic phase lies upon another [as NaCl on MgO; (001) on (001) in parallel orientation] with two unit cell distances of the former almost matching three unit cell distances of the latter. What is supposed to be happening? Can the two phases be held together by electrostatic forces? If so, then there must be as many regions where like charges confront each other and produce repulsion as where unlike charges produce attraction. The product of two sinusoidal distributions of different frequencies averages out to zero. It seems then that either (1) other kinds of forces are involved or (2) that the dislocation structure plays a vital role in allowing atoms of unlike charge to meet more often than they would if the two crystals abutting at the interface were perfect.

It is really premature to codify the data, as it seems that new techniques, particularly low-energy electron diffraction, will be necessary to show what is really happening in detail. Just as we have solid-state electronics (the biggest users of the phenomena of epitaxy) which deals with the flow of electrons and holes in solid anisotropic media, we also have problems of the chemistry of such media—just how does the chemical bonding in an epitaxial interface work? This compendium certainly poses many questions, such as how vitamin B<sub>12</sub> molecules orient themselves on quartz; could inorganic molecules have served as the places where the organic molecules which became life were concentrated and combined with each other; did the enantiomorphy of quartz play any part in allowing 1-amino acids to predominate over d-?

These tables give just the first crude tabulation of the data and it must be expected that they will be superseded as the phenomena become better understood. As things stand now they are a useful invitation to work in this field.

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**THE GEOLOGY OF DONEGAL: A STUDY OF GRANITE EMPLACEMENT AND UNROOFING.** By Wallace Spencer Pitcher and Antony Robert Berger. Wiley-Interscience, New York, 1972. xii + 435 pages. \$39.95.

On their title page the authors have characterized the granite controversy by the following quote from Auden: "A poem is never finished, it is only abandoned." To judge from the succeeding 435 pages, the poem was certainly not abandoned in Donegal! Beginning a quarter of a century ago at the end of the Second World War, H. H. Read and Robert Shackleton initiated this study of the Donegal gran-

ites which eventually claimed the efforts of about 45 workers.

The first three chapters outline the regional geologic framework of the Dalradian (Late Precambrian to early Cambrian) rocks of Donegal and place them in relation to the Caledonian mobile belt as a whole. Chapters 4 through 13 present rather detailed summaries of the pre-middle Ordovician plutons and the structures of their envelopes. Chapters 14, 15, and 16 summarize the controls of contact metamorphism, interpret the fabric of granitic rocks, and discuss the forms and origins of the plutons. Late events of deformation, sedimentation, and the Tertiary dike swarm are discussed in the brief concluding chapters 17 and 18.

The authors have dissected the total geologic framework of granite emplacement in a most admirable manner that will appeal to a broad cross section of geological scientists. Here the reader will find a forceful treatment of the problems in using textural relationships between minerals in such granites to establish a paragenetic sequence of significance in interpreting crystallization from a magma. Interestingly, the authors reject the epizonal-mesozonal-katazonal classification of granite emplacement on the basis of evidence that the considerable range of contact effects from typically epizonal (cauldron subsidence) to typically katazonal (strongly foliated, largely concordant) exhibited by the granites of Donegal were all formed at about the same crustal level. The resulting style appears to depend on complex relationships between granitic intrusion, deformation, and regional metamorphism. The plate tectonic model for evolution of the magmas and structures is given only cursory treatment, and it is evident that the goals and method of approach were most strongly influenced by the frames of reference current in the pre-drift era. Similarly, the potentials of isotope geochemistry do not seem to have been adequately exploited. Nevertheless, in a period of regional geology characterized by the recasting of old data into new frameworks, it is refreshing to receive a major new contribution of objective field data.

Oh yes, the granites are magmatic.

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FLINT. By Walter Shepherd. Faber and Faber, London, 1972. 255 pages, \$18.50.

As stated by the author, this is "a book intended to provide at least a comment on all the common queries about flint." In this effort Shepherd does a creditable job, and on the whole the book makes fascinating reading. In addition, the author has ably summarized a diverse and widely scattered literature.

A book on flint is, not unexpectedly, what would be of primary interest to an inhabitant of the British Isles. There is a heavy emphasis on the origin of chalk. Most of the examples in the book, both geographical and specimens, are British. There are chapters on the nature of flint,

segregation from sea water, derived flints, prehistoric uses, and flint in the historical period. The ten appendices cover silica solubility, silica in natural waters, the effects of folding on the water table, silica and vegetation, silicates in chalk, water on a molecular scale (including some controversial information on polywater!), Stone Age cultures, English flint workings, and even a listing of the word for flint in 28 languages, including Eskimo, Swahili, Yoruba, and Zulu. The last is somewhat misleading, because in many tongues there is no word for what we know as flint, but rather a word for a local rock that has the same appearance or function.

There are the usual typographical errors, such as petrifying (petrifying) and  $\text{HCO}_3^-$ . A more disturbing feature, however, is the author's lack of conclusions on controversial subjects. For example, in discussing Liesegang phenomena experiments by the author and others, Shepherd describes the work in great detail, but leaves it entirely up to the reader to produce the correct interpretation. The same applies to a discussion of flint segregation. The lack of conclusive statements is perhaps best summarized in a comment by the author (p. 104): "We must thus be cautious because we are equally certain that a great many other things have also been happening in connection with flint, in other places and at other unknown periods." That kind of comment would seem to be capable of ending almost any argument!

The book contains numerous illustrations and 32 plates, some of which are in color and most of which are of passable quality. Some of the flints pictured are extremely intriguing and well exemplify the concepts referred to in the text.

Shepherd creates the impression that flint was one of the more critical raw materials to ancient man. Yet his discussion of stone tools and fabrication is largely restricted to England. There is a notable lack of information about the occurrence of flint throughout the rest of the world. In addition, the sources of much of the information pertaining to archeology are not stated. It is apparent that some of the tables, such as the one on prehistoric toolmaking periods, are out of date. Most of the literature referenced is quite old, and newer papers are not included. This limits the usefulness of the book and does not give an adequate summary of current opinion. The same argument applies to other parts of the book as well. Popularized treatments of some subjects have been used by Shepherd as source material. There is always in this approach the danger of missing key points or misinterpreting some ideas that might have been present in original source materials in current literature. Many terms used in the book are not explained, and credits are not always given for information.

Nonetheless, *Flint* is an enjoyable book, very easy to pick up and read through. Sins of omission are forgiven because of the author's intent to provide a reasonably comprehensive introduction for the layman. The book is certainly not intended, nor could it be used, as a primary source for current or technical information. But at a cocktail party if someone corners you and asks where he can get a book that answers most of his pressing questions about flint, this is certainly the one to recommend.

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CHIMIE CRISTALLINE. By J. Zemann. Translated by E. F. Bertaut. Dunod, Paris, 1970. xiv + 162 pages.

Zemann has done a fine job of putting a lot of data into a very small pocket-book type of publication. He briefly discusses the various types of crystal structures and chemical bonds, giving classic examples of each type. In the second part of the book, the author discusses in more detail silicates, hydroxides, hydrates, sulfides, crystal defects, solid solutions, and polymorphism. The French text is excellent and easy to read.

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ÜBER EINIGE MINERALIEN DER GRUBE LENGENBACH. By Werner Nowacki. Reprinted from *Uerner Mineralien Freund*, nos. 3-6, 1969, nos. 4, 6, 1970. 52 pages, 83 figures (6 in color). Order from T. Imhof, Ried-Brig (Vs), Switzerland, price 6.00 SFr.

This small, nicely illustrated pamphlet very briefly characterizes the minerals found at the famous Lengenbach quarry in the Binnatal, Canton Wallis, Switzerland. The descriptions primarily deal with the many unusual sulfosalts found at the locality and chiefly refer to recent crystallochemical and structural studies. A very brief history of the mineralogical work on the occurrence is included.

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### List of Books Received

ARC PLASMA TECHNOLOGY IN MATERIALS SCIENCE. By D. A. Gerdeman and N. L. Hecht. Vol. 3, *Applied Mineralogy*. Springer-Verlag, New York, 1972. x + 206 pages. \$23.80.

THE EARTH AND HUMAN AFFAIRS. By the Committee on Geological Sciences, Division of Earth Sciences, National Research Council, National Academy of Sciences. Canfield Press, San Francisco, 1972. 142 pages.

GEOLOGY OF EASTERN NORTH AMERICA. By Johann David Schöpfung. Translated by Edmund M. Speiker. Vol. 8, *Contributions to the History of Geology*. Hafner Publishing Company, New York, 1972. x + 171 pages (+194 pages of original German text in facsimile reprint).

LABORATORY AND FIELD INVESTIGATIONS IN GENERAL ECOLOGY. By Robert G. Rolan. Macmillan Company, New York, 1973. x + 235 pages.

LANDFORMS OF COLD CLIMATES. By J. L. Davies. M.I.T. Press, Cambridge, Massachusetts, 1969. xvi + 200 pages.

LANDSCAPE INDICATORS. NEW TECHNIQUES IN GEOLOGY AND GEOGRAPHY. Edited by A. G.

Chikishev. Translated from Russian by J. Paul Fitzsimmons. Consultants Bureau, New York, 1973. x + 165 pages. \$29.50

MINERAL RESOURCES. PROBLEMS IN MODERN GEOGRAPHY. By Kenneth Warren. Halsted Press, New York, 1973. xvi + 272 pages.

MINING IN THE NEW WORLD. By Carlos Prieto. Consulting Editor, Marvin D. Bernstein. McGraw-Hill Book Company, New York, 1973. xvii + 239 pages. \$8.95.

A SENSE OF THE EARTH. By David Leveson. Natural History Press, Garden City, New York, 1971. 176 pages, 31 photographs, 5 drawings. \$6.95.

ULTRASONICS. THE LOW- AND HIGH-DENSITY INTENSITY APPLICATIONS. By Dale Ensminger. Marcel Dekker, Inc., New York, 1973. xvii + 570 pages.

WATER WELL TECHNOLOGY. *Field Principles of Exploration Drilling and Development of Ground Water and Other Selected Minerals*. By Michael D. Campbell and Jay H. Lehr. McGraw-Hill Book Company, New York, 1973. xvi + 681 pages. \$24.50.