the Mineralogical Record

Volume 2/Number 2
MARCH/APRIL, 1971

WHAT'S YOUR BAG

IF IT'S MINERALOGY, GEOPHYSICS, SEISMOLOGY, VOLCANOLOGY, PETROLOGY, PALEONTOLOGY OR ANY OTHER GEOSCIENCE YOU CAN COME UP WITH THEN WE CAN HELP YOU WITH YOUR RESEARCH BECAUSE OUR BAG IS GEOSCIENCE LITERATURE. WE HAVE EXTENSIVE BACKFILES IN ALL THE IMPORTANT JOURNALS AS WELL AS GOVERNMENTAL REPORTS IN SEVERAL LANGUAGES. WE HAVE NOT AS YET ACQUIRED EVERYTHING THAT WAS EVER WRITTEN ABOUT GEOLOGICAL MATTERS BUT WE ARE TRYING. YOUR INQUIRIES ARE SOLICITED.

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Luzonite

- copper arsenic sulfide
- Chinkuashih mine, Keelung, Taiwan
- 4x5 $50.00, 2x3 $20.00, 2x2 $10.00, 1x5 $5.00, 1x1 $3.50, 1" $2.50
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Pandaite

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- ref: E. Jager *et al*, Min. Mag. *32*, 10-25 (1959)
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- Narushima, Nagasaki-ken, Kyushu, Japan
- flattened euhedral crystals 5/8" to 1" - @ $17.50 to $25.00

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Cover painting by Mrs. Ingebord Vass. Apatite crystals with quartz from Panasqueira, Portugal. Smithsonian Institution specimen.

To the Editor

Comments on Volume I

Dear Sir:

Enclosed is a check for my renewal to the *Mineralogical Record.* I certainly enjoyed the last four issues and will be looking forward to this years publication.

I would also like to suggest that you include some articles on basic crystallography in future issues.

John B. Higgins
Alexandria, Virginia

Dear Sir:

Keep up the good work. The fourth issue arrived and I must say you are still right on target. I took those copies abroad and from the interest shown you should have a number of subcriptions by now . . .

H. A. Mitchell
Ridgewood, New Jersey

Dear Sir:

Please renew my subscription to your excellent magazine. I await each new issue with keen anticipation. Congratulations on a magnificent first year of publication, and may you continue to maintain your present high standards.

W. R. Foster
Professor & Chairman
Department of Mineralogy
The Ohio State University

Dear Sir:

I should like to help you in your publication by expressing my dislikes (only one—you are quarterly instead of more often) and my likes.

1. The general writing and content of all articles is very good. Subject matter-excellent.
2. I appreciate your bibliography (references cited). Often the ability to learn in a new field is predicated on one's ability to find data or books in that field.
3. *Re* Winter edition, p. 134, Cook letter—"will your magazine carry articles about lapidary arts?" You answered "decidedly not"—good for you, I agree not only with your policy but also the reasons back of your answer.
4. I am a rockhound of some 30 years standing who has become *very* interested in mineralogy, crystallography and micromounts in the last 3 months. As such, I should appreciate a little (not much) on the basics in these fields for beginners. Also I am interested in seeing articles on micromounting. Collecting location data is also appreciated. In short you folks are doing just great—keep it up.

Robert A. Woods
Indianapolis, Indiana

We are now bimonthly. Ed.

Dear Sir:

I'm looking forward to each upcoming issue—the magazine is indeed an excellent one.

Doris J. Biggs, Editor
"The Keystone Newsletter"
Lancaster, Pennsylvania

Dear Sir:

Please renew my subscription to your *Mineralogical Record* . . . an excellent magazine for the amateur collector as well as the more advanced and professional. I don't want to miss a single copy.

Harold P. Trefethen
Amherst, New Hampshire

Dear Sir:

Please renew our subscription to your wonderful magazine. May you have much success in your venture.

The Wideners
Richmond, Virginia

Dear Sir:

I have been very pleased with your new publication—and hope it will grow and be with us a long, long time.

Miles H. Hudson, M.D.
Valdese, North Carolina

Dear Sir:

What prompts me to write this letter is your editorial in the Winter issue, it really hit a nerve. I happen to belong to one of "those" clubs you so ably describe. We are doing everything according to the rules, at our lectures we usually have more guests than members, therefore you can't raise any questions that could possibly create a controversy.

The lectures are usually good, but by the time we are through with all the announcement, plus the door prizes (which as far as I am concerned is a gimmick), I begin to wonder if it is worth it. Even though we have some knowledgeable people in the club, answers are very hard to come by, these people keep pretty much to themselves. The only reason I don't quit is because all the other clubs I know of are the same.

Lester Schweitzer
Oak Park, Michigan

Dear Sir:

I particularly like your answer to a letter regarding cutting and polishing. As a matter of fact if the magazine was altered to appeal to "spit and polish" collectors I would not renew.

Every issue has been better than the previous one. Any attempt to please both the professional mineralogist and so-called "Dana collector" would appear to be an impossible task. One satisfactory bridging of this gap would be to give more space to new localities in the U.S.

I like the magazine and will continue to do so as long as it avoids physics as played up in the misnamed *American Mineralogist.*

Ernest E. Fairbanks
Portland, Maine

Dear Sir:

I have enjoyed this publication very much and appreciate the valuable information you publish. I may see you or your representative at the American Federation Show in Seattle.

T. W. Tuttle
Pasco, Washington

Dear Sir:

It is terrific!

Mrs. Wallace McGregor
Oceanport, New Jersey

Dear Sir:

Each issue of the *Mineralogical Record* is so rewarding. This last one (Winter, 1970) on Langban-type deposits is tops and we try to compare it with our Franklin, N.J. known specimens. The added attraction is to see pictures of and articles by our friends Paul Desautels and Neal Yedlin.

Thank you for a fine periodical.

Alex, Knoll
Lakewood, New Jersey

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A Variation on Competitive Exhibiting

EDITORIAL PAGE

I am sure that many of our readers are not familiar with the system adopted in this country for awarding points and trophies to collectors who enter a display of minerals (30 to 50 specimens) in competitive exhibits at mineral shows. The complex guidelines for judging, the "*uniform* rules," have become a nightmare and are practically impossible to dicipher. Needless to say inequities in the qualifications of the judges influence the results far more than the rules and make the point totals completely meaningless. However the uniform rules do generate controversy and stir many otherwise lethargic collectors to get excited about something. It is also true that a small number of persistent exhibitors have learned to be attentive to the importance of accuracy in labeling and have actually become very good at presenting an attractive display. In fact, many museum curators would benefit from noting the techniques utilized by some of these exhibitors.

I would like to propose the adoption of a radically new type of mineral competition, on a trial basis. This proposal involves the selection of the "Best in show" of a given species—much as is practiced in flower or dog shows. Prior to the show, or series of shows, one or more mineral species is (are) designated as the one(s) selected for competition. At any one show all collectors are invited to enter their best specimen of the designated mineral. All entries will be placed in the same case or in adjacent cases if more than one is required. The judges' task will simply be to select the most outstanding specimen in the case. A larger number of judges may be used, perhaps 6 or more, and each will vote independently. The specimen receiving the most votes will be the winner! In this way judging becomes so easy and fast that show sponsors should have no difficulty finding volunteers to perform this usually odious task. The judges may be permitted to consult prior to voting so that each may mention features that he or she feels are good or bad about each specimen. No longer will judges be required to compare apples with oranges.

Ideally this program should begin on a local level, perhaps the club level. The club winners may then compete on the county or state level. These winners may then go on to Regional Federation Competition. The Regional winners would then be eligible for the *grand national prize*—victory in competition at the National Show!

The judging at the local level may not be of the same quality as that of federation judging. This may inevitably lead to accusations that the local winner was not the best specimen. To minimize this problem the rules may allow a dissatisfied entrant to enter the specimen in two different *local* shows. If he loses at one local show he may win at the other and therefore have another chance to compete against the specimen he lost to in the first. At each successive level of competition it should be an easy matter to upgrade the caliber of the judges.

It would be practical to retain the size classification now used—cabinet, miniature, thumbnail and micro—and select winners in each category. The specimens entered could be of mixed size but it would hardly be proper to enter a micromount in competition against a cabinet specimen.

Naturally such a program will have to be well-coordinated so that a given mineral can be judged at successively higher levels in the proper chronological sequence. This needn't present any difficulties however as several different species may be in competition on different levels at the same time.

It no doubt will be argued that such a system will favor the wealthy collectors who can better afford superior specimens. Well that may be but the same argument can be, and is, brought up with the present system. Haven't horses of the wealthiest horse breeders consistently won most of the top prizes? This objection may still be overcome by recognizing two classes—purchased specimens and self-collected specimens. The prospect of an entrant misrepresenting a specimen he bought as one he personally collected is not too great. Most collectors have many friends who are very familiar with their collections, so I think such cheating would be minimal.

What are the criteria that are to be used by the judges in deciding which specimen is the best? I propose that each judge should decide which specimen he would most like to own—that is the one for which he should vote. Factors such as rarity of occurrence at a certain locality, unusual growth habits, associated minerals, freedom from damage, overall aesthetic appeal, etc. will influence each judge differently but this is as it should be. Since the factors that make a specimen more desirable to one person than another are largely subjective, the method of selecting a winning specimen should be wide open to subjectivity. Personal biases will still operate but no attempt will be made to force one individual's biases on another. Some judges may feel that exposed sawn

(Continued on page 56)

Q/A column

(Q) ***Dana's System of Mineralogy* gives only one occurrence for legrandite, the Flor de Pena mine, Lampazos, Nuezo Leon, Mexico. I have a doubly terminated crystal without matrix that I obtained about 1962, and presumed to be from this locality. In 1969 a second specimen, on limonite matrix was obtained from a reputable source, was labelled as from the Ojuela mine, Mapimi, Durango, Mexico. Can this be? Where can be found a published report? Is there information on current production and availability of specimens?**

John E. Hufford

(A) *The Flor de Pena mine is the type locality for legrandite but it does not appear to have produced more than a small number of specimens. The Ojuela mine, on the other hand, has produced thousands of specimens and is the material upon which the paper "Re-examination of Legrandite" by Desautels and Clarke,* American Mineralogist, **48,** *1258-1265, 1963, was based. Specimens have been appearing in record numbers and record sizes for the last 2 or 3 years so legrandite may therefore be considered rather plentiful. In spite of this the price of legrandite specimens has remained at a high level. It is probable that both of your specimens are from the Ojuela mine.*

(Q) I have obtained a specimen of *alvite* from Helle, Norway in a trade. Could you give me a brief summary of the reported description and its chemical formula. I have not been able to find this information.

W. M. Bryant, III

(A) *We quote from Hey,* Chemical Index of Minerals, *2nd ed., p. 110 . . . "The original analysis showed a silicate of Th, rare earths, and iron, with a little Zr and some 14% of Al_2O_3+BeO (Dana 6th edn, 487); another analysis of material classed as Alvite showed a silicate of Zr and Be (Dana 6th edn, 487), with a little rare earths but little or no Th; and a more recent analysis of material labelled Alvite shows a silicate of Zr and Fe, with only small amounts of Be, Th, or rare earths (M.A. 3-55). The true composition and nature of Alvite remains quite uncertain."*

(Q) Is offretite presently considered to be a valid mineral species or is it a synonym of erionite? I have some 1mm colorless, hexagonal crystals from Malpais Hill near Winkelman, Arizona that were said to be offretite. If offretite and erionite are accepted species, how can I distinguish between the two?

Arthur W. Rocker

(A) *The offretite-erionite story well illustrates why one should not be too quick to throw out old labels. Who could blame most collectors for thinking that "The Identity of Erionite and Offretite" by Hey and Fejer,* Mineral Mag, **33,** *66-67, 1962, was the last word? Yet, in 1969 it was shown, in a paper by Sheppard and Gude ("Chemical Composition and Physical Properties of the Related Zeolites Offretite and Erionite,* Amer. Mineral, **54,** *875-886), that the two are different species but very closely related. Offretite is alkaline earth-rich and has a $Si/(Al+Fe^{3+})$ ratio of 2.48, while erionite is generally alkali-rich and it has a $Si/(Al+Fe^{3+})$ ratio of 2.92 to 3.74 resulting in characteristically higher refractive indices. The optic sign for offretite is negative, positive for erionite. Significant differences between the x-ray powder patterns of these two minerals exist for ready identification. Barring the availability of optical and x-ray equipment, a rule of thumb suggested by*

(Continued on page 56)

(Continued from page 50)

Dear Sir:

I believe that this is the finest magazine of its type that I have seen. Every issue thus far has contained a wealth of information for the advanced mineral specimen collector and amateur mineralogist. And I believe that many of the articles are of interest to the professional mineralogist, as well. Also I believe that your publication will aid in uniting amateur and professional in their common interest.

If possible, I would like to see an occasional article on mineral localities with their suite of minerals and drawings of the crystal forms (morphology) of the mineral found at that locality. I believe that this would be a great aid to the amateur mineralogist in identifying unknowns from such a known locality which has been written up in this manner.

Again I say that I enjoy your magazine immensely and will certainly bring it to the attention of others.

Wayne W. Holt
Rochester, New York

Dear Sir:

I think this magazine is the best there is. I have tried others and found them slanted heavily towards the lapidary or too technical for me to understand.

T. Dombek
Phoenix, Arizona

Dear Sir:

Please accept my sincerest congratulations for the high-quality content of the *Record.* It is meeting a long-time need for a large fraternity of serious minded mineral people. You and your associated colleagues who have made this possible deserve more than words of commendation.

Elmer B. Rowley
Glens Falls, New York

Dear Sir:

Like semi-classical music your publication satisfies the "intellectual mineral soul" yet provides the lightness necessary to make life really worth living.

William H. Smith
Easton, Connecticut

(Continued on page 84)

what's new in minerals

THE TUCSON SHOW

The mineral show at Tucson, Arizona in February lived up to its reputation as one of the best, if not the best, mineral shows available to the collector. It excels in several categories: outstanding displays of minerals, high quality of mineral dealers, and success in attracting an impressive representation of amateur and professional mineral enthusiasts. It certainly has no peers in this country in the latter category. No other American show can attract dealers from France, Italy, Switzerland, Germany, Canada and Mexico, curators from at least a half-dozen leading museums in North America, and collectors from a wide range of other countries including the foremost collector in Australia, Mr. Albert H. Chapman.

However it is not the purpose of this column to elaborate on the "name" personages in attendance so I won't do so. Instead I want to comment on the *minerals* in attendance. As usual there are many exciting things to see in new material at the Tucson Show. Unlike last year when Mapimi adamite and Los Lamentos wulfenite seemed to dominate, there was a great variety of minerals but no one in superabundance. Of course, superb adamites and wulfenites from the aforementioned localities were to be seen but not in overwhelming numbers. The most exciting new find in Mexico is paradamite from the type locality, Mapimi. One dealer reported that he had as many as 30 specimens of this very rare mineral.

Brazil continues to amaze and this time it is the phosphate minerals from pegmatites in Minas Gerais. What sets so many of them off to advantage is their matrix of coarsely crystallized deep pink to lavender-pink quartz. Most abundant and most spectacular is eosphorite in sprays of sharp, dark-brown crystals up to 2-3 cm and as random sprinklings of transparent brown crystals on quartz and tourmaline. Associated with eosphorite in many specimens are single crystals, groups of 2 or more crystals, and spherical clusters of forest green roscherite.

Other phosphate minerals are found in lesser numbers by diligent searchers including excellent, but small, crystals of wardite and xanthoxenite. Fine single crystals of brazilianite, several cm across, were offered in good number and large, usually etched, yellow amblygonite crystals were to be found. Not to be outdone by Minas Gerais, the state of Bahia provided some incredibly large, well-formed, loose axinite crystals of a dark smoky color. Single crystals up to about 8 cm in length were seen.

The most outstanding material from the United States was probably the San Benito County, California neptunites in carefully selected miniature size specimens consisting of large and beautiful single crystals on matrix or loose. Some outstanding pink beryls of large size from Thomas Range, Utah were also seen.

An impressive number of the most beautiful Tsumeb dioptase specimens I have ever seen were shown. The deep green crystals were pristine and many showed to great advantage on snow-white calcite.

From Romania came fine specimens of such uncommon minerals as berthierite and semseyite plus excellent specimens of the better-known minerals barite and stibnite. A large number of Sicilian sulfurs, many with celestite, were on the counters. Panasqueira was well-represented, particularly by wolframite and apatite, and the price of its specimens is remaining high.

The minerals described above are those seen in numbers. It would be a terrific chore to attempt to list all of the fine minerals represented by a very small number of specimens.

One exhibitor showed a specimen of a new mineral from Tsumeb. The published description of the mineral has not yet appeared in the literature so we will not refer to it by name. What is interesting though is to see a cabinet specimen of a new and rare mineral of sufficient quality and beauty to easily take its place among some hundred of the most beautiful specimens ever gathered in one display case. More about this mineral after its description is published.

POLYDYMITE AND VIOLARITE

In the Winter (1970) issue of the *Mineralogical Record* an occurrence of polydymite was reported from Gray's quarry, Hamilton, Illinois. Response from Anthony Gricius regarding that report has prompted a further look at the Gray's quarry material. Closer examination of the polydymite-violarite relationship has been made thus providing sufficient information to expand the report.

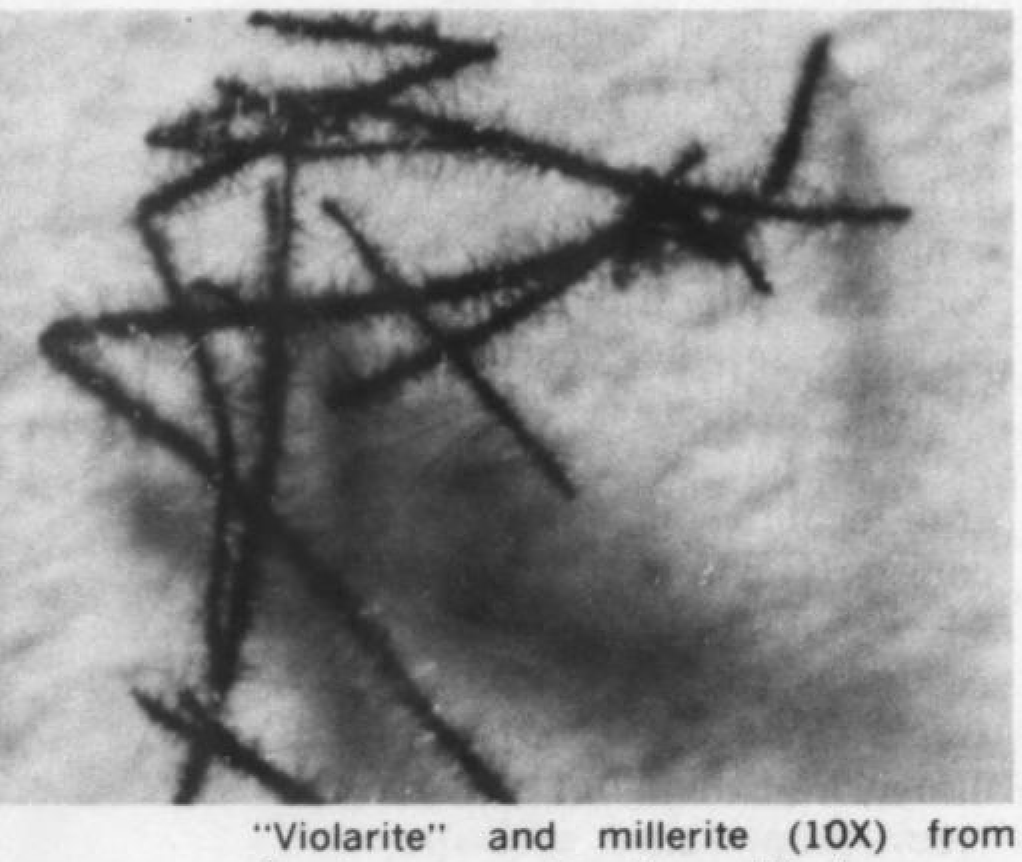
Mr. Gricius' communication follows:

"I was very interested in the recent item on polydymite that appeared in the fourth issue of *The Mineralogical Record.* Seven years ago I had identified violarite (Ni_2FeS_4) in specimens from Gray's quarry and other localities in the area of Hamilton and Warsaw, Illinois. . . . The violarite was identified by its x-ray diffraction pattern, by the violet color of its polished surface under vertical reflected light, and by qualitative chemical tests (positive results for nickel and iron, negative for cobalt and copper). Violarite seems to be a common alteration product of millerite in the central United States. Millerite altering to violarite has been found at several localities in southwest Wisconsin (Heyl, et al., *Am. Min.*, **44,** 995-1009, 1959), in northwest Arkansas (Sterling, et al., *Econ. Geol.*, **57,** 453-455, 1962), and at Troy, Lincoln County, Missouri (Heyl, op. cit., and personal communications with Geo. C. Dick of Overland, Mo.). I am enclosing a summary of a cursory x-ray study of some of the nickel minerals found in the Hamilton-Warsaw area. Besides violarite and millerite, the minerals vaesite (NiS_2) and retgersite ($NiSO_4 \cdot 6H_2O$) were identified. Vaesite has previously been found in the fluorite district of Illinois (Park, *Mineralium Deposita,* **2,** 322-375, 1967) but I believe this is the first report of retgersite in this state. None of the material described here was personally collected and all the samples were small. Therefore, my study had to be quite limited. I think that a detailed investigation of the nickel minerals of Hamilton and Warsaw, Illinois, and adjacent parts of Iowa and Missouri would be most interesting and revealing. The confusing array of green secondary nickel minerals found in this region and at many other millerite localities in the Midwest offers a particular opportunity for research.

X-ray diffraction study of nickel minerals from the Hamilton-Warsaw area, Illinois.

(1) Gray's quarry, Hamilton, Illinois.

(A) Black needles, curved fibers, and "bottle-brush" inclusions in colorless massive calcite with quartz. The enclosed photograph (10X) shows the "bottle-brush" type of inclusion leached from a calcite cleavage rhomb. It is obviously similar to the polydymite found by Mr. Robert Francis.



"Violarite" and millerite (10X) from Gray's quarry, Hamilton, Illinois.

An x-ray pattern of the residue insoluble in HCl shows quartz, millerite, and violarite.

(B) Mass of thickly intergrown, dull, black fibers in a small vug in the above specimen.

The x-ray pattern shows violarite and minor retgersite. Under a petrographic microscope the violarite fibers appear very rough or corroded. The retgersite occurs in crevices and pits on the surface of the fibers.

(2) Road cut north of Warsaw, Illinois.

Grayish-brassy "bottle-brush" inclusions in rhombic calcite crystals.

An x-ray pattern of the residue insoluble in HCl shows millerite and violarite.

(3) Exact locality unknown, Hamilton-Warsaw area, Illinois.

Mass of intergrown, fine, brassy needles from a vug. The x-ray pattern shows millerite and minor violarite.

(4) Exact locality unknown, Hamilton-Warsaw area, Illinois.

Dark gray needles, curved fibers, and some "bottle-brush" inclusions in colorless to yellow calcite cleavage rhombs.

An x-ray pattern of the residue insoluble in HCl shows violarite and vaesite."

Four questions arise from the observations of Gricius and those of Heyl, *et al* and Sterling, *et al* as related by him. (1) Is the mineral these authors refer to as violarite actually polydymite? (2) How much iron may polydymite contain before it should be called violarite? (3) Does a continuous series exist between polydymite and violarite? (4) Is violarite (or polydymite) replacing millerite, or is it simply growing upon it?

Polydymite or Violarite?

There is no question that the specimens noted in the *Mineralogical Record* are polydymite. Semi-quantitative spectrographic analysis revealed only a trace of iron. The iron content of ideal violarite is 18.52 percent which is sufficient to register a strong response on analysis. Gricius based his identification of the mineral on its x-ray diffraction pattern, the violet color of its polished surface, and a positive reaction to a *qualitative* chemical test for iron. Heyl, *et al* state "violarite is identified by a diagnostic x-ray pattern, and in polished sections by a light violet-gray color." No analytical work was reported by Sterling, *et al.*

Contrary to the opinion of Heyl, *et al,* the x-ray pattern of violarite is not "diagnostic." It is, in fact, indistinguishable from the pattern of polydymite as revealed by a comparison of the following powder data from the ASTM Powder Diffraction File:

Violarite (ASTM Card 11-95)
Sudbury, Ontario

d	*I*
5.47	20
3.35	30
2.85	100
2.36	50
1.931	20
1.820	60
1.674	80
1.602	30
1.445	20
1.365	20
1.261	10
1.233	30
1.183	40
1.115	40
1.094	30
1.059	50

Polydymite (ASTM Card 8-106)
Siegen, Germany

d	*I*
5.50	20
3.34	90
2.85	90
2.36	90
1.941	30
1.820	90
1.674	100
1.600	10
1.444	50
1.369	60
1.269	30
1.232	80
1.185	70
1.117	10
1.095	70
1.055	60

Apparent important differences in intensities for corresponding lines may be more imagined that real as intensities for both patterns were by visual estimate. The differences in line positions are no greater than they would be from two readings of the same pattern.

It is not known how much iron must be present in polydymite in order to give a violet shade to its color in reflected light. However, on the basis of existing data it seems hazardous to assume that a polydymite with only a few percent of iron could *not* appear violet-gray.

Gricius did not specify the type of qualitative test employed but certainly a few percent of iron should be enough to give a positive reaction. While small amounts of iron are known to occur in millerite, large amounts are not. One would not expect a mineral that is thought to replace millerite to experience a major increase in iron relative to nickel.

This brings us to the matter of nomenclature and the possible existence of a complete series between polydymite and violarite. The analyses reported in *Dana's System of Mineralogy* (7th ed.) include three violarites containing 19.33, 17.01 and 15.47 percent iron, and one polydymite with 3.98 percent iron. X-ray fluorescence analysis of a specimen of polydymite replacing millerite (NMNH #121732, Smithsonian Inst.) from Pafuri, Native Trust, Transvaal, Union of South Africa, revealed nickel, cobalt and iron in the approximate ratio 16:4:1, again rather low in its iron content. As mentioned above polydymite from Gray's quarry contains only a *trace* of iron. Thus, of 6 available analyses, 3 are high in iron by about the same amount and 3 are very low.

Clearly there is a need for analytical work on polydymite-violarite to determine the limits of substitution, if any, of iron for nickel. If a continuous series does not exist, the name violarite is very meaningful. But if there is continuous substitution the name ferriferous polydymite would be more appropriate.

Pseudomorphs or Overgrowths?

I originally assumed that the Gray's quarry material consisted of hairlike *crystals* of polydymite. However, Heyl, *et al,* from observations of polished sections, referred to their material as violarite after millerite. Initially I observed no millerite in Gray's quarry specimens but reexamination confirmed its presence in long, hairlike, black-coated crystals. It may be distinguished from polydymite, even though coated black, because its surfaces are smooth and highly reflective. The polydymite "hairs" are rough-surfaced and not very reflective (Fig. 2). A fragment of what appeared to be a single crystal of polydymite was x-rayed in a powder camera. The pattern proved to be typical of a polycrystalline sample rather than one a single crystal would have produced. This evidence suggests that the polydymite is indeed pseudomorphous, probably after millerite, thus accounting for the acicular habit—one not expected of such isometric minerals.

At Gray's quarry, and elsewhere (Gricius), the pseudomorphs are completely enclosed in transparent calcite. Obviously then the replacement must have occurred before calcite crystals grew over them. This relationship is in conflict with the sequence of mineralization outlined by Heyl, *et al* (The geology of the upper Mississippi Valley zinc-lead district, U.S.G.S. Prof. Paper 309, 1959), who attribute the millerite to "violarite" alteration to a late supergene process but consider all calcite and quartz to be primary hypogene in origin. Quoting from pp. 89-90 "Calcite is one of the last primary vein minerals to be deposited. . . . Throughout the district calcite exhibits a regular sequence of deposition from early, cloudy calcite, commonly pink, gray, or yellow, to clear, colorless calcite in the final stages of deposition. Small inclusions of sulfides are present only in the early cloudy calcite."

Conclusion

It appears that much of the material heretofore called violarite may actually be polydymite. Hey, in *Chemical Index of Minerals,* stated "much so-called polydymite is really violarite." He was, of course, referring especially to the better-known massive sulfides of hydrothermal vein type deposits. Only a detailed study of all available specimens, with suitable analyses, will demonstrate which of these statements is more accurate. That the mineral found in geode-like cavities with millerite and calcite throughout much of the

Eosphorite from Taquaral, Minas Gerais, Brazil. The spray is about 3/4 inch in diameter. Smithsonian Institution specimen. Photo by Joel E. Arem.

midwestern U.S. is polydymite or violarite replacing millerite is seemingly indisputable. The great abundance of polydymite (violarite?) in such occurrences indicates that polydymite (or violarite) is not as rare as indicated in *Dana's System of Mineralogy* (7th ed.).

The statement by Gricius that a detailed investigation of these minerals and associated minerals could prove most interesting is heartily endorsed. Perhaps this discussion will stimulate interest in further studies of these minerals.

COLOR OF AMAZONITES

G. S. Plyusnin, in *Zap. Vses. Min. Obshch.*, **98**, 3-17, 1969 (in Russian), has presented a new explanation for the color of amazonites. He could find no correlation between the color and the content of any of the common chromophores, Rb, Cu or Mn. A gradual weight loss on heating to 1000° ruled out organic material as a cause. Fe^{+2} was also eliminated as a cause since heating produced no change in the magnetic properties of the mineral. Heating Fe^{+2} would be expected to cause its oxidation to Fe^{+3}, thereby changing magnetic susceptibility, and this was not observed. The color of amazonite was, however, shown to be linked to lead content. Pb^{+2} replaces $2K^{+}$ creating strains within the structure which produce shifts in color absorbtion bands. In this case the absorbtion band is displaced toward the short wave region, thus moving the maximum reflection from the red to the green-blue regions; thus amazonite appears green.

MARTINI-GLASS CRYSTALS

A recent issue of ***Earth and Planetary Science Letters*** (Vol. 10, 1971) carried an article entitled "A Martini-glass Clinopyroxene from the Moon," by A. E. Bence and J. J. Papike, pages 245-251. If the title were not enough to attract the reader's interest, the drawings in Fig. 1 (see cut) certainly are. Portions of the description of the crystals follow:

"Vugs containing euhedral crystals occur on the surface of Apollo 11 type B igneous rocks. Stubby, prismatic, pink clinopyroxene crystals up to 2 mm in length were noted in vugs on the surface of rock 10050. One of these clinopyroxene crystals was obtained for detailed x-ray, optical and electron microprobe examination. . . . Petrographic examination revealed that the clinopyroxene contained a colorless core, funnel-shaped near one end, with a long, tabular stem extending the length of the crystal. The remainder of the crystal (approximately 90%) is dark pink. The clear funnel-shaped core and the dark outer rim give the crystal an unusual sector-zoned structure, having the appearance of a martini-glass, when viewed along the *b* crystallographic axis. This structure is quite different from the hourglass structures reported for Apollo 11 clinopyroxenes. . . . Electron microprobe profiles normal to the *c* crystallographic axis show that the crystal is composed of a core of low-Ca clinopyroxene (pigeonite) sheathed by a rim of high-Ca clinopyroxene (sub-calcic augite). Sharp compositional discontinuities occur at the epitaxial surface. The core is depleted in Ca, Ti and Al and is enriched in Fe, Mg and Si relative to the rim." ■

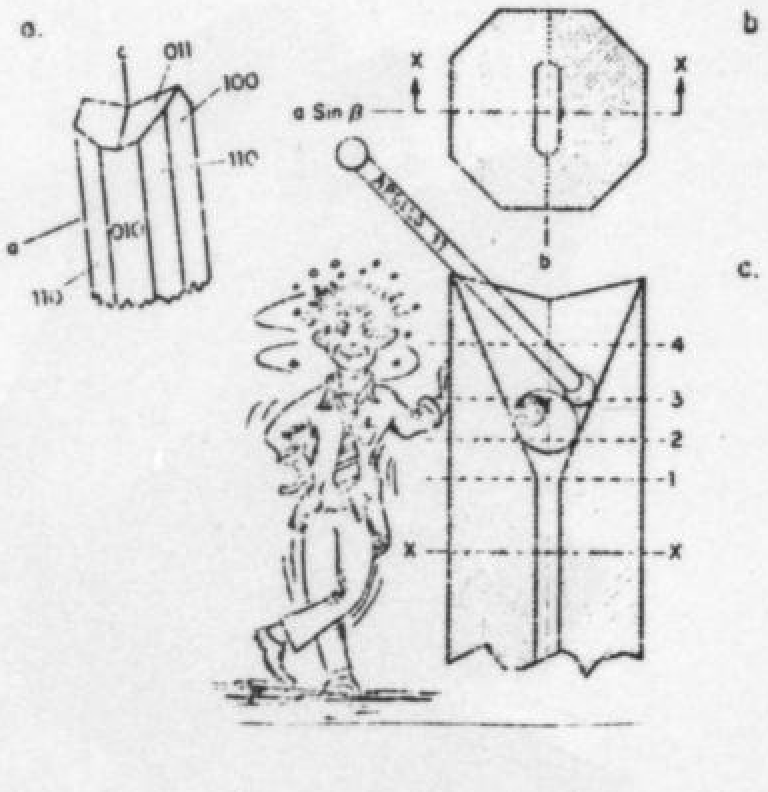


Fig. 1(a) Sketch of pyroxene crystal from vug in Apollo 11 rock 10050. (b) Schematic section normal to the **c**-crystallographic axis of crystal of fig. 1(a) showing the relationships of the core and the sheath. (c) Schematic section normal to **b** with the locations of the successive electron microprobe profiles.

(Continued from page 52)

Sheppard and Gude should help. Siliceous alkali members (erionites) occur in rhyolitic tuffs; whereas aluminous alkaline earth-rich members (offretites) occur in mafic lavas.

(Q) I recently visited the Bancroft, Ontario area and had the opportunity to collect tremolite (?) at Wilberforce. Collecting was good, as the weather was clear. There seems to be a controversy concerning the name, though. Local residents (Bancroft) call the material *edenite* which is an aluminous amphibole, and others have called it tremolite. I am aware that some authorities include nonaluminous tremolite and actinolite in the hornblende group, and that considerable research remains to be done on the amphiboles. Could you clear this up?

Joseph Polityka

(A) *In answer to the first part of your question, all that we have seen from Wilberforce has been labelled tremolite and we see no reason to doubt the correctness of these labels. Edenite is described as an iron-free variety of hornblende and thus must be aluminous. Tremolite-actinolite is aluminum free. The amphiboles have been rather extensively studied and the considerable research devoted to them is nicely summarized in* Amphiboles, *by W. G. Ernst, Springer-Verlag, New York Inc., N.Y., 1968.* ■

(continued from page 51)

surfaces are completely unacceptable but there will be no "uniform rules" requiring the loss of 5 points for such a horror. The beauty of the label will not be considered. However, the manner in which the specimen is presented and positioned may very much influence the judges so showmanship will play a role, but in a subtle way.

It is not suggested that this form of competition should completely replace the existing form. It may serve only as a complement to the other but one which I believe, will generate great interest among collectors in the results. So, you club officers and federation officials, what do you think? Are you willing to try a bold new approach? You don't stand to lose much by giving this idea a trial run. Isn't it time for something new? At least there will not be pages of cumbersome rules to struggle with and labor over. ■

John S. White, Jr.

The State of the Art: X-Ray Crystallography (I-The Basics)

Joel E. Arem
Smithsonian Institution
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This is the first of a series of invited papers called "The State of the Art—the tools and techniques of modern mineralogy." The series will explore aspects of some of the most sophisticated instruments in operation today—how they are used and what information they yield. It is hoped that these papers will enable the interested reader to more profitably examine technical literature in each of the areas discussed and, more important, to gain some appreciation of the research aims in contemporary mineralogy and the problems that are being faced today. For the collector this appreciation will undoubtedly cast new light on the value of mineral specimens as natural objects of great fascination, whether they be museum display pieces or dràb, unimpressive-looking lumps. For the professional, an overview of major areas of research may give insight as to how better to inform the specimen-gatherers, the collectors, of what constitutes material of high research value. The merging of these outlooks is sure to be profitable and enjoyable, and of benefit to the science of mineralogy.

The science of crystallography is very old. Its prehistoric beginnings are found in the very first use of natural materials for tools and weapons. Primitive man did not know that flint breaks with conchoidal fracture, but merely that flint is sharp when broken and makes good arrowheads. Rocks are made of mineral crystals. Metals are crystalline. Our present civilization is materials-oriented, and thus is maintained on the strength of our knowledge of crystals and their properties.

Crystallography was largely empirical until the 18th century, when casual observation began to give way to careful experiment and correlation of data. But for 200 years thereafter, all that could be learned about crystals had to be deduced from their external features, growth characteristics and physical and chemical properties. The description of a crystal was primarily morphological—an elaborate summary of the angular relationships among its plane faces. This limitation to outward appearances was smashed irrevocably in 1912.

In that year Max von Laue, assisted by Walter Friedrich and Paul Knipping, showed that crystals could act as three-dimensional diffraction gratings for X-rays (the meaning of this will be clarified later in this article). In a single experiment, two long-standing problems were solved: the question as to the true nature of X-rays, and the centuries-old debate regarding the constitution of solid matter.

Firstly, X-rays were shown to be a wave-like form of energy, similar to visible light but with much shorter wavelength. Second, crystals were, for the first time, proved to be made of minute particles—the same "uncuttable" units of matter named "atoms" by the ancient Greeks—arranged in regular arrays.

Crystallographic studies no longer had to be confined to external crystal forms. It was now possible to examine the internal arrangement, in crystals, of the very building blocks of matter—the atoms of the various chemical elements—and thereby deduce why crystals differ from one another in shape and properties. The full impact on physical science of the Laue experiment cannot yet be evaluated. It certainly ranks as one of the greatest scientific achievements in human history.

Modern crystallography has, in X-rays, the advantage of a truly amazing tool. With these once-mysterious rays scientists can peer into a world beyond the range of the most powerful microscopes, a world populated by atoms and molecules and structured by the rigid architecture of the crystalline lattice. We can, through elaborate inference, plot in detail the structural arrangement in minerals, metals, and even liquids and biological materials. Yet, unfortunately, most introductory academic courses in mineralogy defer discussion of the crystallographic knowledge revealed by X-rays. Instead, these curricula revert to the concepts of mineralogy that existed before 1900 and begin with a study of crystal forms and physical properties, such as hardness, luster and streak. The utter confusion caused by a sudden immersion in a "sea" of Miller indices, morphological form names and assorted Latinized nightmares usually "turns off" the hapless student. Only the most persevering of enthusiasts finally discover the fact that the internal structure of a crystal is actually a cause of external forms and properties, as well as a clue toward understanding aspects of crystal chemistry and growth. It is tragic that this revelation is reached so late, if at all.

Parts I, II and III will attempt to clarify the general aspects of crystal structure and symmetry, crystal morphology, X-rays and their interaction with matter, X-ray single crystal techniques and X-ray powder techniques. Crystallography is a subject that can entail the profoundest complexity, yet can be delightfully simple and logical if presented in the proper sequence of relevant concepts. This material constitutes the first part of *State of the Art—X-ray Crystallography.*

Crystals and Atoms

We have come a long way since the days of Democritus, the Greek scholar (470-400 B.C.) who propounded the idea that all matter is made up of tiny particles, far too small to be seen, called *atoms*. The world atom derives from Greek words meaning *uncuttable* (though in the nuclear age this connotation is no longer valid.) To explain how objects can maintain their shape through made of tiny spheres, Democritus had to maintain that atoms tend to stick together. Indeed, a modern, concise summary of inorganic chemical theory might be: atoms tend to stick together. Our knowledge is, however, much more refined. Atoms tend to stick together in specific ways.

Various types of forces, called chemical bonds, hold atoms together. Four general types of bonds are generally distinguished. The *metallic bond* is found characteristically in metals and accounts for their unique properites: metallic luster, electrical conductivity, malleability, ductility and alloying capabilities. A very weak type of bond, known as the *van der Waals bond,* occurs between molecules that are electrically *neutral.* This state is much like that of an octopus with a fish in every tentacle and no arms free to grab any more. Such bonds, caused by electron motion within atoms and molecules, are virtually the only forces acting, for example, between sheets of the mica minerals. These bonds are so easily broken that one can cleave a sheet of mica further and further, to layers of microscopic thickness (theoretically, in fact, to molecular thickness).

Two other types of bonds are characteristically found in most minerals. These involve interatomic transfer of electrons, the infinitessimally small, negatively charged particles that spin around the positive nucleus of every atom. Electrons moving in a wire are familiar to us as electricity.

When electrons are shared between atoms, they are held incompletely by any of the individual atoms involved. The result is a kind of tug-of-war. Like a human -sized tug-of-war, the rope (in this case, the atomic bond) remains rigid, and the participants cannot move away from or closer to one another. This type of bond, called the *covalent bond,* is indeed rigid, directional and very strong. Covalent bonds account for the superhardness of diamond and the high melting points of many silicates.

If the electrons actually forsake one atom for another, but the atoms themselves do not move apart, an *ionic bond* is formed. *Ions* are atoms that have acquired electronic charge, either positive (due to a deficiency of electrons) or negative (due to an electron surplus). Ionic bonds are weak enough to be torn apart by the action of water molecules, which are surprisingly good at this sort of behavior. That explains why ionic compounds, such as the familiar salts halite and chalcanthite, dissolve in water. Solution is the process of brute separation of atoms, ions or molecules present in a crystal, due to the pulling power of a solvent.

Bonds may be directional, and where there is directionality there can be order. Order is the clue to crystal symmetry and structure. To appreciate the fact that atoms and molecules (clusters of atoms) arrange themselves at all in crystalline materials, one must recognize the existence of chemical bonds acting in specific directions in space. This recognition also allows one to understand what actually takes place when a crystal grows.

Crystal Growth

Big crystals from little crystals grow. The most familiar type of crystal growth occurs when molten material solidifies. An example of this process is the formation of frost on a window pane. The patterns that appear are made up of ice crystals that result from the solidification of molten ice (the substance we call water). This is an example of *monocomponent* crystallization—the crystals are made of the same chemical substance as the liquid from which they formed. *Polycomponent* crystallization takes place when crystals of a substance form within another substance that has a different bulk chemical composition from the first. A familiar example is rock candy—sugar crystals grown from a concentrated solution of sugar in water. The solution, a liquid, consists of 2 substances, while the crystals that form within it are of a single substance—sugar.

In both types of crystallization a change occurs in the environment, such as a drop in temperature, that favors the existence of a solid rather than a liquid (melt) or solution. Thus, water turns to ice below 0° C., and lowering temperatures may cause salts to precipitate from their solutions.

In a solution or pure liquid, atoms may be floating about either as separate entities, tightly surrounded by water molecules, or as atomic groups that might be called *molecular clusters.* In either case, crystallization results in a furious rush of atoms trying to join together in a specific pattern—that of the crystallizing solid. But the binding forces that exist between atoms dictate that the atoms can join together only in certain ways.

While it is true that the sizes of various types of atoms are important, because the packing scheme of a particular crystal may not contain spaces for atoms too large or too small, the bonding forces are also critical. Crystals usually tend to grow in directions corresponding to directions of strong bonding. This is intuitively logical, since a strong bond is a likely "magnet" for an atom about to leave the liquid and join the growing crystal. Atoms

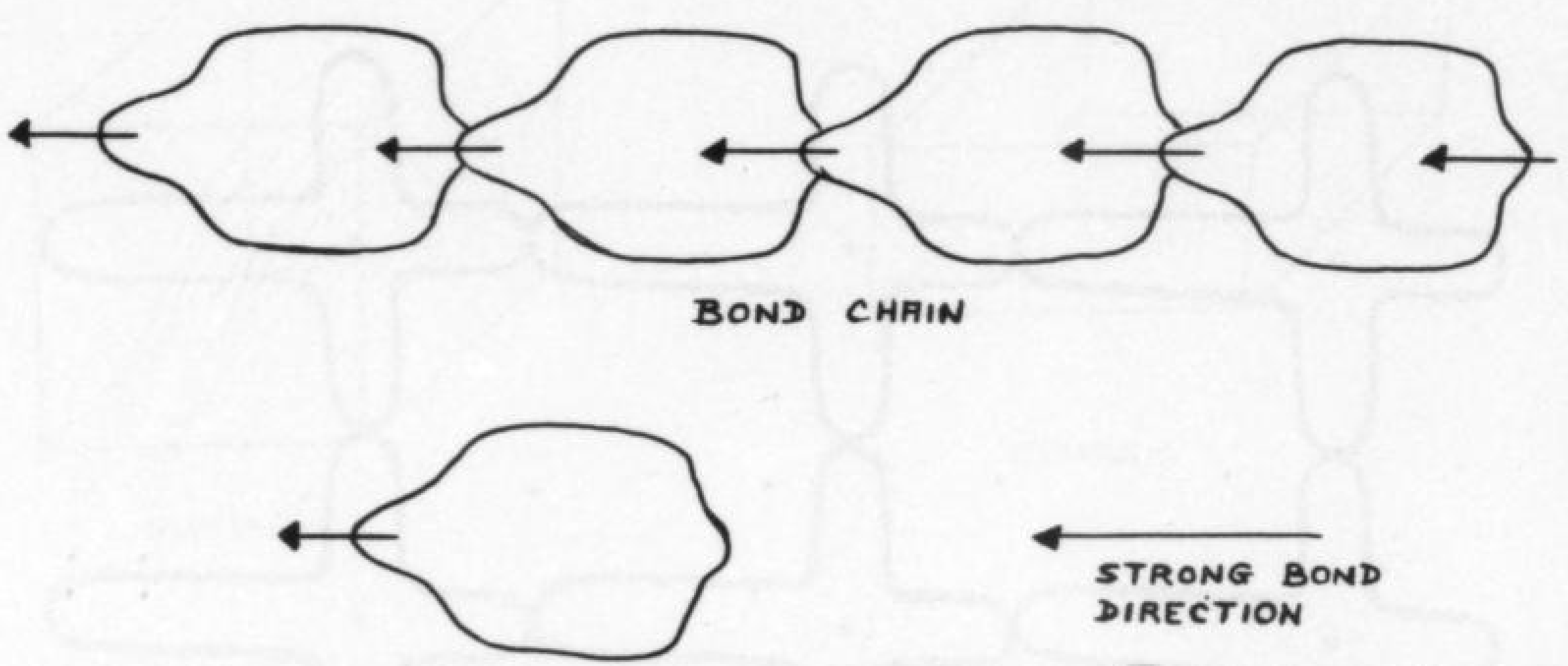


Fig. 1. Atomic groups form by attachment to an existing nucleus, preferentially along "bond chains." The strong bond direction is one of rapid crystal growth.

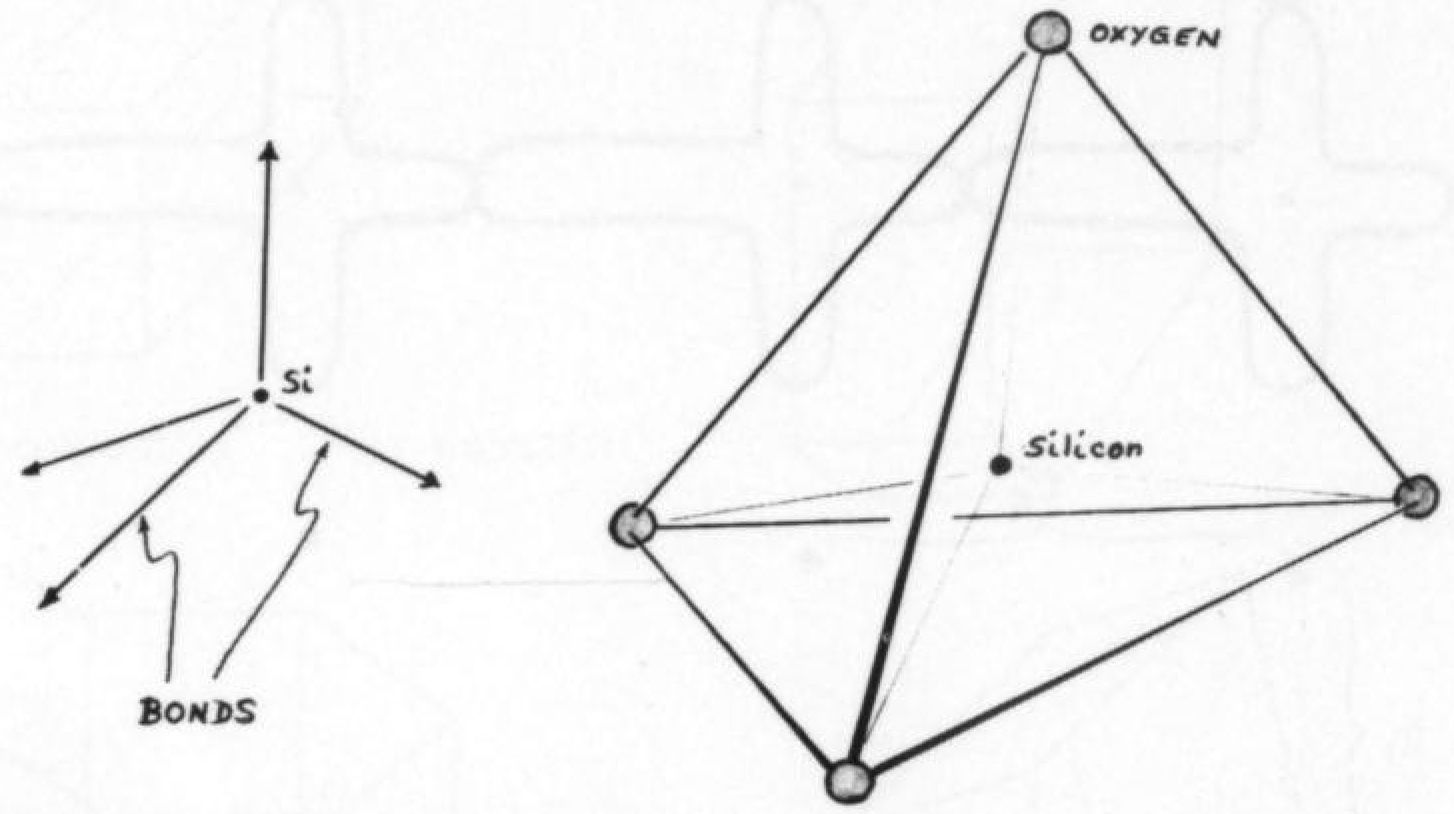


Fig. 2. Tetrahedrally-arranged bonds from silicon to oxygen atoms result in the SiO_4 tetrahedron, the building block of silicates.

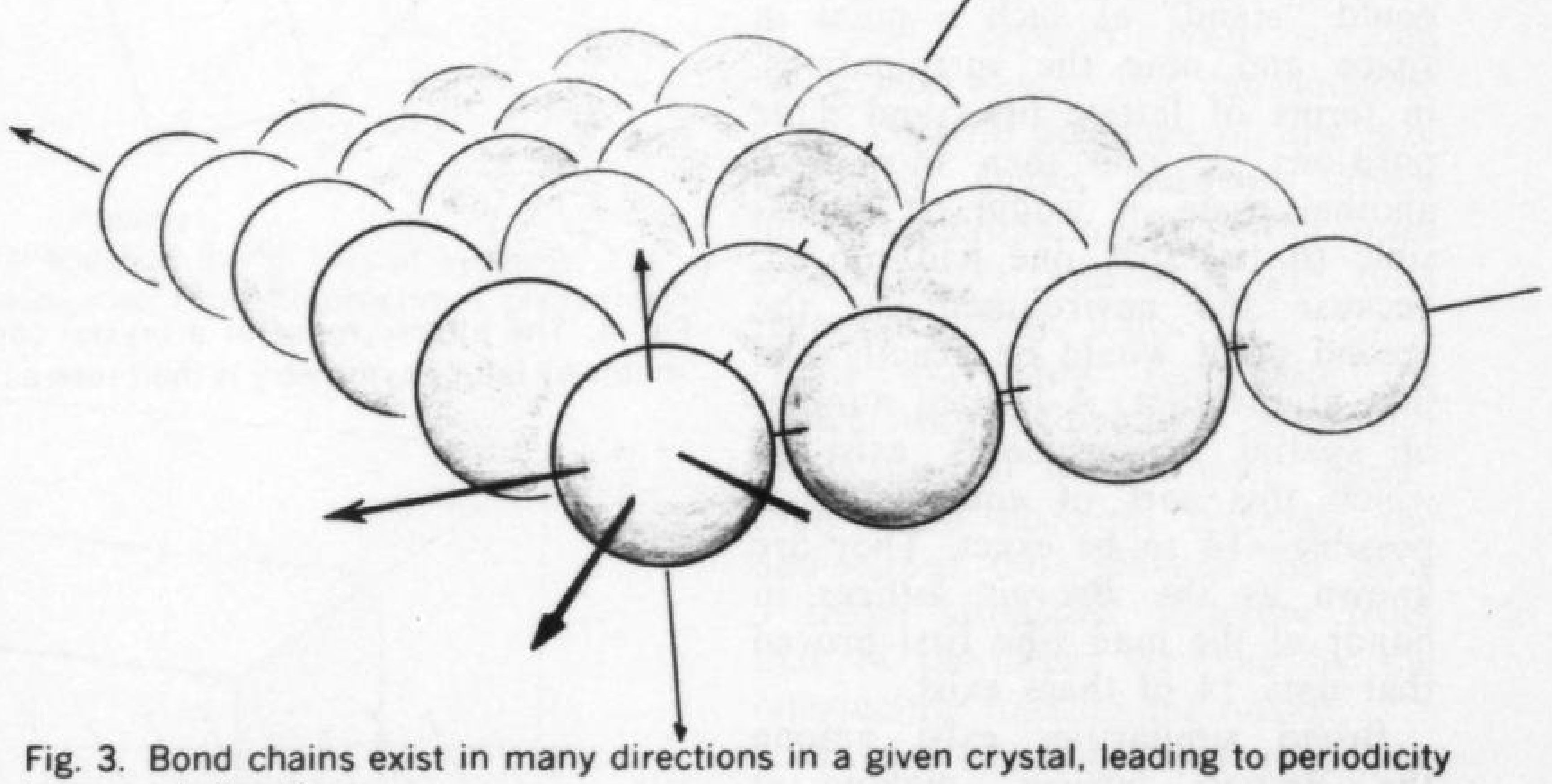


Fig. 3. Bond chains exist in many directions in a given crystal, leading to periodicity in several directions.

then continue to pile onto the crystal, forming a "bond chain," like pieces of a jigsaw puzzle fitting into place one by one (Fig. 1).

The bond directions and strengths are largely a function of the shapes and chemical makeup of molecular units. For example, an atom of silicon (Si) tends to form four bonds, all very strong, to four oxygen (0) atoms. These bonds are spaced equally from one another. In three dimensions, this means that they extend toward the corners of a tetrahedron (Fig. 2) and the result is the SiO_4 tetrahedron. These Si-O bonds are so strong that the tetrahedron remains as a molecular entity, even at temperatures where most minerals are in a molten state. When such a melt cools, the tetrahedra begin to link up in the various arrangements characteristic of silicate minerals.

Bond directionality and atom sizes set severe restrictions on the ways atoms and molecules can pack together to form crystals. Obviously, a crystalline material cannot exist full of large open spaces caused by misalignment of layers of atoms. Nature abhors such cavities and the crystal would either be unstable, and redissolve, or adjust to close up the spaces. Individual tiny blocks of uniform, crystalline material may, however, be misaligned in various types of crystals, a situation known as *mosaicity*.

It is also noteworthy, as seen in Fig. 1, that the molecules settling into place along a bond chain are of a specific type and orientation. There is a kind of monotony along this direction in the crystal. One encounters the same atoms and the same shape of molecular unit over and over gain, one after another, ***ad infinitum***. The same type of regularity would prevail in all directions through the crystal, since many types of bond chains can exist (Fig. 3). This repetition in various directions, with geometrically-shaped units paced together to fill space and leave no holes, is the most characteristic feature of crystals. The term solid is, by definition, synonymous with ***crystalline***. All solids are crystals. Glasses are rigid, but not solid, because they do not possess long range order, or periodicity. Consequently, glasses have no fixed melting point, but rather soften gradually and eventually begin to flow. The melting point of a crystal signals the breaking of bonds, and consequent collapse of the structure. This occurs at a specific temperature. Periodicity is the distinguishing feature of crystals, as opposed to liquids and gases.

We might imagine a dot placed at the center of every repeating unit in a crystal. We then find that the spacing between the dots is constant (as might be expected) in specific directions in the crystal, since the units themselves are of constant size and spacing. But the dots can indicate the periodicity of the crystal, in a schematic way, just as well as the odd shaped units. (Fig. 4) It is sometimes more convenient to forget about the shapes of the units themselves and simply show the periodicity of the crystal as a pattern of regularly spaced dots. If we connect the dots by lines, the result (in the 2 dimensions of a plane) is called a *net* (Fig. 5). In three dimensions, as in a series of nets placed one above another and connected by more lines, we have a *lattice*.

The lattice is an abstraction. A crystal is actually made up of atoms and molecules, held together by atomic bonds. It does not have lots of lines and dots buried somewhere inside it. The real crystal does not even know about lattices. The lattice is merely a shorthand, a notation (like a stick figure—people aren't really made of sticks) used to indicate the spatial repetition, or periodicity, of structural units in a crystal. In lattice notation, the distances between the centers of equivalent structural units are called *lattice translations* (Fig. 4). The lattice, because of the uniformity of such spacings, is said to have ***translational symmetry***.

The distinguishing feature of the lattice is that any lattice ***node*** (the intersection point of lattice lines) is exactly like any other node. One could "stand" at such a point in space and note the surroundings, in terms of lattice lines and node positions. If one then moved to another node, it would be impossible to tell that one had moved, because the environment at the second point would be exactly like that at the first. A limited number of spatial arrangements exist in which this sort of equivalence is possible—14 to be exact. They are known as the ***Bravais lattices*** in honor of the man who first proved that only 14 of them exist.

Broad similarities exist among the Bravais lattices, making it possible to group some of them together on the basis of such properties as lengths and intersection angles of lattice translation lines (i.e., lattice parameters. The resulting 6 groups are known as the crystal systems, as illustrated in Fig. 6.

The intersections of lattice lines outline "blocks" of specific shapes. A useful way of describing these blocks is by reference to a set of

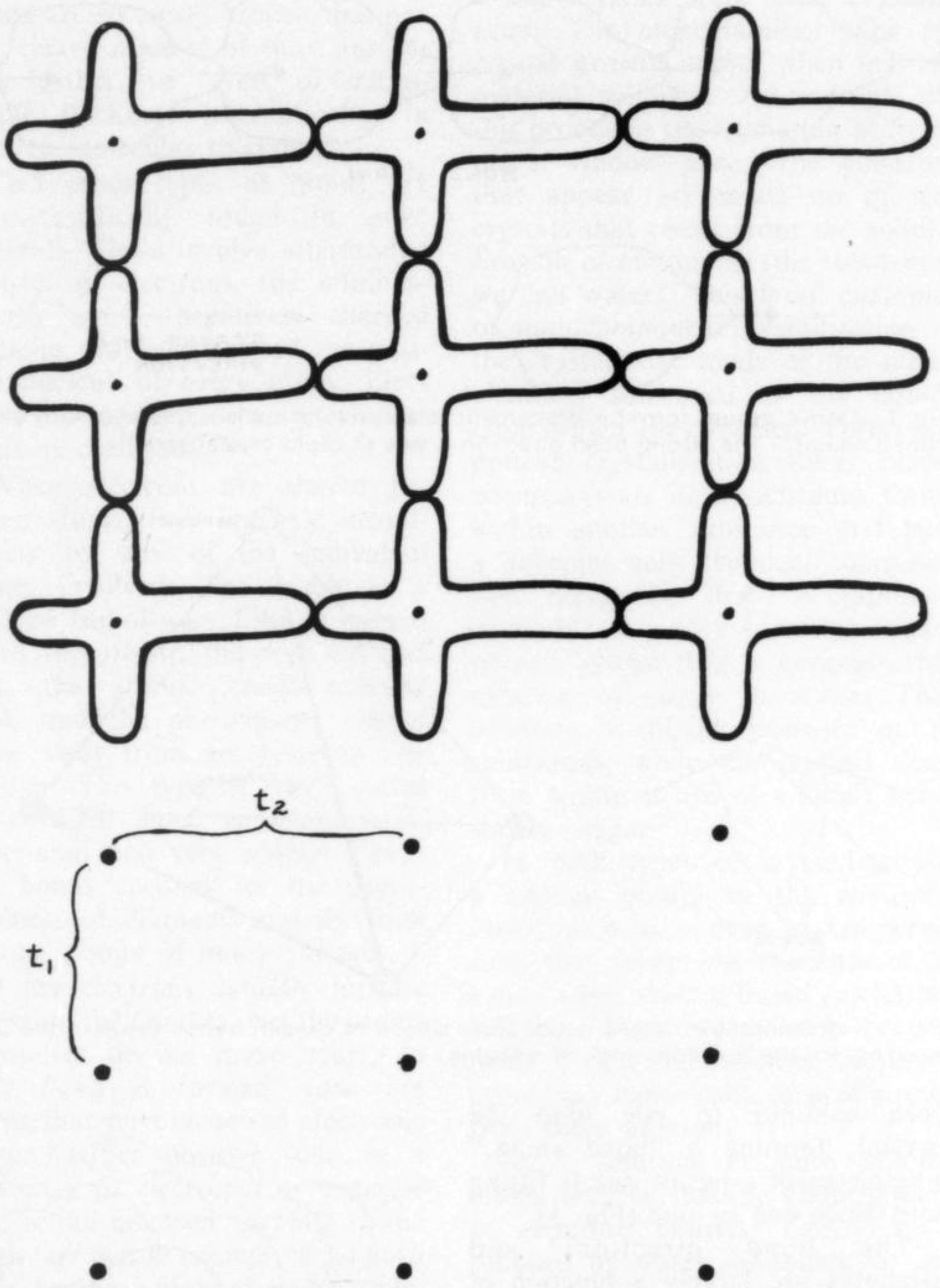


Fig. 4. The atomic motif of a crystal can be represented by a dot; the repetition of motifs by lattice symmetry is then seen as a regularly-spaced dot array.

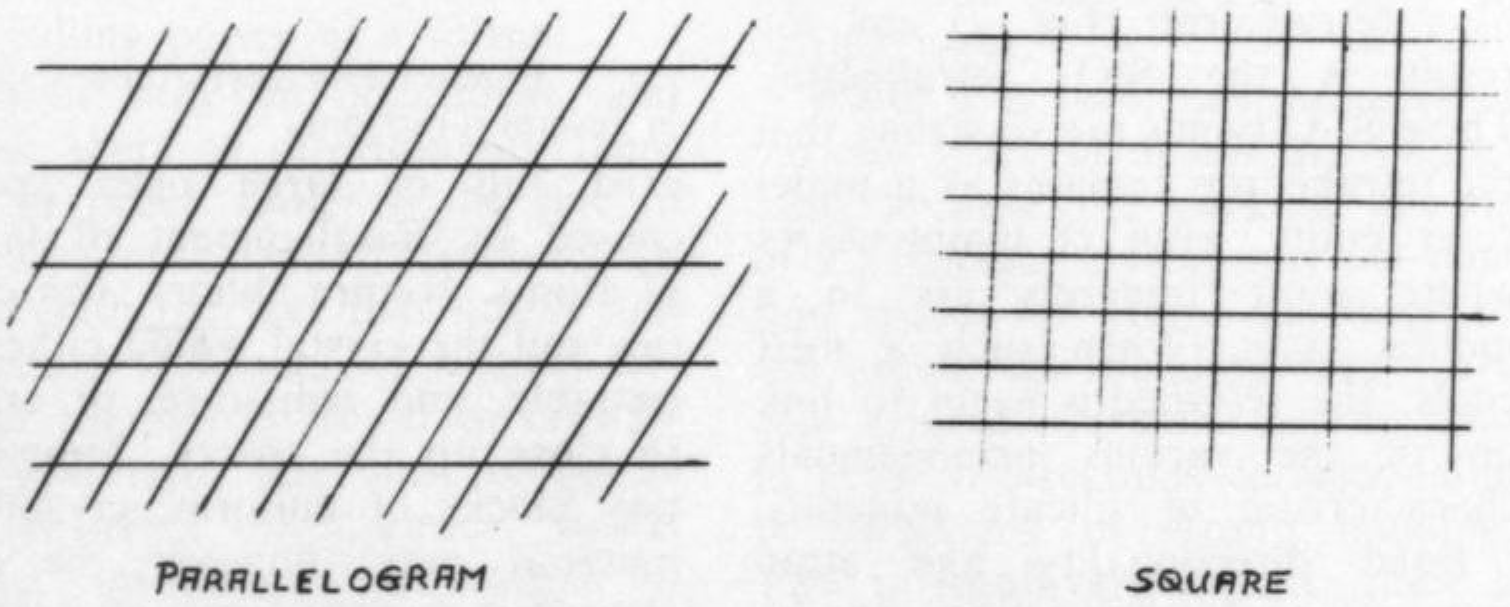


Fig. 5. Connecting the dots of lattice representations results, in 2 dimensions in nets. Two types of nets are shown.

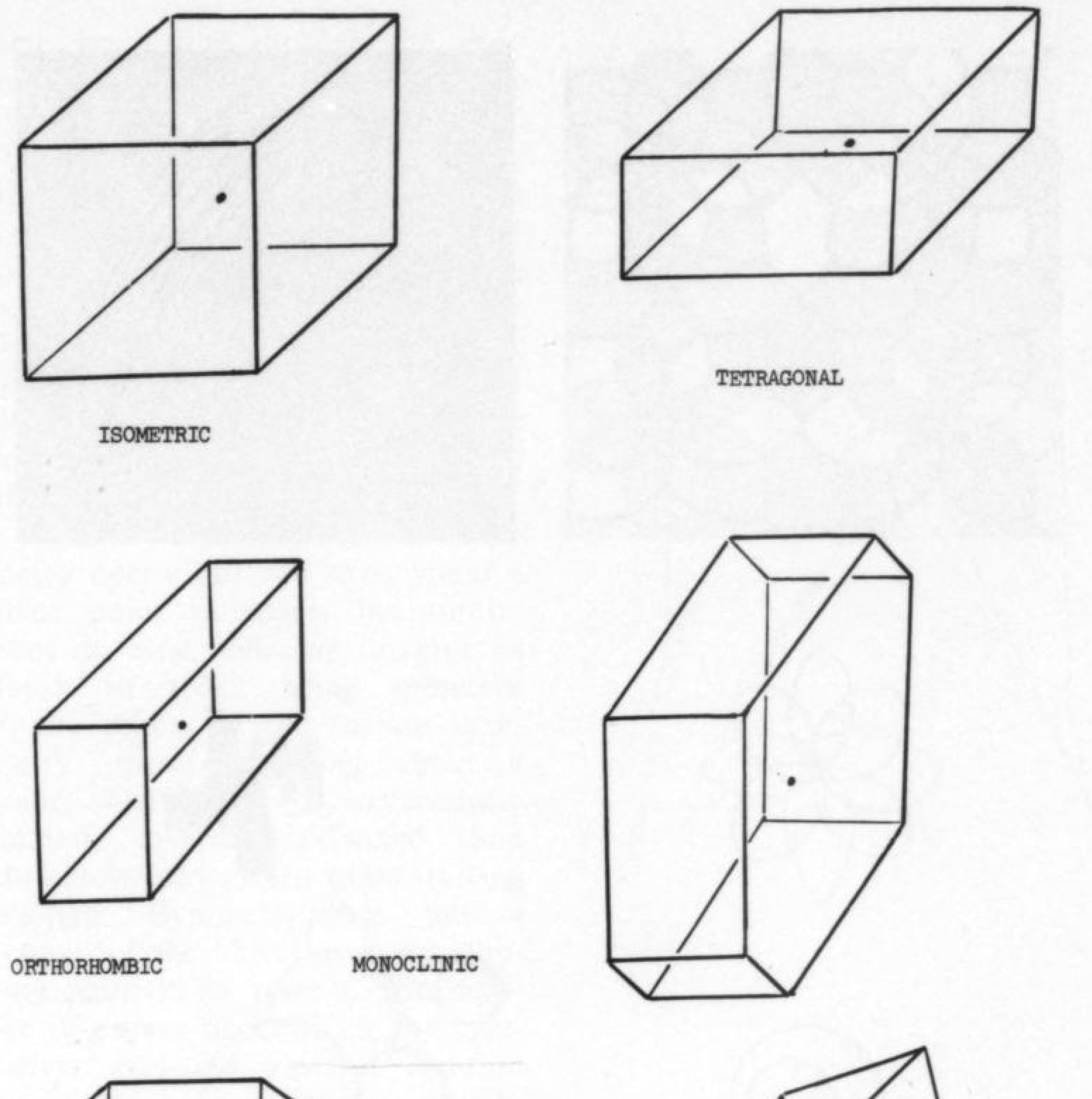


Fig. 6. Outline representations of the unit shapes of the 6 crystal systems. The 'rhombohedral system' is a division of the hexagonal, though sometimes presented as a seventh system.

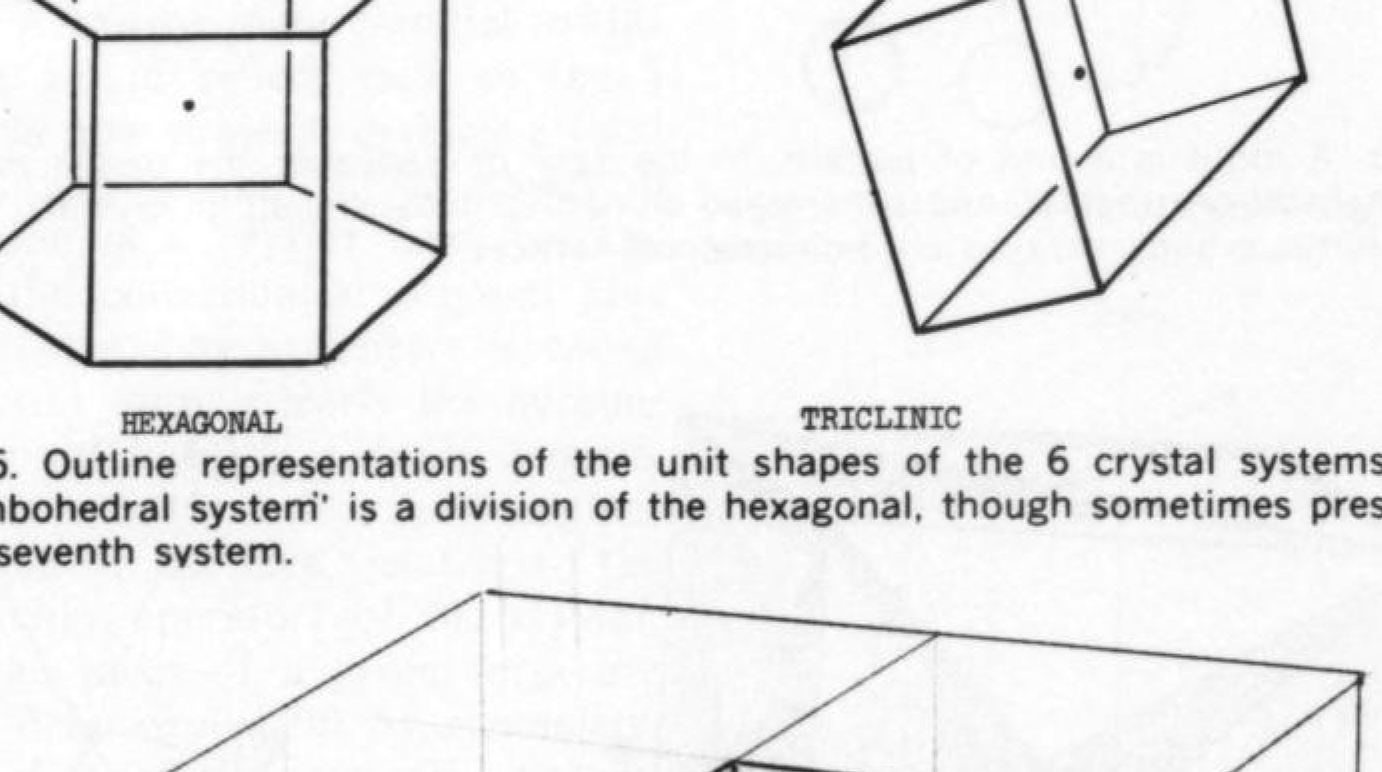


Fig. 7. The lattice can be thought of as outlining the edges of an array of "unit blocks," whose dimensions are those of unit size. In the orthorhombic system the block is shaped like a brick, where all edges meet at right angles($\alpha = \beta = \gamma = 90°$) and all sides (a, b, c) are of unequal length.

coordinate axes (imaginary lines that delineate 3-dimensional space). We can chop up space into blocks of any desired size and shape; but as long as the blocks are uniform they can all be described according to the lengths of their edges and the angles of intersection the edges make with one another. (Fig. 7)

In the case of a cube, for example, the simplest type of block to describe, edges of the block all meet in right angles (90°) and all edges have the same length. These edges can also be made to coincide with the reference axes. Thus we say that the cube can be described in terms of three *axes* of equal length that intersect at 90 degrees. The cube, and therefore this axial description, characterizes the *isometric system*. The *orthorhombic system*, typified by the common brick (Fig. 7) is characterized by three axes that meet at right angles, but all three axes are of different length. Similar terminology is used to describe the other crystal systems. Lattice terminology thus involves axes and distances (translations).

But we must also consider the atomic or molecular units present in "real" crystals. Now we can work backwards. We can imagine a lattice with spacings of any size and any angles between lattice lines, remembering that the lines connect dots and that the dots represent atomic units.

We may now repopulate the lattice with odd-shaped molecular units, instead of the dots. Something then becomes obvious: the odd-shaped units chosen can have a shape altogether different from that of the areas outlined by the intersecting lines of the lattice.

We are not concerned about the size of the units—this aspect of crystal structure is handled by lattice considerations. We are, however, concerned about their *shape*. The clue to describing shapes is found in the fact that we could "replace" each unit by a dot located at its center. The shape of the unit might therefore be described in terms of the arrangement of objects (atoms, in real crystals) about a point in space. In crystallographic terminology this

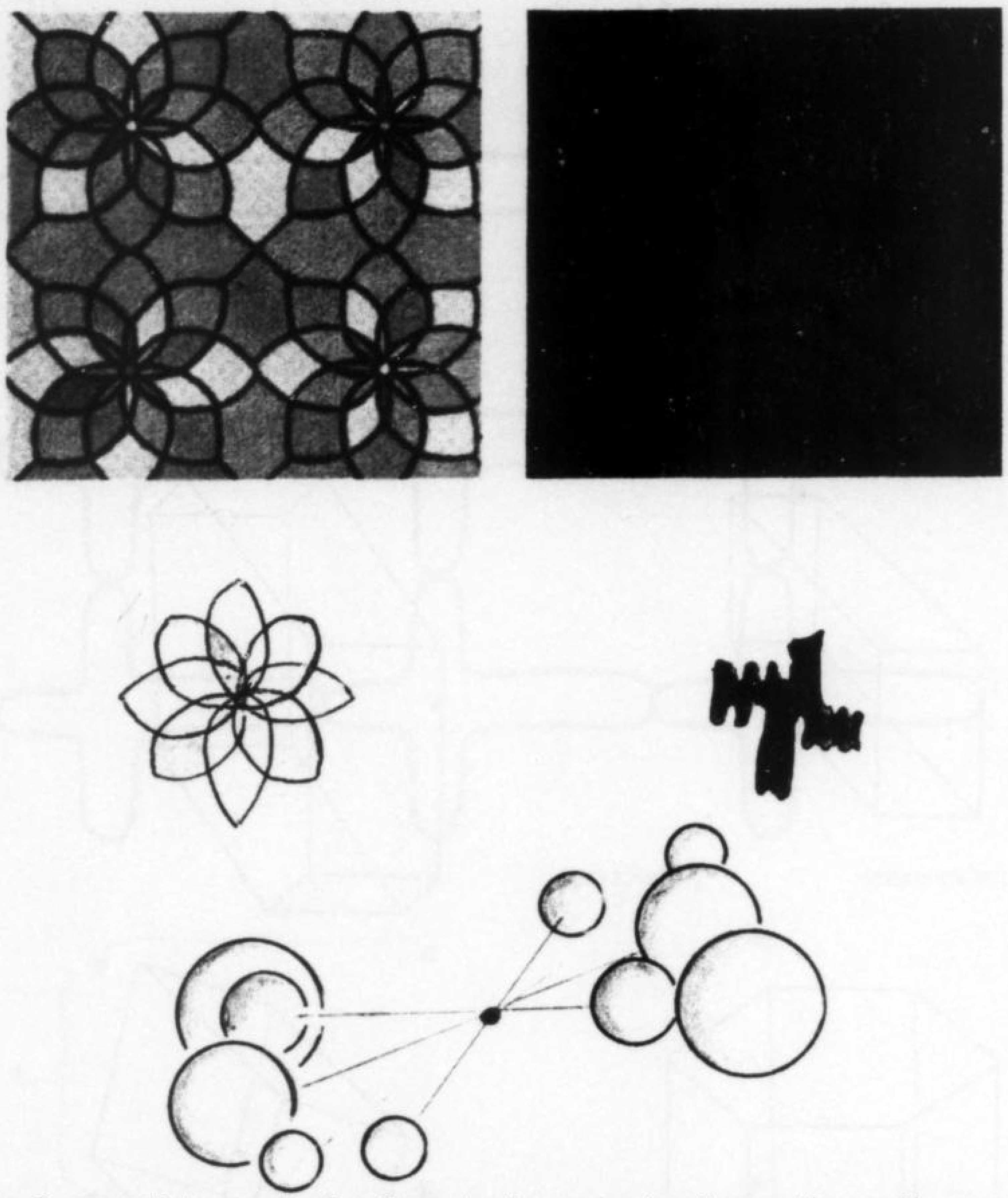


Fig. 8. A motif is a unit of pattern. In the case of wallpaper the motifs may be symmetrical or irregular, and are arrayed on nets (2-dimensional). In crystals, motifs are atomic groups, arrayed on 3-dimensional lattices.

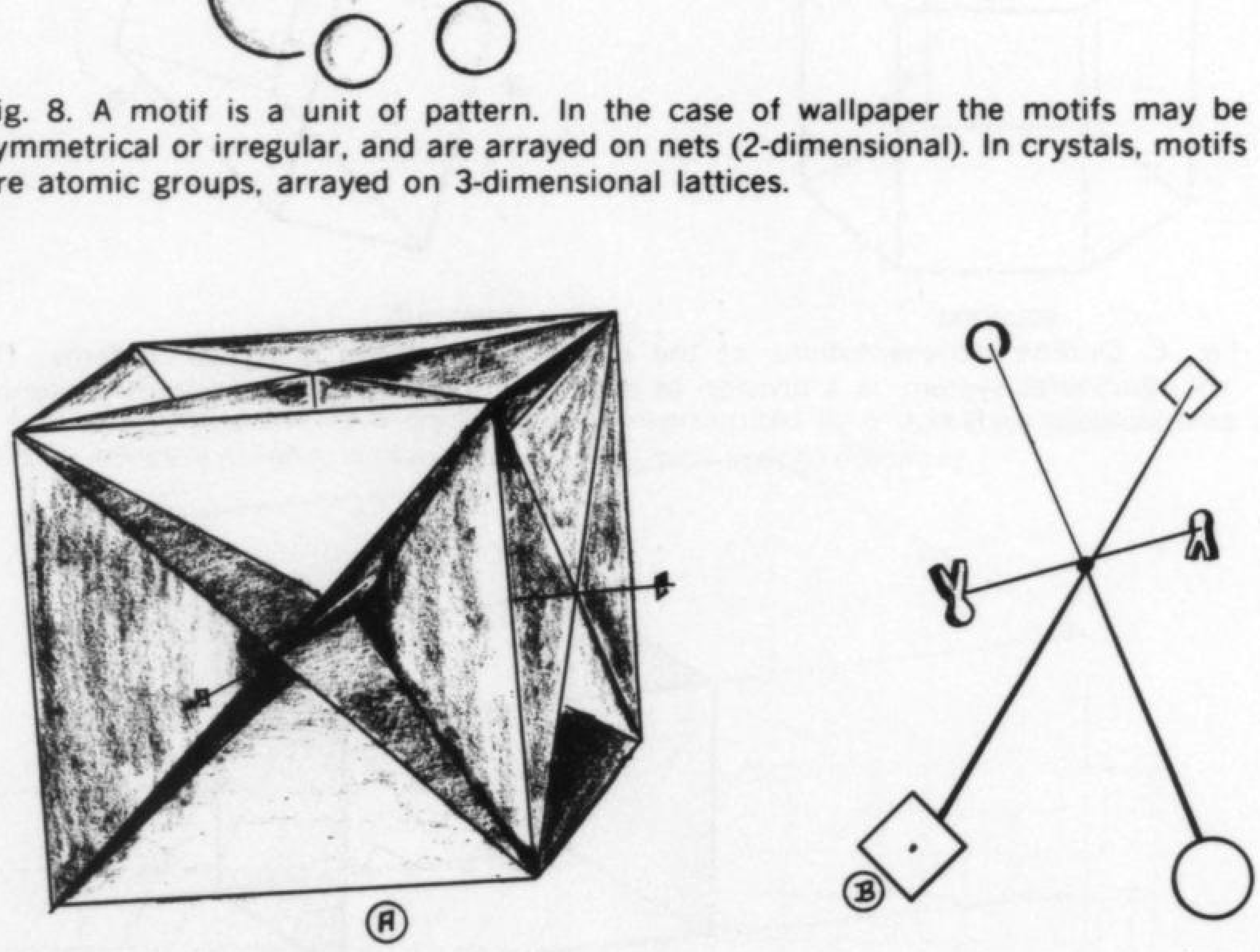


Fig. 9. The cube has many planes of symmetry (A), all intersecting in a point at the center. (B) shows the effects of a center of symmetry.

is known as *point symmetry,* and the collection of atoms distributed about this point is called a *motif* (Fig. 8).

Motif symmetry (point symmetry) does not involve translations (displacements) through space. This is the role of lattice symmetry. Instead, point symmetry involves rotations, reflections and inversions —all of these are *symmetry operations* that take place about a fixed point in space. Rotations refer to axes of rotation; since in real crystals, as mentioned earlier, symmetrically-distributed atoms must fill space to leave no "holes," only certain rotational periodicities are permissable. Specifically, crystallographic rotations can only involve 1-, 2-, 3-, 4-, and 6-fold axes. It is perhaps easiest to visualize the operation of a rotation axis by imagining a rotating cube oriented so that the observer sees a square. One axis (a 4-fold axis), about which the cube may turn, runs through the centers of the "top" and "bottom" cube faces.

Both of these faces lie perpendicular to the axis. An interesting feature of cube rotation is soon apparent —the operation leaves no evidence of itself. That is, the appearance of the cube after a rotation of 90 degrees about a 4-fold axis is identical with that at the start. You could not tell (except by marking the first cube face) that the cube had been rotated at all. The "sameness" of an object after rotation is what is meant by *rotational symmetry.* In the case of the cube rotating about a 4-fold axis, the repetition occurs 4 times in a complete revolution (4 × 90° = 360°).

Examination of a cube reveals that this object possesses three distinct 4-fold axes, and these all intersect at right angles. In addition, the cube contains axes of 3-fold symmetry (through opposite corners) and 2-fold symmetry (through the centers of opposite edges), as well as many planes of symmetry. A plane of symmetry usually refers to a *mirror* plane, since objects on opposite sides of such a plane appear to be mirror images of one another. Fig. 9a shows that many planes of symmetry can exist in the same object, but they all intersect (along with symmetry axes) at the object's center. This is why such symmetry is called point symmetry—all the repetitive features caused by symmetry operations seem to "revolve" about this central point where the symmetry *operators* (planes, axes) intersect. This point itself may also be a type of symmetry feature, called a *center of symmetry.* For every point on the surface of objects containing this feature there is a symmetrically identical point located diametrically opposite the first, on a line through the symmetry center and an equal distance away from the center point (Fig. 10). Another type of symmetry operator, called a *rotoreflection axis* involves normal rotation, followed by reflection across a plane perpendicular to the rotation axis (Fig. 10). A fifth operator, the *rotoinversion axis,* combines rotation plus inversion through the center of symmetry described above.

Various combinations of symmetry operations can exist about a given point in space, but limitations do exist. One can imagine an object in space being subjected to the effects of the various symmetry operators acting about a point. The object is successively rotated, inverted, reflected, and ultimately may return to its starting position. Symmetry has left a "copy" of the object at every stopping point in its travels. The number of copies depends on the symmetry: a 4-fold axis of rotation would leave three copies distributed, along with the original object, in a plane perpendicular to the axis. A mirror plane parallel to this plane would reflect each of the 4 objects now present, making a total of 8, and so on. If the object in question is a crystal face, we say that the collection of original plus copies made by symmetry is called a crystal *form*. Clearly the number of crystal faces in a form depends on symmetry and the original position of the face, relative to the symmetry operators of the crystal. All the faces of a given form are said to be *equivalent by symmetry*. One class of the isometric system, for example, has so much symmetry that a single face may be duplicated as many as 47 times! The resulting form is called the hexoctahedron (hex = 6, octa = 8, 6 × 8 = 48) and is occasionally observed on natural crystals. In fact, this *multiplicity* number (48) is so unique that the hexoctahedron can be identified by counting the number of similar-appearing faces on an isometric crystal. If there are 48 identical faces, the form can only be the hexoctahedron.

The presence of certain types of symmetry automatically implies the existence of other operations.

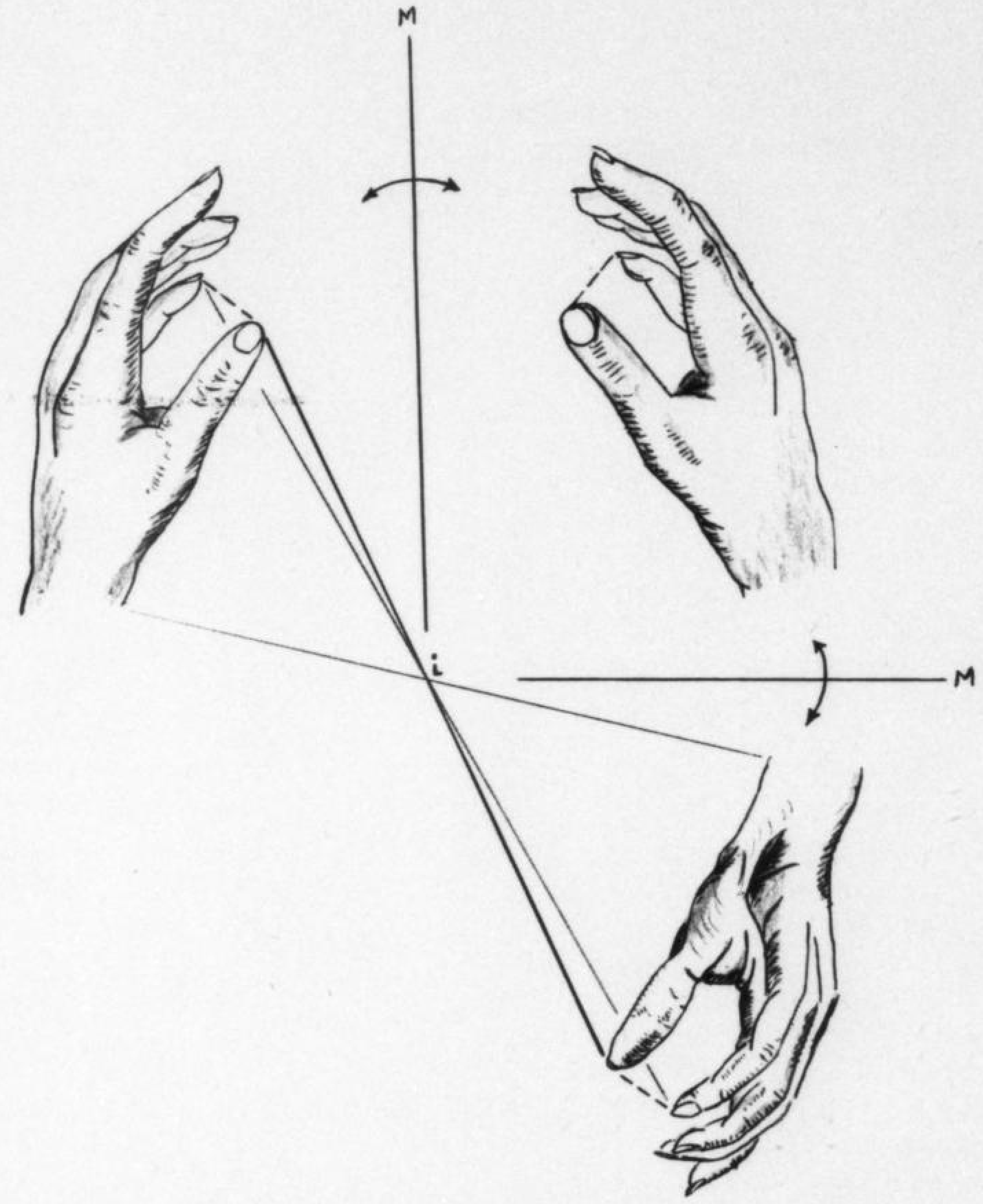


Fig. 10. The effects of combining reflections and inversion about a point.

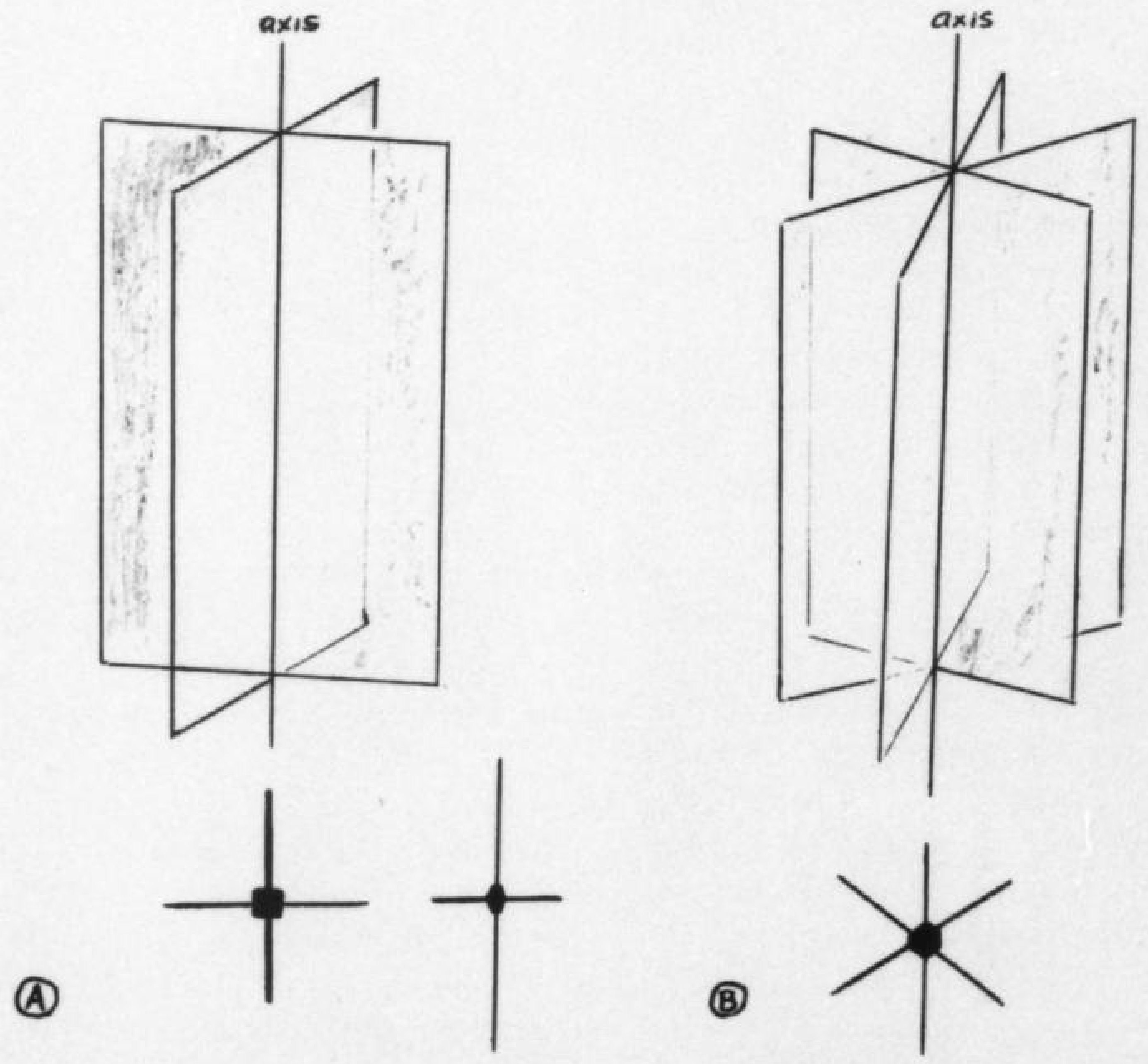


Fig. 11. (A) The intersection of two mirror planes at a right angle produces either a 2-fold or a 4-fold axis along the line of intersection. Three intersecting mirror planes generate a 6-fold axis (B).

For example, intersecting mirror planes automatically create a symmetry axis along the line of their intersection, as shown in Fig. 11. It is important to remember that the point group, a collection of symmetry operations, describes the arrangement of atoms in groupings within crystals. Point group symmetry refers to the environment about a fixed point in space. It is obvious that limitations must exist on the number and types of symmetries that can all act about a given point. Any particular point group must be self-consistent. These restrictions limit the number of possible combinations to a mere 32, which correspond to the 32 *crystal classes*. An isometric crystal, for example, may belong to a point group containing 3 axes of 4-fold symmetry, 4 axes of 3-fold symmetry, 6 2-fold axes, 9 planes, and a center of symmetry. This represents the full symmetry of a cube, and the crystal class accordingly is called the ***holohedral class*** (holos = whole). But an isometric crystal may have less symmetry than that of a cube, and still belong to the isometric system *if* it has 4 independent 3-fold axes (as distinguished from the hexagonal system with but one 6-fold or 3-fold axis). Thus, several crystal classes can be described that all belong to the isometric system, but have different symmetries.

A crystal contains more than one atomic group. To fully describe crystal structures we must fill space with many such motifs in a repetitive, periodic manner. This is accomplished by combining the motif symmetry with lattice symmetry.

Many permutations and combinations are created by this merging of symmetry types. However, it was noted as early as 1879 that in 3-dimensional symmetry arrangements two *new* types of symmetry operations have to be considered.

We can imagine a group of 4 objects related by a 4-fold rotational axis, as shown in Fig. 12. Let us now imagine that instead of being restricted to a plane (as would be the case in pure rotation) the objects are displaced along the rotation axis, as though placed at regular intervals along a helix. This new symmetry feature is therefore known as a *screw axis*. We may encounter 2-, 3-, 4- and 6-fold screw axes in crystals, as well as the rotation axes already described.

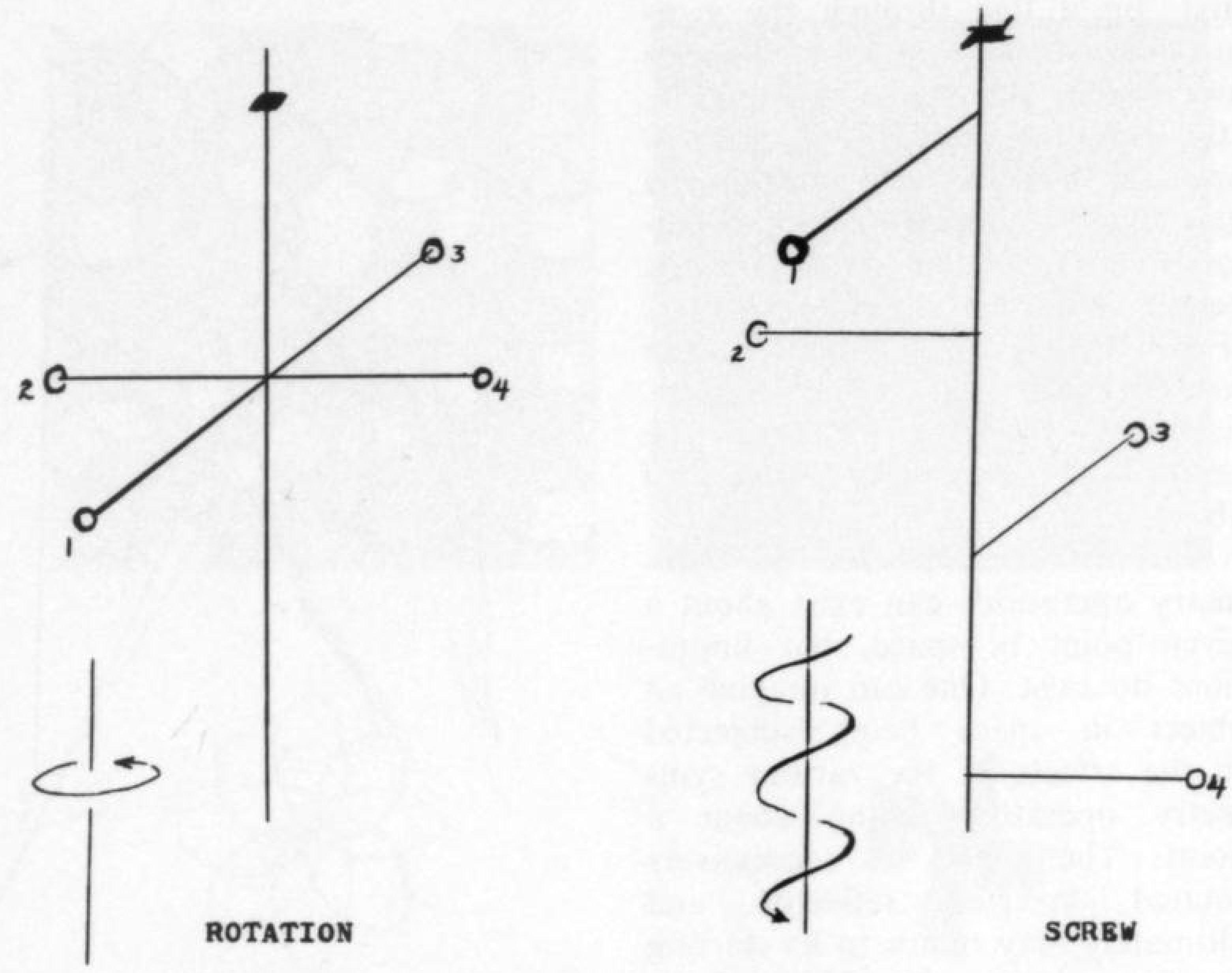


Fig. 12. A screw axis has the same rotational period as a rotation axis, but has an added translation (displacement) component parallel to the axis.

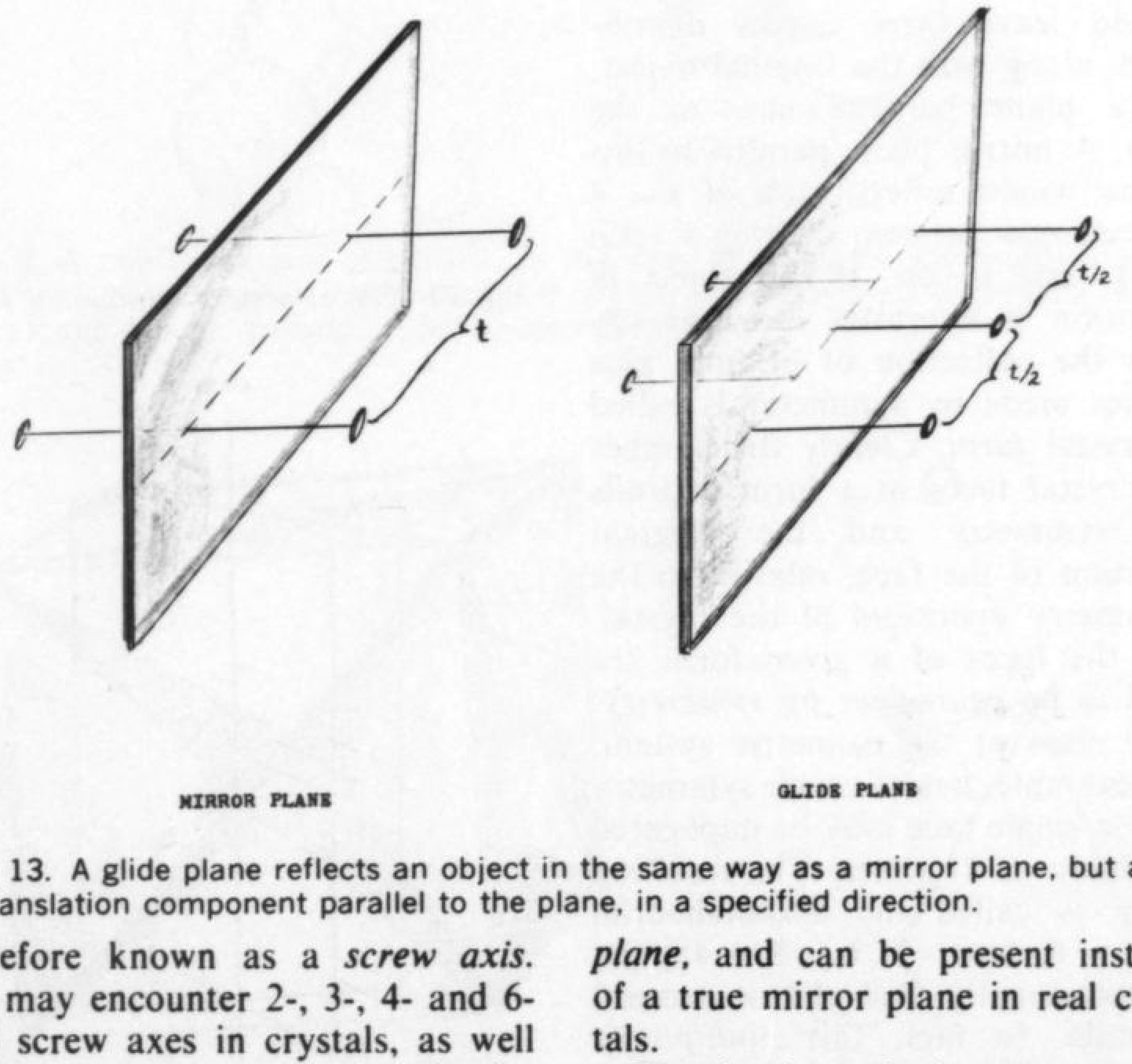


Fig. 13. A glide plane reflects an object in the same way as a mirror plane, but adds a translation component parallel to the plane, in a specified direction.

Similarly, imagine a mirror plane that relates two objects by reflection across the plane (Fig. 13). If we introduce a displacement component to the reflection operation, the objects become separated in a kind of zig-zag relationship across the plane. This is known as a *glide* ***plane***, and can be present instead of a true mirror plane in real crystals.

The final synthesis can now be made. When we combine the 32 point group symmetries with the 14 translational symmetries of the Bravais lattices, and then add the new glide and screw operation possibilities, the total symmetry combinations possible in crystals number 230. Every crystalline substance is atomically arranged in accord with the symmetry of one of these 230 *space groups*. Within the space group lies a complete description of the symmetry restrictions that must be obeyed for any substance crystallizing in that group. For this reason, determination of the space group is one of the first jobs of the crystallographer in deciphering a crystal's structure.

One can readily verify that each *lattice* type shows the full symmetry possible for the crystal system to which it belongs. Why, then, are there more than 6 basic crystal symmetries? Bravais, as early as 1848, realized that lower symmetries exhibited by some crystals must be due to the effects of point group symmetry. This has some rather surprising consequences. For example, consider a crystalline material built upon a cubic lattice.

By definition, a cubic lattice has axial units that are all the same length ($a = b = c$) and interaxial angles that are all right angles ($\alpha = \beta = \gamma = 90°$). These criteria are met in every isometric material.

The criteria for the triclinic system, however, are less restrictive. In fact, the axes of the lattice in this system can be any length at all, and the interaxial angles can have any values. One **specialized** case of the triclinic system might be a crystal whose axes, by the sheerest accident of molecular size and symmetry, were all the same length, and with all interaxial angles right angles. Yet the crystal would still be triclinic, in spite of the fact that its lattice is dimensionally cubic. This apparent contradiction is resolved by the fact that motif symmetry determines crystal symmetry. As seen earlier, motifs can have very irregular shapes, perhaps even with no symmetry at all. But a motif might, on the other hand, be highly symmetrical. An isometric cyrstal must be isometric in **all** its aspects, not the lattice alone. This means that such a crystal must be built by motifs that themselves have isometric symmetry (belong to one of the isometric crystal classes). An isometric lattice with triclinic, irregular-shaped motifs cannot be isometric, for this reason. But note that there are no restrictions on the dimensions of a triclinic lattice. Therefore this lattice can take on any shape whatsoever, even isometric, and such a lattice can be populated by motifs with no symmetry at all. This material would be triclinic.

Lattices have translational symmetry and motifs have point symmetry, and the characteristics of each can be independently listed. However, when one describes a crystal structure, consisting of atomic motifs repeated through space according to lattice restrictions, the symmetry involved is that of a **space group** with its own, distinct properties.

Planes of symmetry are mathematical concepts. To say that a crystal has a symmetry plane implies that the plane, within the structure, extends through the entire crystal and effectively mirrors all features of the lattice and motifs on either side. In an isometric lattice such planes are characteristic of the lattice itself. If the lattice is populated with isometric motifs, also containing symmetry planes, then the planes in the lattice coincide with those in the motif, and the lattice and motif are said to be symmetrically ***consistent***. If, on the other hand, the isometric lattice is populated with triclinic motifs having no symmetry, the planes originally distinguishable in the lattice alone do not exist in the structure (lattice + motif). These planes no longer have mirror properties when cutting across motifs with no obvious symmetry! Such a crystal is triclinic, in spite of the fact that the lattice, ***taken by itself***, might have the dimensions and symmetry of an isometric lattice. Thus, a triclinic motif on an isometric lattice results in a triclinic ***structure***, since triclinic symmetry is the only symmetry consistent with the structure as a whole.

The reverse situation produces subtly different results. One might

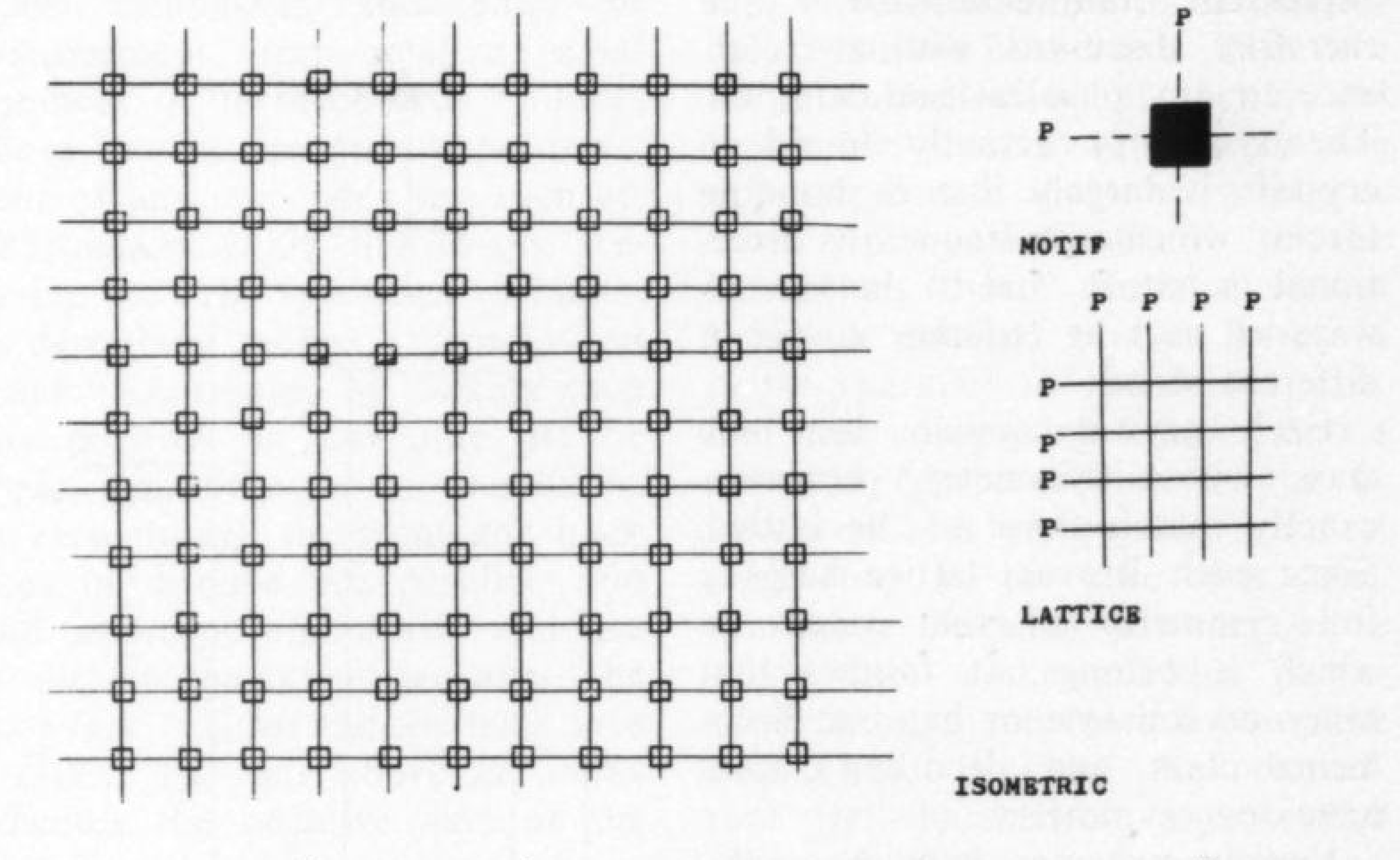


Fig. 14. A square motif is consistent with an isometric lattice, as seen in the overlap of mirror planes, resulting in an isometric crystal. The same motif placed on a triclinic lattice results in a triclininc crystal, since the combined pattern does not contain mirror planes and is triclinic.

guess that an isometric motif on a triclinic lattice should then result in an isometric structure. But in this case, though the motif may have symmetry planes, for example, these planes will not relate the motifs to one another since the planes do not exist in the lattice, as shown in Fig. 14. In terms of the structure as a whole, the arrangement is therefore also triclinic!

Examples of the above situations do exist. Coesite, a high-pressure form of SiO_2, is monoclinic, but with the following cell parameters: $a = 7.17$, $b = 12.38$, $c = 7.17$ Å, $\beta = 120°$. These lattice dimensions are those of a hexagonal mineral!

It is the atomic (motif) arrangement that determines crystal symmetry. This further emphasizes the point that lattices do not have physical existence in crystals, but are merely diagrammatic aids to help us visualize the internal structure of crystals. Symmetry can be expressed mathematically, and therefore discussed without reference to any physical bodies at all. The symmetry actually found in crystals is largely due to bonding forces, which are frequently directional in nature, and to the various ways of packing together atoms of different sizes.

Each crystal system has one class whose symmetry properties exactly match those of the lattice. Since each Bravais lattice has the full symmetry of the system to which it belongs, it follows that every crystal system has one holohedral class, and all other classes have less symmetry.

Various schemes have been devised to describe crystal forms. Unfortunately far too many names have been assigned, by a great many people, and this overwhelming mass of nomenclature usually frightens off the beginning student of crystallography. Crystal faces are the bounding, limiting planes of a crystal and therefore must enclose space. One can describe a box, for example, with such terms as "front," "side," and "back," but obviously this assumes that the position of the box has first been fixed.

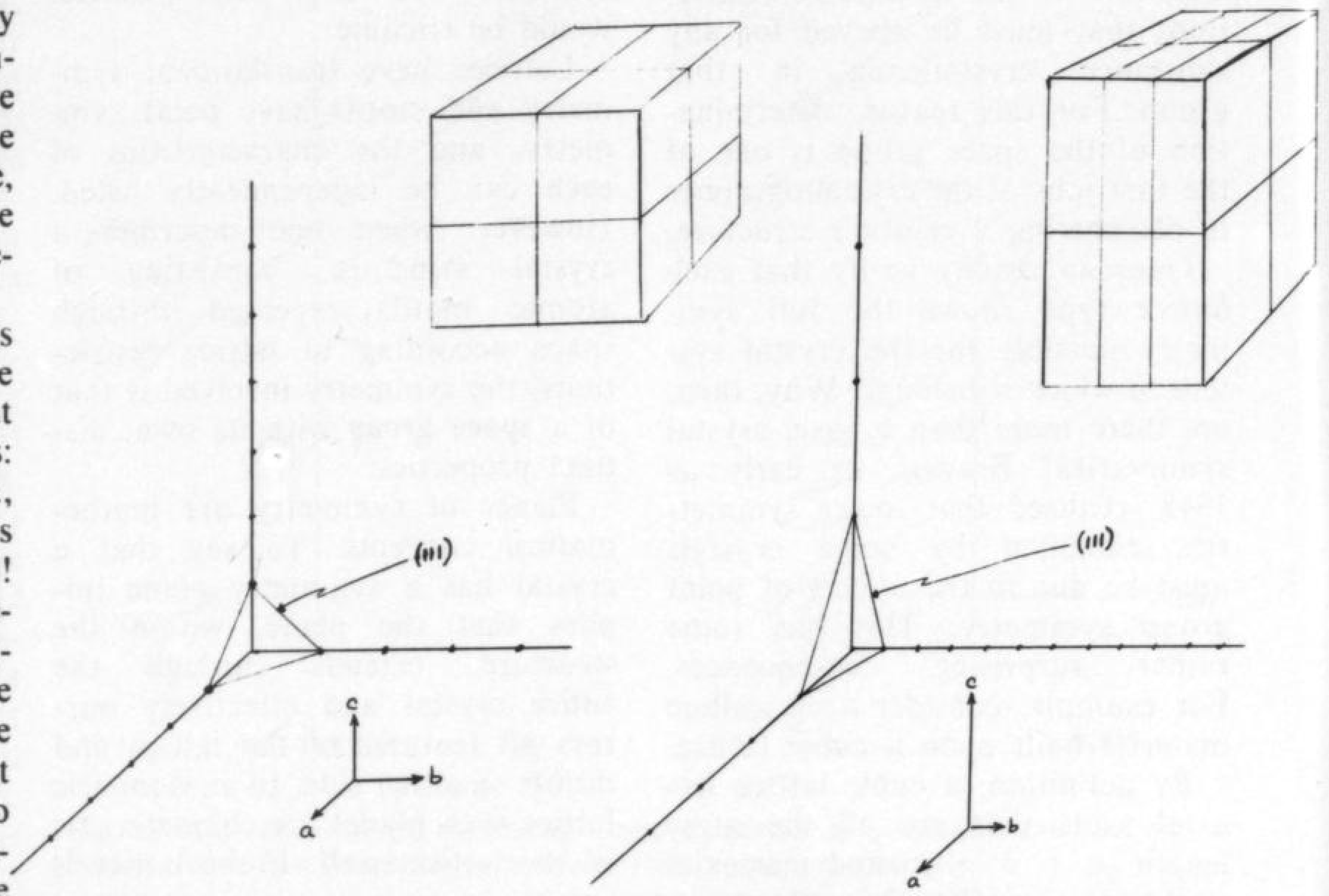


Fig. 15. Parametral (unit) planes, (111) in the isometric and orthorhombic systems.

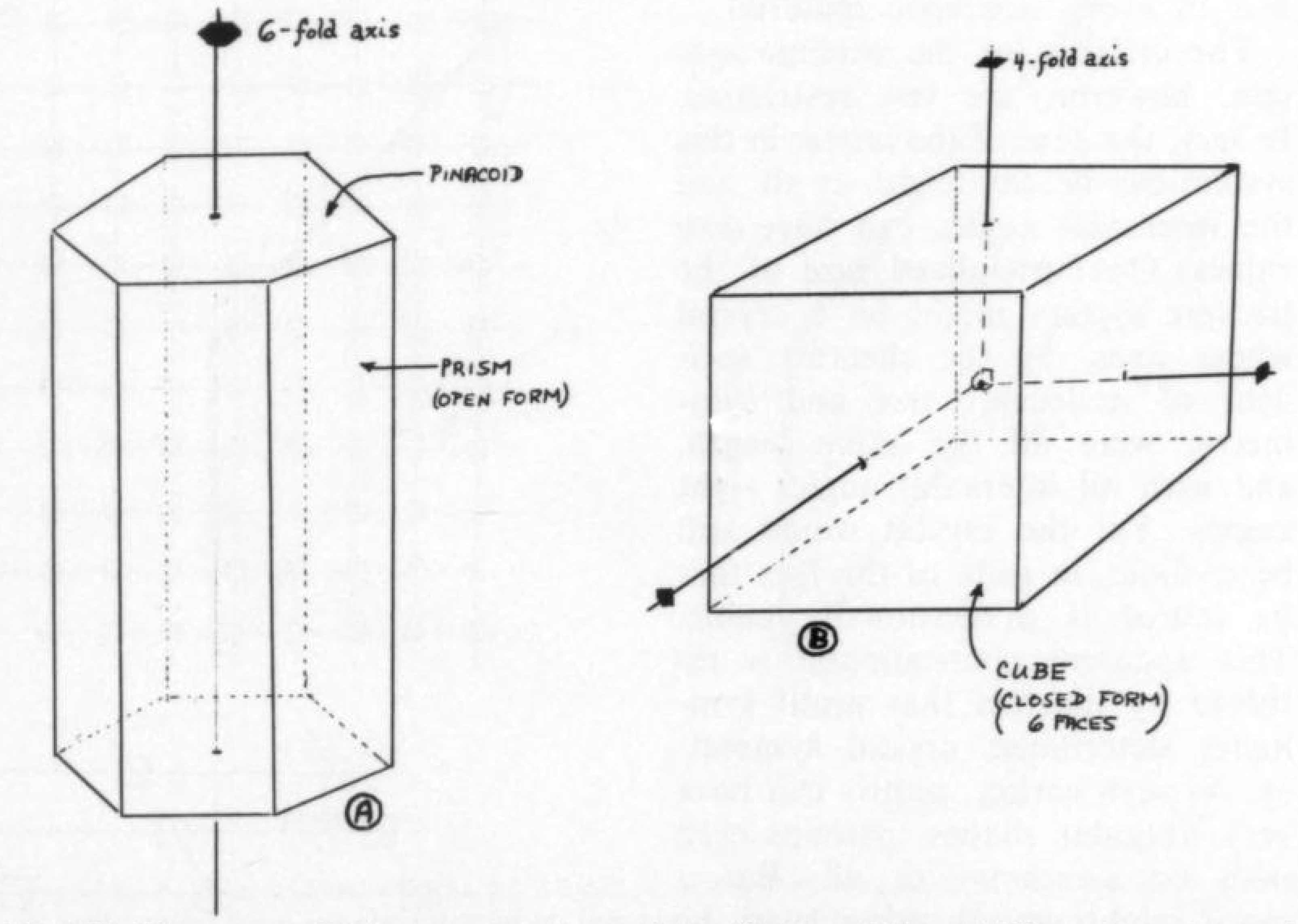


Fig. 16. The prism (A) is an open form (tube-like), and the addition of a pinacoid (2 faces) is necessary to enclose space. The cube, with 6 faces (B) is a closed form.

When this is done with a crystal, it turns out to be more convenient to first label the axes (*a, b, c*), and there are specific conventions regarding how this should be done. Axes of equal length are given the same letter. Thus, the *a, b, c* axes in isometric minerals become *a, a, a;* of tetragonal minerals, *a, a, c,* etc. All the crystal faces are then described in terms of the way they cut the crystal axes. One simple method of doing this is to indicate how far out from the coordinate (axial) origin a given face cuts the three axes. But "how far" is a meaningless term unless one has units of measurement. In the case of crystals, the handiest units to use are those already present in the lattice —the basic translations that defined the periodicity of the lattice to begin with. The lattice is periodic in three dimensions, and so there is a ***unit translation*** for each dimension. These can all be the same size (as in isometric crystals) or all different lengths, as shown in Fig. 15.

Early in the 19th century, Christian Samuel Weiss suggested describing crystal faces in terms of the actual numbers of units, from the origin, at which the faces crossed the coordinate axes. Thus, a face intersecting the axes at a distance of one unit translation along each axis would be *indexed* (named) (111), the three numbers in parentheses indicating interceptions of the *a, b* and *c*-axes respectively. Note that different crystal systems may have lattices with different dimensions and shapes, but in every case the lattice is built by repetition of a unit translation in each spatial dimension. Therefore in every crystal system there is a face that can be labeled (111), indicating unit interceptions of its particular axes. This face is known as the *unit* or *parametral plane*, and it defines the lattice units with which to label all the other faces on the crystal. The parametral planes in different crystal systems will obviously not look alike (Fig. 15), but all have the common feature of unit axial interceptions on all axes. Any crystal plane that cuts all three axes can be assigned as the parametral plane.

What if a face is parallel to a given axis, and therefore never intersects it? To the mathematician, parallel lines meet at infinity, and so the interception of the face with the axis is given as infinity, symbolized by a "horizontal 8": ∞. Thus, a face intercepting the *a*- and *b*-axes of a crystal, and parallel to the other axis would be indexed as (11∞). This system was found cumbersome by William H. Miller, who therefore proposed inverting the indices obtained by the Weiss method to eliminate the infinities. This results in $(\frac{1}{1}\,\frac{1}{1}\,\frac{1}{\infty})$, which reduces to (110). With similar reasoning one can convert Weiss to Miller indices with comparative ease. Modern crystallographic work uses Miller indices, because they are more useful in various types of computations.

All the rest of face and form terminology is variation on the same theme. The Miller indices of a face can be determined once the unit plane is defined, since this plane establishes the units of measurement for relative axial distances. A form consists of faces whose indices are merely permutations of any one index set, such as: (123), (213), (312) and so on. Referring to the previous problem of describing a box, "front" and "back" are treated by making each axis positive on one side of the origin, and negative on the other. So even though the front and back faces of a cube are parallel, and both intercept one *a*-axis and are parallel to the other two axes, the front face is (100) and the back face is $(\bar{1}00)$. The bar above an index indicates the negative side of the respective axis.

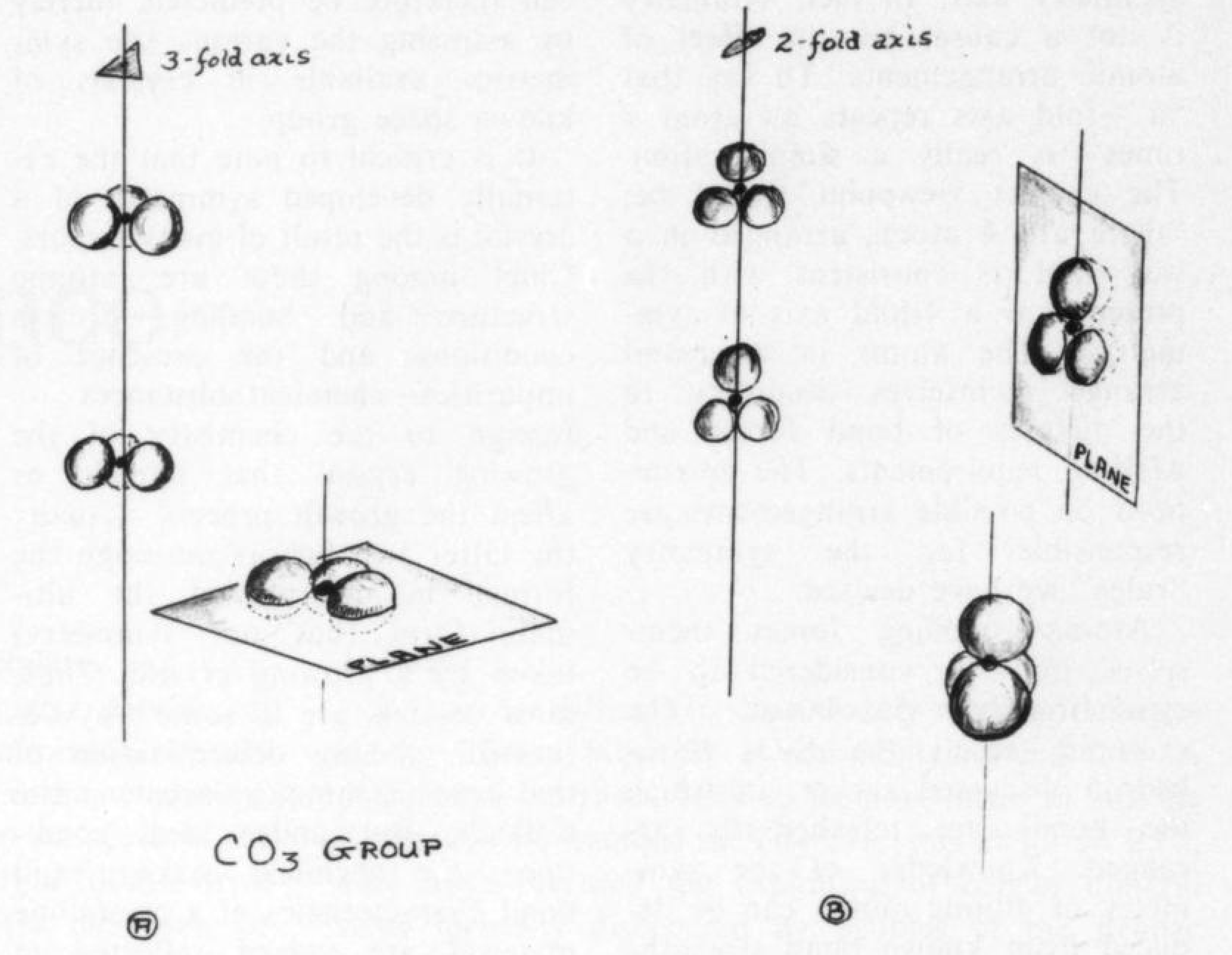


Fig. 17. A carbonate (CO_3) group can be consistent with a 3-fold (A) or 2-fold (B) axis.

A form may be a *closed* or an *open* form, depending on whether or not it entirely encloses space. In a hexagonal crystal, for example, the 6-fold axis of symmetry causes a face parallel to the axis to be repeated 6 times about the axis. Even limitless extension of these faces produces a 6-sided tube, but the tube remains open at both ends. There is no symmetry element in the crystal that can transform such a face into a position perpendicular to the symmetry axis. In order to enclose the space of the crystal there must be present another type of face, whose indices reveal that it is already assumed to be perpendicular to the 6-fold axis. This face may be duplicated, if the crystal has a center of symmetry, on the opposite end of the tube, giving us the "top" and "bottom" of the hexagonal "box." Such a crystal therefore consists of two forms: a *prism* (parallel to the 6-fold axis, and here comprising 6 faces) and a *pinacoid* (perpendicular to the 6-fold axis and comprising 2 faces) (Fig. 16a). In the case of a cube, symmetry elements can act on a single face and duplicate pervasively enough to create a complete box. Thus, the cube, the octahedron, the docahedron and several other characteristic forms are all closed forms. One face is sufficient to describe such a form, since all the other faces of the form are symmetrically equivalent to the first (Fig. 16b).

The symmetry operations act on atoms within the crystal, as well as external faces. If, for example, 4 atoms bond together in a crystal such that the atoms lie at the corners of a square, we may describe this arrangement by saying that there is a 4-fold symmetry axis running through the center of the atomic group. Another way of looking at this is to say that such a group is *consistent* with a 4-fold symmetry axis. In fact, symmetry is not a cause, but an **effect** of atomic arrangements. To say that "a 4-fold axis repeats an atom 4 times" is really a simplification. The correct viewpoint would be: "there are 4 atoms arranged in a way that is consistent with the presence of a 4-fold axis of symmetry." The atoms in a crystal arrange themselves according to the dictates of bond forces and packing requirements. The *restrictions* on possible arrangements are responsible for the symmetry "rules" we have devised.

Atomic bonding forces themselves may be considered to be symmetrically distributed. For example, recall the SiO_4 tetrahedron discussed earlier, in which the bonds are tetrahedrally arranged. Knowledge of the symmetry of atomic motifs can be deduced from known bond strengths and packing geometries. This type of information has made possible a quiet, but profound revolution in the entire field of organic chemistry.

Knowledge of the symmetry of atomic motifs is extremely useful in understanding the structures of many materials. Consider the triangular CO_3 group, in which the carbon atom (C) is surrounded by three oxygen atoms (O) lying in a plane. This *carbonate group* is present in calcite, aragonite, dolomite and many other carbonate minerals. In the so-called rhombohedral carbonates, the group is consistent with a 3-fold axis and is oriented with the plane of the oxygens perpendicular to this axis. But what about the orthorhombic carbonates? In aragonite, witherite and strontianite, the carbonate groups must be consistent with mirror or 2-fold symmetry. The only possible orientation for them is this symmetry environment is on mirror planes or 2-fold axes, as shown in Fig. 17.

Similar reasoning can lead to remarkably accurate insight about certain aspects of crystal symmetry. Specific atomic clusters form characteristic motifs, whose symmetry, in crystals, must be consistent with structural site symmetry. The structural positions of many types of atomic clusters can therefore be predicted, merely by assessing the various site symmetries available in crystals of known space group.

It is critical to note that the externally developed symmetry of a crystal is the result of many factors. Chief among these are: atomic structure and bonding, growth conditions, and the presence of impurities—chemical substances foreign to the chemistry of the growing crystal that impede or affect the growth process. Usually the latter two factors outweigh the former in determining the ultimate form (but not symmetry) taken by a growing crystal. Thus, most crystals are in some way deformed, making determination of the true symmetry much more difficult. But under ideal conditions, the chemical makeup and bond characteristics of a crystalline material are indeed reflected in external form.

In any case, these factors are revealed by physical properties measurable on a whole crystal or on tiny fragments. Such properties as refractive index, hardness and cleavage are direction-dependent. All this really means is that the bond strength and atomic arrangement differs in different directions within the crystal. Light vibrations are enormously sensitive to these differences and, in fact, light travels (and vibrates) at different rates in different directions in all but isometric crystals. The point of the octahedron of a diamond is much harder than the octahedral face, but every octahedral point is equally hard. Mica cleaves easily because the bonds between layers of the mica structure are weak van der Waals bonds. These are easily broken, while the bonds in the sheets themselves are very strong and less easily broken. Knowing the types and positions of bonds in a crystal enables one to predict likely directions of cleavage, as well as optical properties.

Form, physical properties and growth characteristics are all features that reflect internal structure and the symmetry of atomic groupings and bonds. Structural knowledge is extremely powerful, in that it leads to accurate predictions about crystalline materials. It enables one to understand, in a detailed way never possible with morphological data alone, the reasons for variations found in the physical and chemical properties of natural crystalline materials.

Perhaps even more significantly, structural information often leads to successful synthesis. This has opened the door to a world of undreamed-of technologies, highlighted by transistors, lasers and superconductors. Such technologies may ultimately lead to long-sought goals, among them controlled fusion—harnessing the power of stars.

With the incentive sparked by the lure of such attainments, we may next turn to the immediate problem: how is structural information actually obtained?

Chessy, France

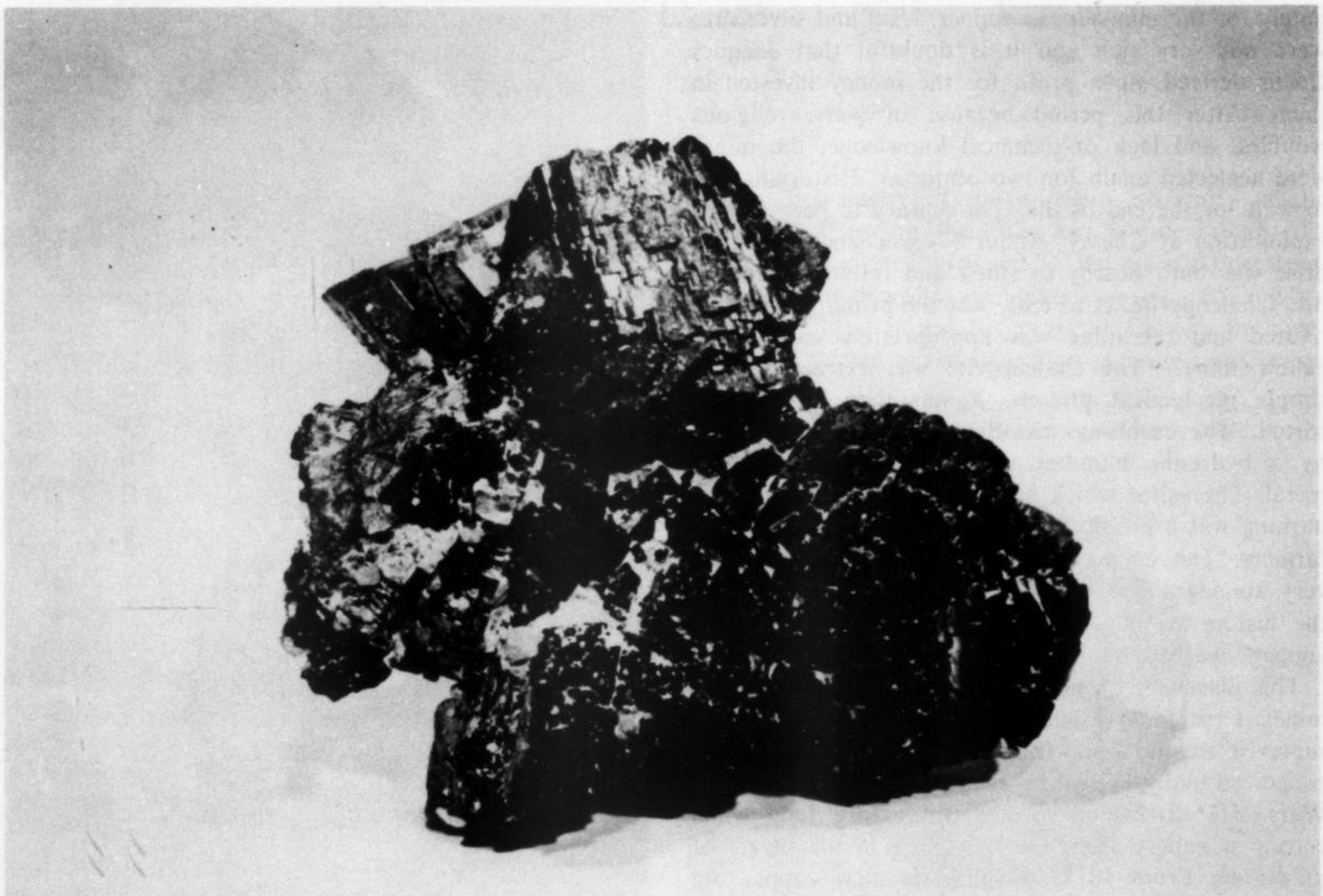
M. Santoni, Lyons, France

France is not a richly mineralized country and interesting mining places are rare. The quartz deposits of the Oisan in the Alps and the copper mine of Chessy near Lyons are almost all that are worth mentioning. Chessy is a medieval village situated in the south of the region called "Le Beaujolais". It is only a 20 mile drive along route no. 485 from Lyons to the old mine, or rather to the dumps, scattered over about half a square mile north of the village. The mine has been closed for more than a century. However, the specimens of copper carbonates found there are so celebrated that the Chessy mine has almost become a legend.

History

It is rather difficult to state exactly when work began at the Chessy mine. It is commonly agreed that its origins can be traced back to Roman times. In fact the Romans, who founded the city of Lyons about 50 B.C., may have resumed the exploiting of copper mineral veins formerly discovered by peoples of the Bronze Age. Many traces of the Romans have been discovered near Chessy. We also know that the Romans were in great need of copper and lead—for instance they used much lead for pipes of the aqueduct to Lyons. Thus, it may be supposed, they had lived in the region and exploited the veins for about four centuries until the

Fig. 1. Azurite crystal group from Chessy, France. 8 cm across. Smithsonian Institution specimen. Photo by Joel E. Arem.



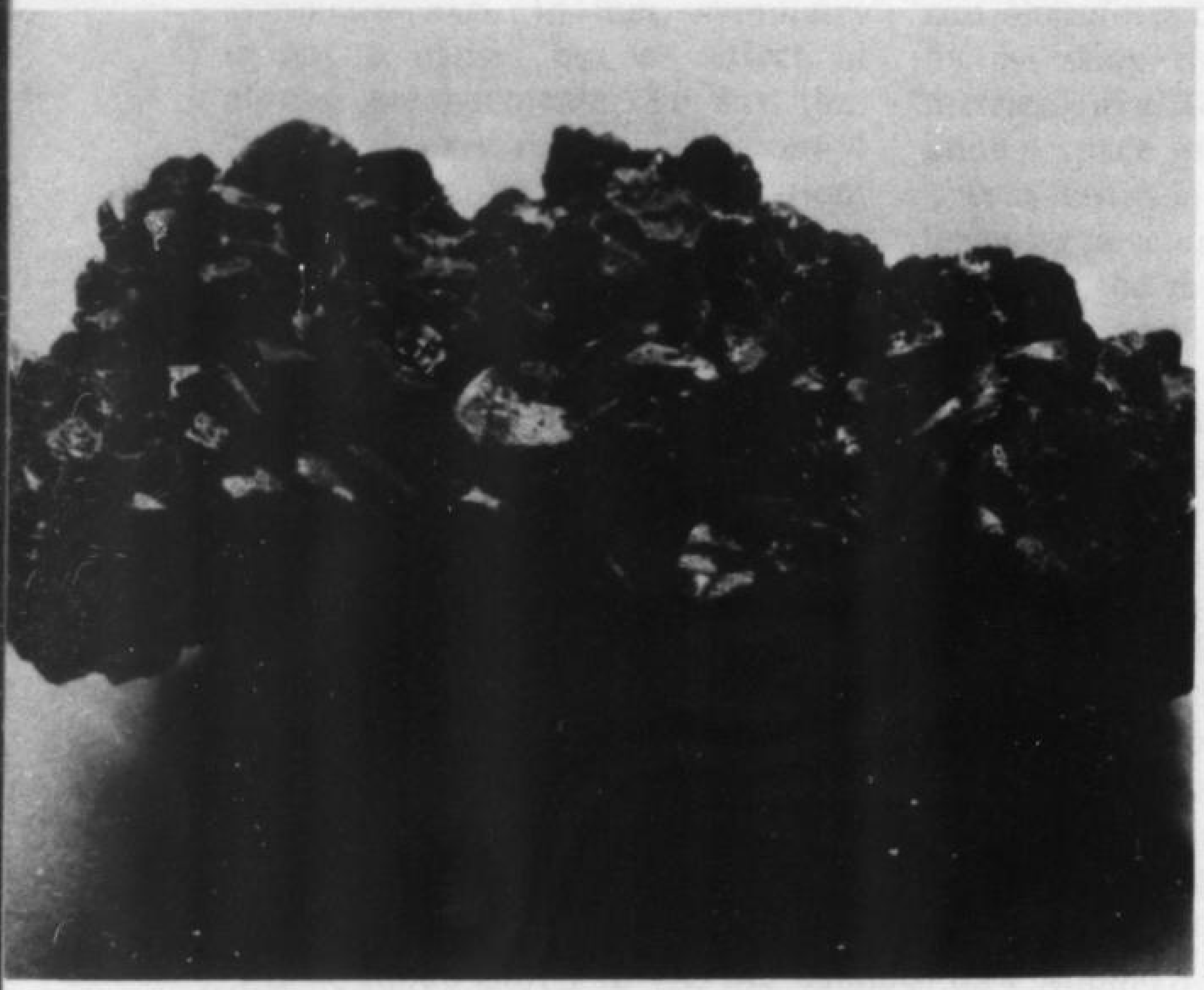


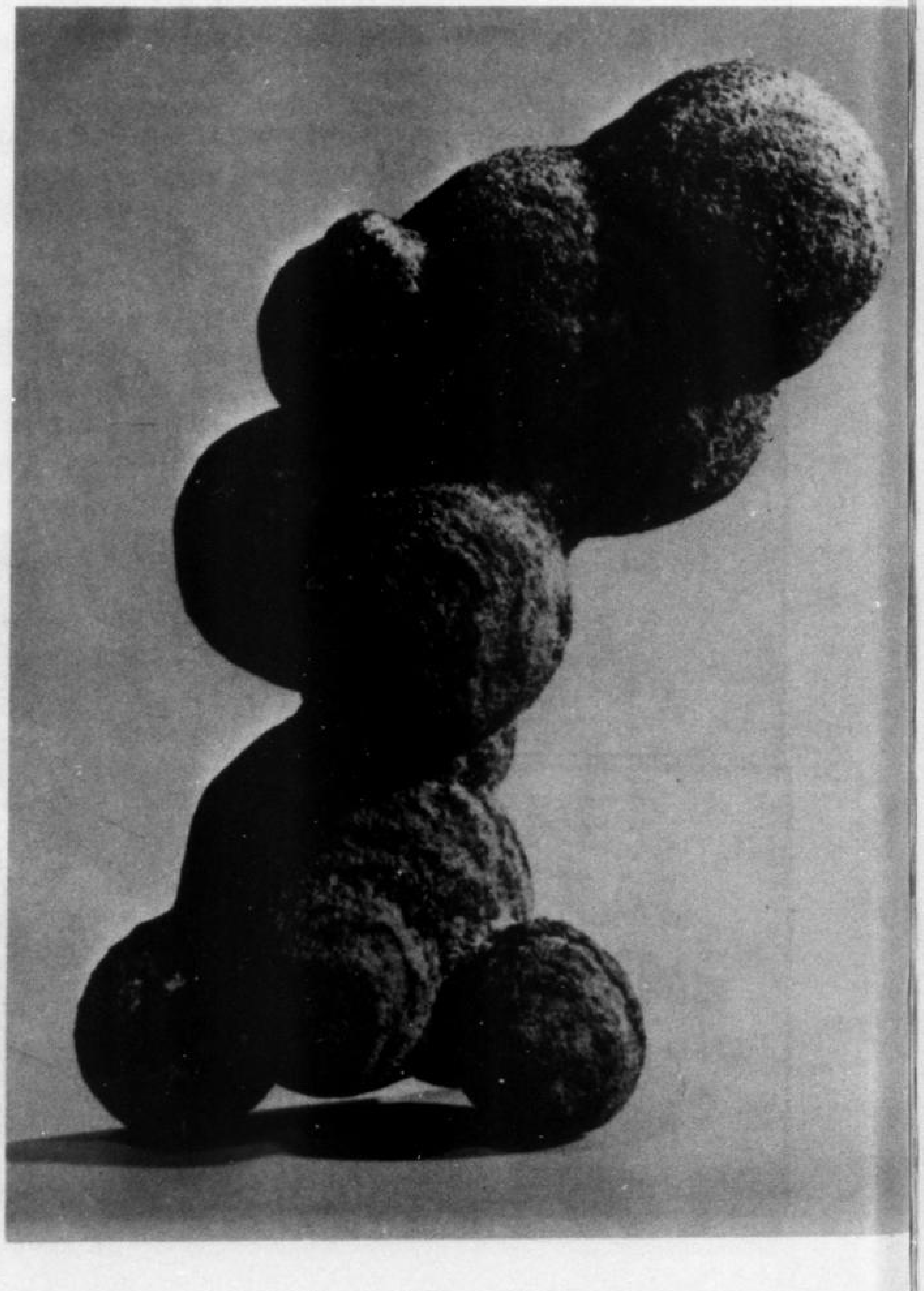
Fig. 2. Azurite crystal group from Chessy, France. About 25 cm across. Museum of Lyons specimen.

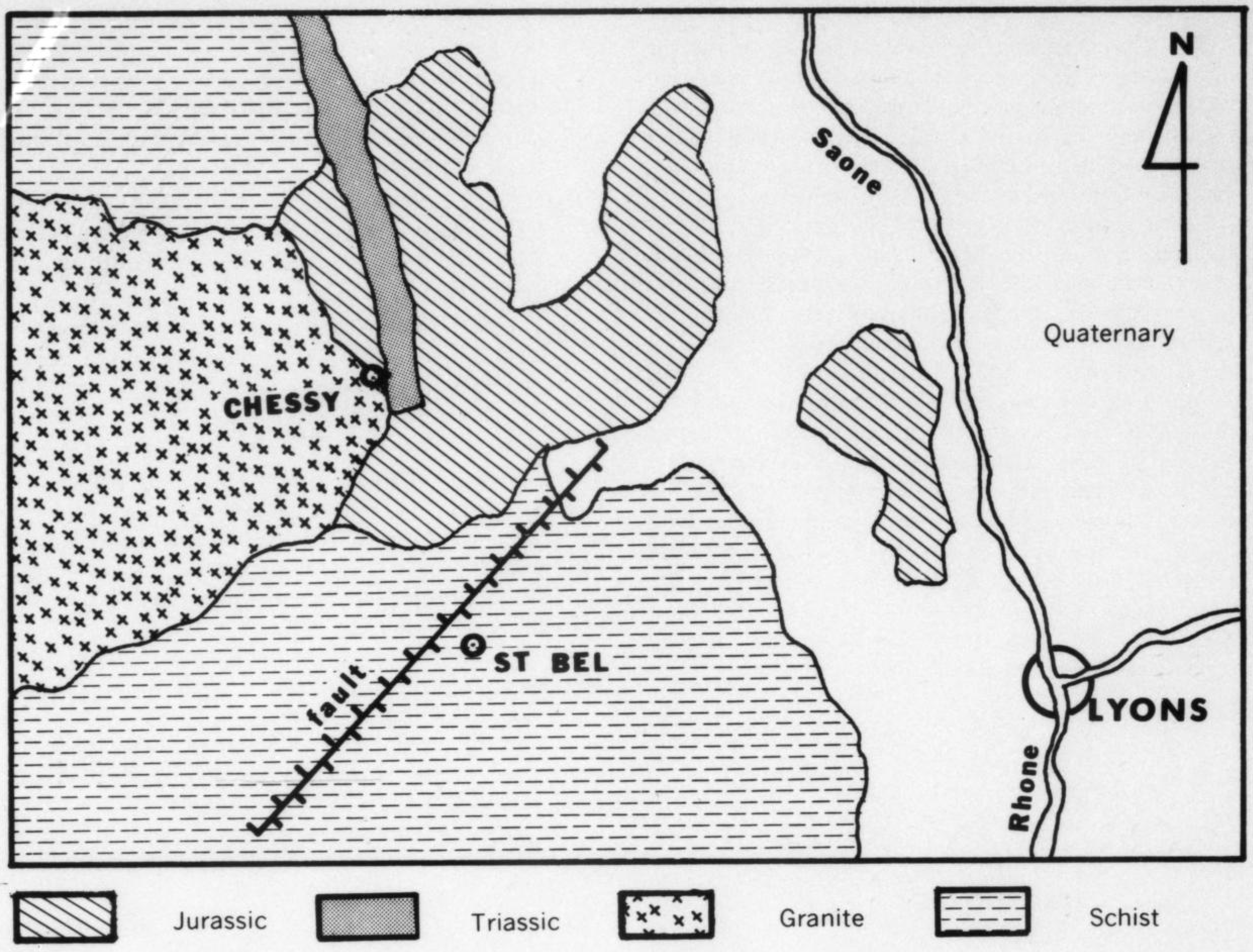
Barbarian invasions devastated the country. After that time, the Beaujolais mines were abandoned and it was not until the year 1440 that they are mentioned in historical works for the first time. In that year the minister of finances of King Charles VII, Jacques Coeur, revivied many mines in the region. This activity was directed toward all the deposits of Le Beaujolais but mostly to the mines of Chessy and St. Pierre. Unfortunately for the minister the copper, lead, and silver ores were not very rich and it is doubtful that Jacques Coeur derived much profit for the money invested in them. After this period because of wars, religious troubles, and lack of technical knowledge, the mines were neglected again for two centuries. Historians had to wait for the end of the 17th century to hear of new exploitation at Chessy. About 1715, a smelting enterprise was built nearby to smelt and refine the copper ore. Chalcopyrite, ($CuFeS_2$), was the primary ore to be treated and the mine was appropriately called "the yellow mine." The chalcopyrite was extracted by a simple mechanical process, it was then burned and sorted. The resulting metallic masses were stamped by a hydraulic hammer until they produced usable metal. The sulfur which pervaded the air from the ore burning was a problem. It destroyed crops of the local farmers. The copper thus crudely produced was not very abundant and the mines were of little import in the history of industry and mineralogy until "azure copper" was discovered in 1811.

This discovery came about quite by chance. A chief miner, Cristian Woelner, had come from Germany to supervise the mine and to try to increase the output of copper so badly needed in that time of the Napoleanic Wars. He discovered a magnificent ore lode when cutting a gallery from south to east in the layers of sandstone. From 1811 to 1845, the new copper ore discovery was worked quite extensively. The output was about 150 metric tons a year and a hundred miners were at work in the pits and galleries. The most important gallery was about 150 meters long and 3 meters wide. The vein itself had been traced in the sandstone and clay for a distance of 400 meters. The azurite (*chessylite*) was found rather in geodes or pockets than in lodes or veins. There was, for instance, a famous "blue grotto" which was so high that visitors could stand in it and marvel at the magnificent crystals glittering in all shades of blue.

About 1845, the azurite pockets gave out, and copper could not be profitably mined any more. A new mining firm tried to resume the working of chalcopyrite. They intended to recover not only copper but sulfur too for at that time sulfuric acid was produced from the new English lead-chamber process. A factory was built near the Azergues River but the venture did not last for long. By 1875, the new process of producing sulfuric acid from salt ruined the Chessy undertaking. This is, in fact, the end of the story. All mining activity ceased at Chessy. The chemical factory and its tall chimney were pulled down and the pits and galleries were

Fig. 3. Round balls of azurite "sand" crystals. 13 cm high. Smithsonian Institution specimen. Photo by Joel E. Arem.





Geology of the Southern Part of "Le Beaujolais."

Geology of the Southern Part of "Le Beaujolais."

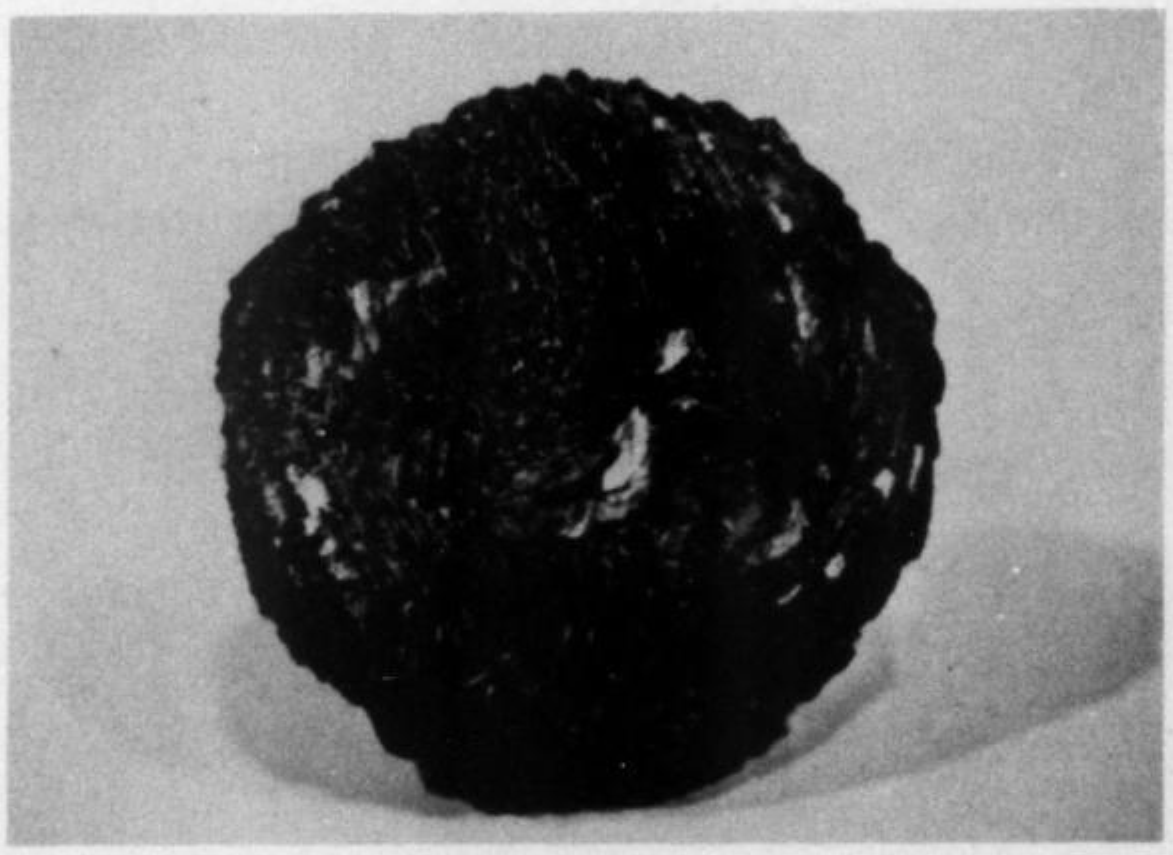
blasted and filled. From time to time La Compagnie St. Gobain made new borings in the old veins but to no avail.

Now the only visitors are hopelessly optimistic collectors who harrow and scrape the dumps in vain in search of "chessylite" specimens. No one is reported ever to have discovered anything valuable. And, for solace, the collector pays a visit to the Museum of Natural Sciences in Lyons where he can marvel at the fine specimens on display.

Geology

The Chessy mine is a fine example of a deposit in a transitional stratum. "Le Beaujolais" is mostly composed of the remnants of an old Hercynian range which has been uplifted again in the Tertiary era. That area, lying north of Chessy, is constituted of marls and sandstones covered over by Triassic Lias. These formations butt against crystalline schists in the southeast and against primary granites in the southwest. There is a fault line directed southwest to northeast which roughly follows the separation between crystalline rocks and Triassic sediments (see map). Chessy lies nearly at the northern extremity of the fault line. Close to the fault and 8 miles south, the pyrite mines of St. Pierre and St. Bel are still operating. These pyrite deposits are related to the chalcopyrite which has been mined for years at Chessy. Both deposits are related to the formation of azurite at Chessy.

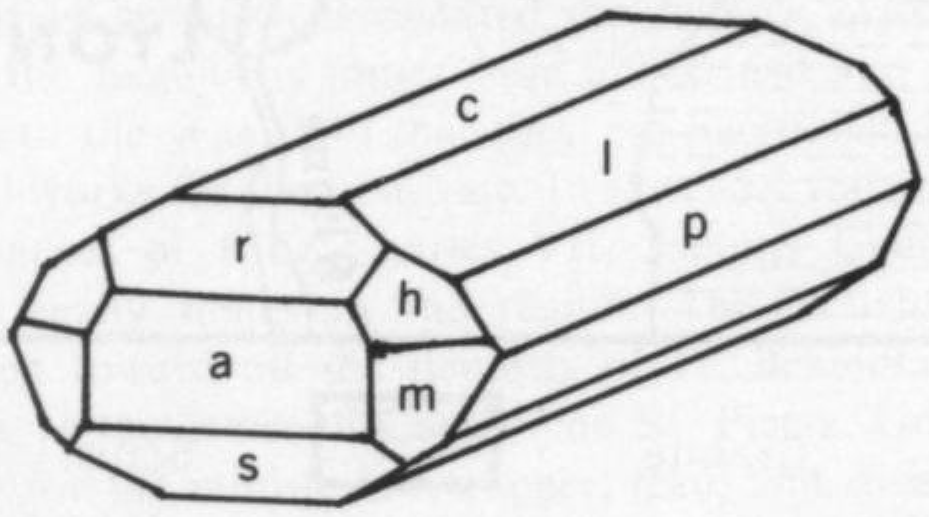
Fig. 4. Azurite crystals in a spherical mass. The diameter is 4 cm. Smithsonian Institution specimen. Photo by Joel E. Arem.

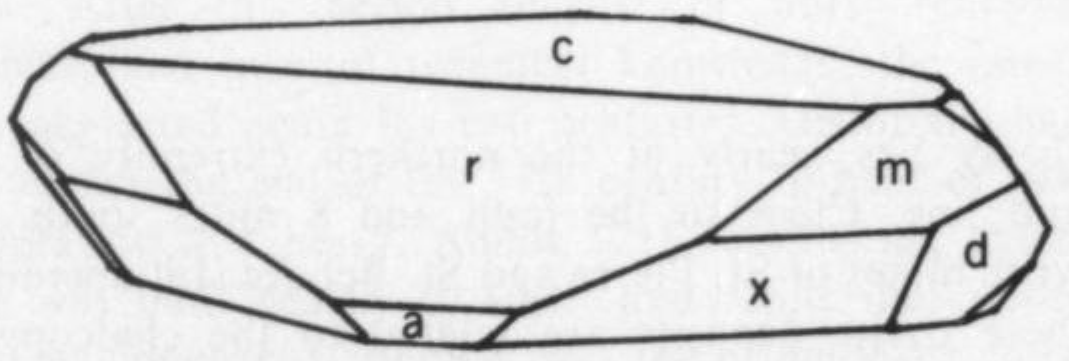


The azurite resulted from the alteration of the sulfates coming from the decomposition of chalcopyrite in the neighboring schists. These sulfates reacted with the calcite of the marls. The reaction produced calcium sulfate, which disappeared, and copper carbonate which has remained in the sandstone and clay.

Along with azurite, many of the mineral species of the copper series have been found at Chessy. Included are chalcopyrite, the main ore for years, malachite (fine specimens are on display in the Museum of Lyons), cuprite (tiny octahedra may still be found on the dumps), bornite and also smithsonite.

The name *chessylite* was given by Brooke and Miller in 1852 to the azure copper mineral found at Chessy. Before that time azurite was known, of course, since it had been mined with malachite in Russia. Brooke and Miller wanted to give a special name to the newly found ore because of its fine and varied crystallized forms. Azurite belings in the monoclinic system. The common habit is an oblique prism with a flat base. Many different forms have been described but most crystals resemble the drawings below:





Azurite Specimens in the Museum of Lyons

The Museum of Lyons certainly has the richest collection of *chessylite* specimens in the world. As early as 1820 the collection was established by purchases and gifts. One of the most important groups is made up of specimens given in 1853, but other azurites have been purchased and donated in the second half of the 19th century. Now there are about one hundred specimens in all. They range widely in size and aspect and show all the different crystal habits. To better organize the specimens for the visitor it is possible to distinguish:

a) massive lumps with crystals set in groups on top. One of these pieces weighs about 25 pounds and is a deep Prussian blue.

b) "kidney-stones" which look like flint nodules. When sawed they show thin, blue needles radiating from the center. There are many pieces of this kind ranging from 1 in. to 8 in, in diameter.

c) Several specimens (Fig. 2) are composed entirely of platy crystals piled one upon the other, sometimes twinned. A very fine piece is over 10 in. long and is a dark blue color which makes it difficult to photograph.

d) A large number of balls and clusters of balls are melon-shaped and average 2-3 in. in diameter. They are lined all over the surface and are a lighter blue.

e) There are many other habits too. Some crystals look like stalactites, 2-3 in. long set on flat bases. The stalactites look like smithsonite but are various shades of blue, from very light to dark Prussian blue.

The Museum of Lyons is now undergoing repair and reorganization. The visitor should wait a few months until everything is well-arranged and appropriately presented. It is possible that by the fall of 1971 every case will be arranged and every mineral worth presenting will be shown to the public.

It will then be quite an interesting museum, not only because of its collection of "chessylites" but for many other minerals. On display there will be fine quartz clusters from the French Alps and Madagascar, sulfur and aragonite from Italy and many fluorites from "Le Massif Central." For a foreign visitor visiting the Museum will be worth a visit, even if he has to delay along his grand tour from Paris to the Riviera.

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News from Canada

Dr. Denis Thorn of London, Ontario, was elected President of the Central Canadian Federation of Mineralogical Societies at a general meeting of the Federation in Toronto in early March.

Dr. J. A. Mandarino, of the Royal Ontario Museum, has been named Honorary President of the Walker Mineralogical Club of Toronto, succeeding the late Dr. V. B. Meen.

The Minerals of Panasqueira, Portugal

by Richard V. Gaines and **Decio Thadeu**
Pottstown, Pennsylvania **Lisbon, Portugal**

The Panasqueira tungsten mine has in recent years become widely known among mineralogists for the profusion and beauty of the minerals found there. The first concessions date from the end of the last century and it is possible that there had even before this been some exploration for the tin content of some of the veins; but there is no pòsitive information about this. In 1928 the concessions were taken over by the Beralt Tin and Wolfram, Ltd. (a largely British concern). Regular operations began in 1934 and gradually expanded to the point where today Panasqueira is one of the most important tungsten mines in the world.

Present operations result in production of about 2,000 tons of mine run ore, containing about 0.3% WO_3 plus some tin, copper, and silver, per day. The 1970 production of concentrates was about 1,700 tons containing over 75% WO_3 plus 34 tons of cassiterite concentrates at 73% Sn, and 696 tons of chalcopyrite concentrates with 22.6% Cu and 868 grams per ton Ag. The quality of the wolframite concentrates is so consistently high that "Beralt" wolframite has become the standard of the industry.

The Panasqueira mine is in reality a group of mines, known as Corga Seca, Barroca Grande, Panasqueira,

Fig. 1. Panasqueira mine, Portugal. Beneficiation plant and dumps at Rio.

Vale da Ermida, Rebordões and others of lesser importance; all are more or less interconnected. The ore is collected at the main adit of Barroca Grande; it is submitted to a rough concentration at Barroca Grande and, afterwards carried by an aerial tramway to the concentrating plant at Rio, on the south margin of the Zêzere River. Panasqueira itself is a village, as is Barroca Grande; they are on the steep slopes of rugged, pine forested hills and valleys. Panasqueira is 40 km and Barroca Grande 34 km by paved road east of Fundão in west central Portugal.

Literally hundreds of veins have been mapped, many of which have had production. The economic veins vary in thickness from 10 centimeters or so to over a meter, with an average between 30 and 50 cm; their length and continuity down dip are also variable, being at times only a few meters or as much as some tens of meters; the smaller veins could be better characterized as lenses. Naturally, with so many and such small veins, it is necessary to keep up a constant and intensive prospecting and development effort to maintain reserves. The success of this effort is attested by the fact that reserves are proven sufficient for many more years of operation.

Most of the veins dip very gently, ranging from practically horizontal to a maximum of 20°; the average is 10° to 12°. One system of veins which is quantitatively not important, dips up to 40°. The veins consist of white quartz, and the wolframite and other minerals most often are found in the quartz growing inward from the edges of the veins; they may also form irregular masses anywhere in the veins. Sometimes the central portion of the vein forms a vug, more often this vug is adjacent to the footwall of the vein. Into these vugs project quartz crystals and various ore minerals. Since these minerals crystallized out of solution with a minimum of interference, and since they can often be recovered with a minimum of damage to the crystals, all of the most spectacular specimens found come from such vugs.

The genetic classification of this deposit is pneumatolytic with an important hydrothermal phase, which means it is of deep seated and high temperature origin. The quartz and ore minerals are believed to be related to a nearby granite intrustion, and to have crystallized out of hot pneumo-aqueous solutions in preexisting cracks and faults in graywacke-slates and arenaceous rocks of pre-Ordovician age. The economic veins are practically limited to the exocontact zone of the mentioned granitic intrusion. The suite of minerals found is, for the most part, simple and typical of deposits of the paragenesis tin-tungsten-quartz in other parts of the world (Zinnwald, Bohemia, Czechoslovakia; Erzgebirge, East Germany; Kazakhstan, Central Asia, USSR; Mawchi, Burma; Kiangsi, China; Tasna, Bolivia; etc.). Superimposed upon the tin-tungsten mineralization there is a more recent lead-calcite mineralization occurring in brecciated faults as a cement without economic interest.

Of the minerals found at Panasqueira, wolframite, arsenopyrite, and apatite provide larger and more perfectly crystallized examples than any other known locality. Siderite also forms very large and showy crystals, and beautiful groups of large quartz crystals are common. While some other localities in Portugal, Bolivia and Brazil may provide larger or finer cassiterite crystals, the groups from Panasqueira are at times exceedingly fine, sharp, and much prized.

A complete list of the minerals found to date, in approximate order of abundance, follows. Those marked with an asterisk (*) are uncommon, or may have been observed only once or twice; those marked with a cross (†) are supergene.

Elements

*Bismuth
*Silver
*Gold

Sulfides

Arsenopyrite
Chalcopyrite
Sphalerite
Pyrite
Marcasite
Pyrrhotite
Stannite
*Bismuthinite
*Galena
*Chalcocite
*†Covellite
*Stibnite
*Molybdenite
*Pentlandite
*Cubanite
*Loellingite

Sulfosalts

*Pyrargyrite
*Stephanite
*Freibergite

Halides

Fluorite

Oxides

Quartz
Cassiterite
Rutile
Goethite
*Magnetite
*Hematite
*†Tungstite
*†Hydrotungstite

Carbonates

Siderite
Ankerite
Calcite
*Dolomite

Phosphates and Arsenates

Apatite
*Amblygonite
*†Scorodite

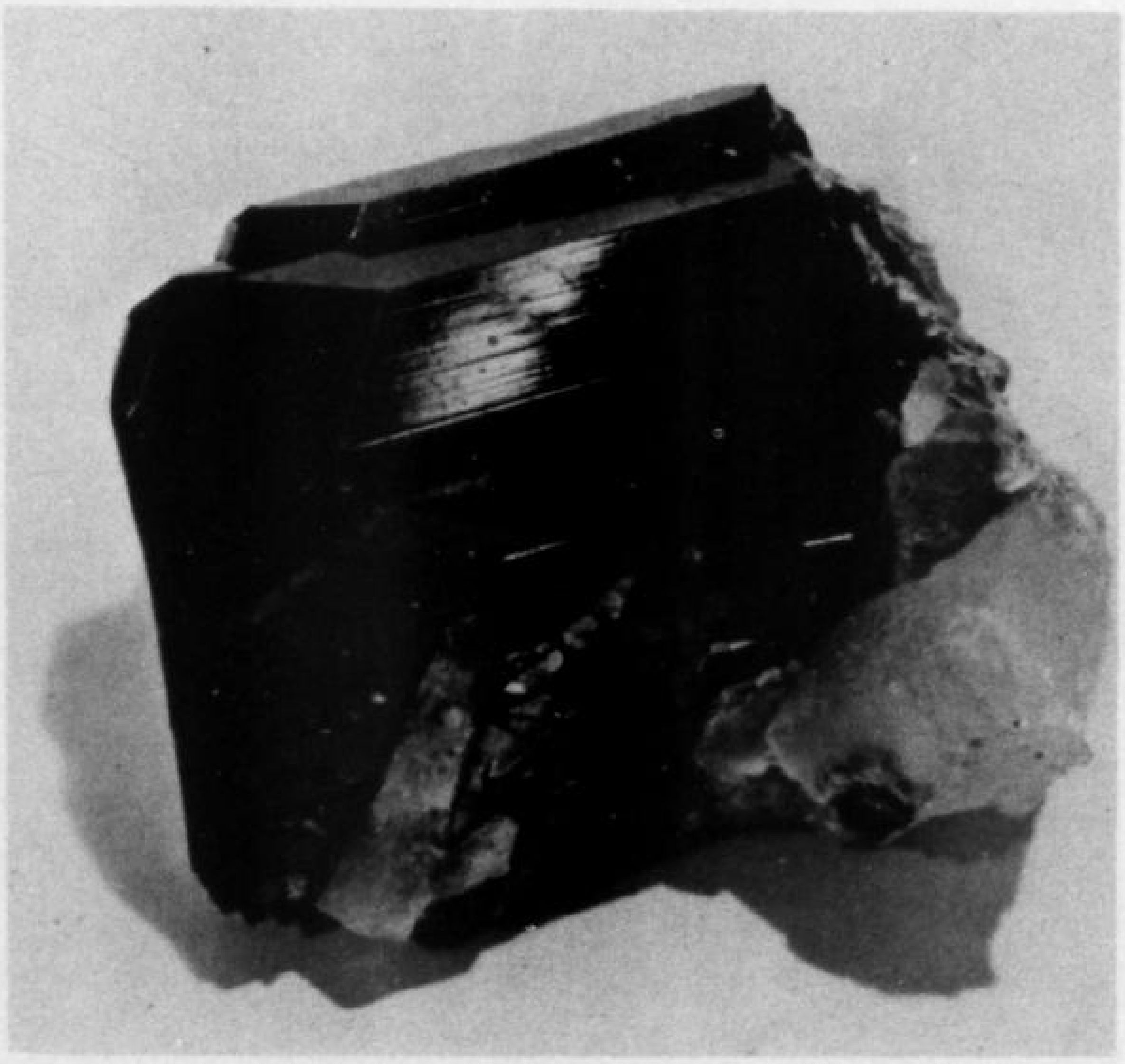
Tungstates

Wolframite
*†Scheelite

Silicates

Tourmaline
Muscovite
Topaz
*Beryl
*Bertrandite

Fig. 2. Wolframite in stubby, tabular crystals, 7 x 5 cm. Smithsonian Institution specimen. Photo by Joel E. Arem.



Not all of these minerals have been found in any one part of the mine. The silver minerals are confined to the Vale da Ermida section. The percentage of cassiterite exceeds wolframite at Corga Seca, Guerra and Vale da Ermida sections.

There follows a description of the mode of occurrence of some of the more noteworthy of these minerals:

Quartz

This is the principal mineral of the veins. When crystallized in vugs the crystals may be clear and up to 30 cm and more long. Often quartz crystals, as well as crystals of wolframite and apatite, are covered with a thin layer or selvage of muscovite or calcite, which may be flaked off but then leaves a slightly etched surface.

Cassiterite

Cassiterite is unevenly distributed in the veins, being common in the Vale da Ermida, Guerra and Corga Seca sections and in the deeper levels of the eastern Barroca Grande section, but almost absent from some of the richer wolframite veins. In recent years the tin concentrates sold by the mine have averaged only about 2% of the quantity of tungsten concentrates sold, which is also a measure of the relative abundance of cassiterite as compared to wolframite in the mine. By shifting the mining to tin-rich areas the ratio could change, as it has several times in the past—as recently as 1950 the cassiterite percentage reached 12%.

The color varies from black to pale brown through several shades of reddish brown. Crystals have been observed up to 3 cm across; they are invariably twinned and the conjugation of the {101} and {011} twins caused very curious complexes of 9 or 10 crystals shaped like cross-bits. Sometimes thick masses of crystals line the walls of veins originating a "comb" texture, at other times the crystals are thinly scattered on quartz mass but always near the walls of veins.

Wolframite

The magnificent crystals of wolframite from Panasqueira reach a maximum length of about 20 cm. They are a lustrous black color, the faces occasionally as sharp and perfect as mirrors. Single crystals are the exception; more commonly they occur in groups. A very common habit which seems to be characteristic of this mine is in radiating groups like the leaves of a partly open book in which individual crystals radiate from a line parallel to the "c" axis. Also, contact twins are seen with the composition face {100}.

Fig. 4. Cassiterite showing "cross-bit" habit. Crystals twinned on (101) and (011), Barroca Grande section. Specimens in the Ore Deposits Museum, Instituto Superior Tecnico, Lisbon.

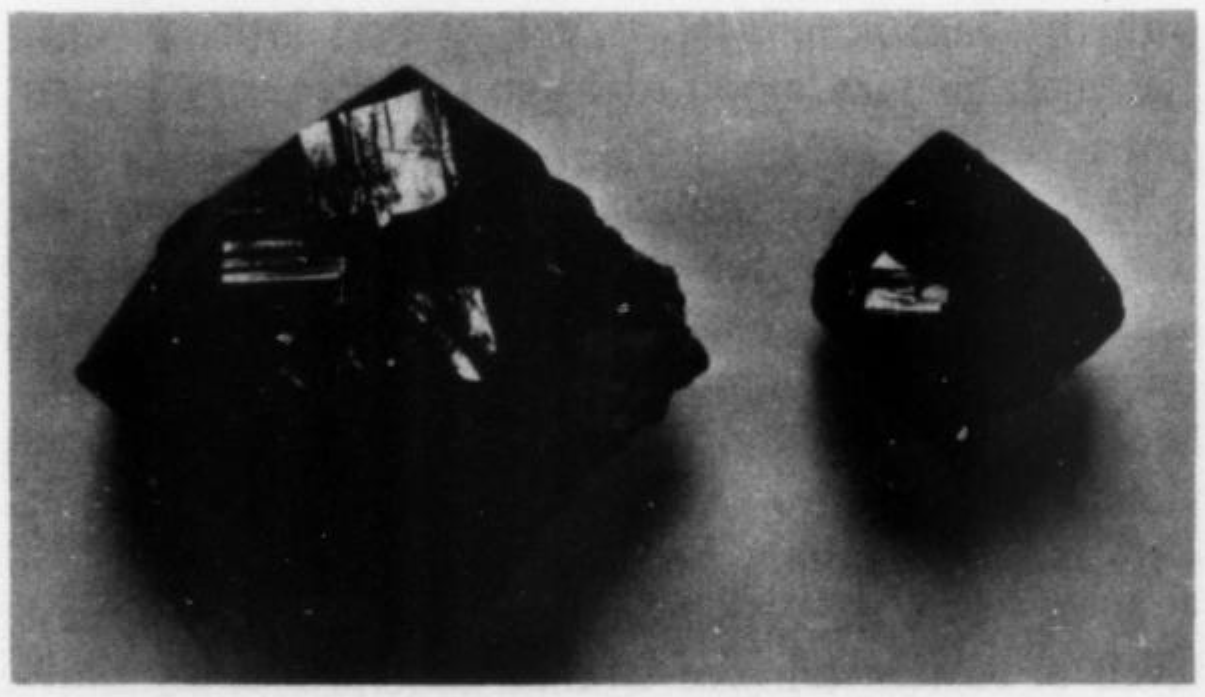


Fig. 3. Wolframite in parallel crystals, Barroca Grande section. Specimen in the Ore Deposits Museum, Instituto Superior Tecnico, Lisbon.

The Panasqueira wolframite is rather temperature sensitive, and crystals exposed to heat changes tend to cleave or spall suddenly. For this reason pieces of wolframite that get on the dumps tend to disintegrate to a pile of cleavage fragments within a short time. Similarly, fine specimens have been ruined by washing in hot water.

Often one or more faces of the wolframite crystals will be coated by layers of other minerals, particularly muscovite, or druses of siderite or apatite crystals.

The forms commonly observed are: {100}, {010}, {001}, {110}, {011}, {102}, {112}, {111}.

Arsenopyrite

Arsenopyrite forms extensive druses of crystals of more or less uniform size. Some crystal groups are extremely sharp and brilliant, the individual members attaining a length of about 3 cm. The common forms are {101}, {210}, {110}. At times very thick, broad, rough crystals are seen also in druses; these crystals are made up of groups of sub-parallel individuals, which attain a cross section of up to 3 × 5 cm, and a length of 6 or 7 cm. The color of the arsenopyrite is tin-white, and when it is associated, as it often is, with crystals of wolframite, apatite, or any of the other vug minerals, the assemblages can be very striking.

Chalcopyrite

Chalcopyrite is comparatively infrequent as crystals growing free in vugs, being more commonly inter-

Fig. 5. Siderite "ears" on chalcopyrite. The "ears" are 4 cm in diameter. Smithsonian Institution specimen. Photo by Joel E. Arem.

stitial to the other sulfides, or associated with sphalerite as an exsolution phase. When it does form crystals, they are tetrahedral in aspect and attain small size, as for instance only 2 or 3 cm. Chalcopyrite is recovered in the mill and amounts to about 40% of the quantity of wolframite recovered.

Sphalerite

Sphalerite is always ferriferous (marmatite) and is common in the vugs, where it forms tetrahedral crystals up to 3 cm or even to 5 cm with a rounded step-like habit. Due to its iron content, the color is dark.

Pyrite and Marcasite

Both pyrite and marcasite are rather common in the cavities, but generally as druses of very small crystals, seldom exceeding 1 mm in size. There can be found, however, pyrite cubes of about 3 cm.

Fluorite

Fluorite is a common mineral in the Vale da Ermida veins; it occurs in vugs, forming isolated cubic crystals up to 2 cm or parallel associations of cubes up to 7 cm in size. Rarely, the forms {101} and {321} are associated with {100}. The color is not uniform, showing bands of different shades which lie parallel to the cubic planes; the most common colors are violet, violet-blue, greenish blue, sea green and white or colorless.

Fig. 6. Apatite crystals clustered around the base of a quartz crystal. The specimen is 10 cm long. Smithsonian Institution specimen. Photo by Joel E. Arem.

Siderite

Siderite is one of the commonest vug minerals, having been formed late in the sequence of deposition. It forms rounded cream colored to brownish crystals of characteristic discus-like habit, which may attain a diameter over 9 cm.

Calcite

Calcite is the last mineral to have deposited, and may coat any of the earlier minerals with druses of rounded disk-like rhombohedral crystals.

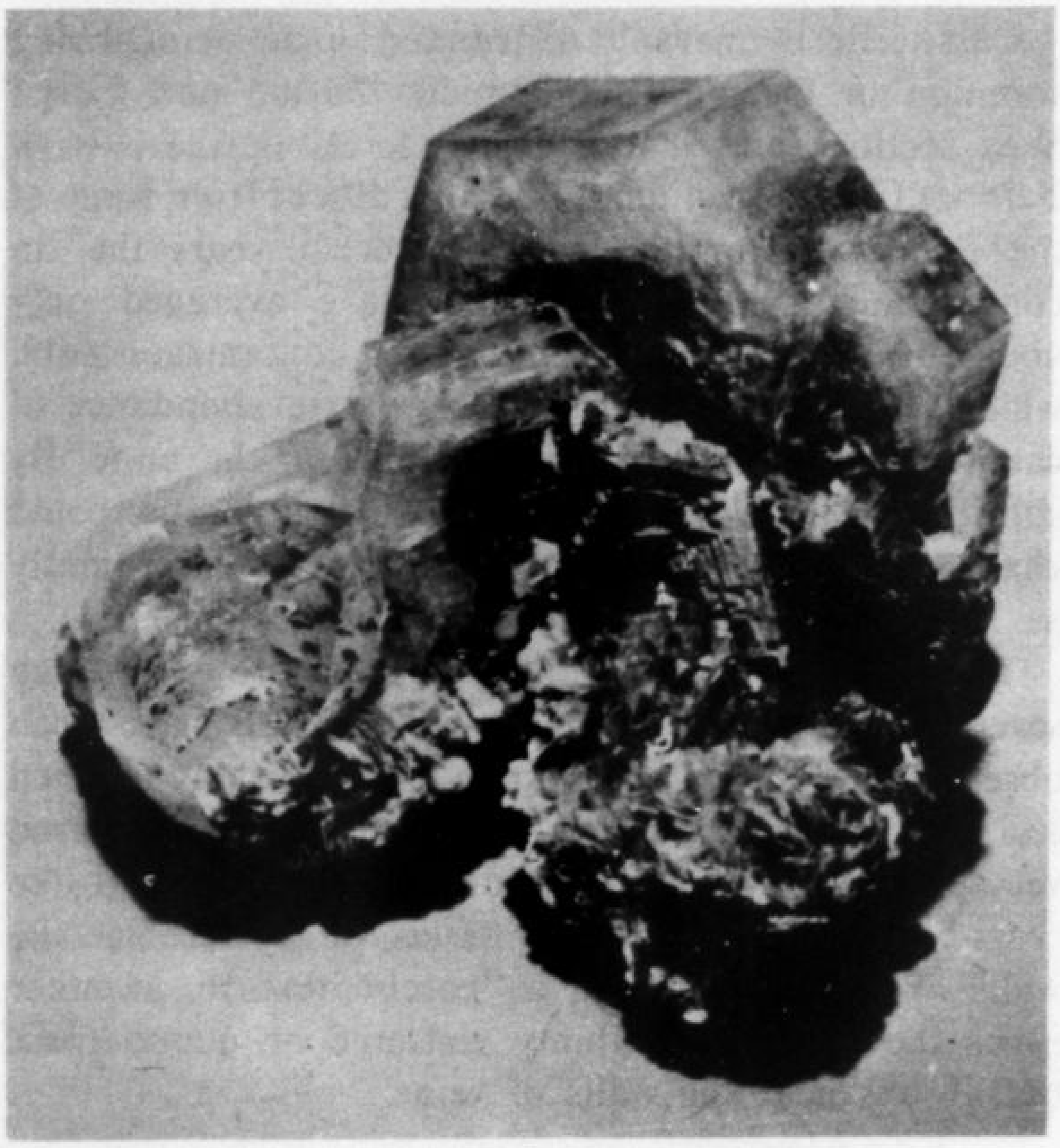


Fig. 7. Apatite crystals showing characteristic zoning. The largest crystal is 3 cm in diameter. Smithsonian Institution specimen. Photo by Joel E. Arem.

Apatite

The apatites from Panasqueira, for their size, brilliance and variety, are unexcelled anywhere. The crystals at times attain a size of 10 cm diameter by 5 cm thick, and are usually rather equant in habit, with the base prominent as well as first order prisms, and these in turn modified by minor accessory prisms and pyramids.

The crystals are usually translucent but may be transparent and, in the case of the larger crystals, are usually markedly zoned with dark and light growth rings. The most common colors are dark bottle green, light green, grey, and colorless, but white, sky blue, violet, and pale rose are also occasionally seen, as well as all gradations between these colors.

In the Vale da Ermida workings and in the deepest levels of eastern Barroca Grande section, a milky white

Fig. 8. Quartz with muscovite, 15 cm in length. Smithsonian Institution specimen. Photo by Joel E. Arem.

or cream apatite is found that fluoresces strongly yellow; it is an apatite of the wilkeite type.

Tourmaline

While tourmaline is very common, it is seldom seen in specimens from the cavities. The reason for this is that tourmaline was one of the earliest minerals to form by metasomatism, in the pelitic wall rock for a distance of up to a meter from the veins. It is always fine prismatic and brownish black in color. In the instances where tourmaline is found in the vugs, it forms velvety druses of acicular crystals. These can be a real hazard to the miners, as the little crystals are sharp and when handled penetrate the skin of the hands and body like nettles.

Muscovite

The commonest silicate mineral seen in the veins is muscovite, and not the lithian variety zinnwaldite as is sometimes stated. Muscovite forms occasionally a selvage up to 2 cm thick along the borders of the vein, and is hence an early mineral; it also had another rather late stage of formation, and is common in and around crystals in the vugs. Often large, fine crystals of apatite, wolframite, or quartz are coated with a druse of muscovite one or two millimeters thick, but these druses can, with care, be flaked off revealing the crystal below.

Topaz

Topaz is found in the veins of the western workings of Barroca Grande section. It forms, closely associated with quartz, a crustification along the borders of the vein with a greyish green color. The minerals are strongly corroded by muscovite. The crystals are rare and consist of a prism and a pyramid only; they are colorless but with numerous inclusions and of very small size.

Recovery of specimens

In common with the management of most mines, the management at Panasqueira discourages the collecting and selling of specimens by the miners. This

Fig. 9. Two groups of wolframite crystals in parallel growth, Barroca Grande section. Specimens in the Ore Deposits Museum, Instituto Superior Tecnico, Lisbon.

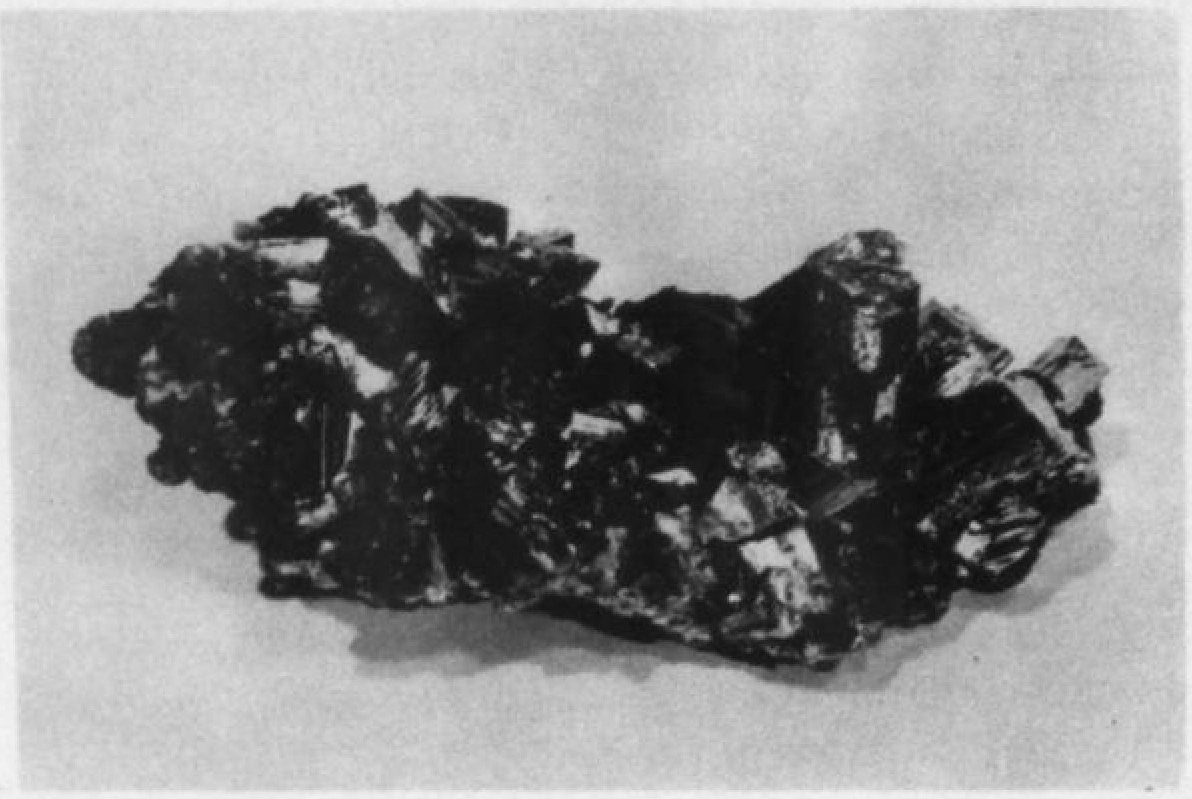


Fig. 10. A group of arsenopyrite crystals 13 cm across. Smithsonian Institution specimen. Photo by Joel E. Arem.

is understandable, as many of the miners would spend all of their time looking for minerals if allowed to do so, interfering with production. In fact, this form of activity is ground for dismissal for any employee caught doing it.

However, as the exceptional quality of the Panasqueira minerals have come to the attention of mineral collectors everywhere, dealers and collectors have come to Portugal to attempt to acquire some of them, and high prices are offered and asked for the better specimens. This has given rise to something of a black market in Panasqueira minerals. Some of the miners go to extraordinary lengths to smuggle specimens out of the mine; for example, the miners are allowed to bring old mine timbers home for firewood, and at times these are cleverly hollowed out to accommodate specimens inside. Usually, the miners then try to sell the specimens, at some risk, to local merchants, who in turn will sell them to collectors or dealers. When it has become known that a foreigner is buying minerals in the area, the Portuguese authorities sometimes step in through the local police, and confiscate the whole lot.

It is really most unfortunate that a system cannot be devised to recover and preserve some of the finer specimens that come to light, for it is certain that many of the best ones are destroyed and sent to be ground up in the mill. The mechanization of the exploration, on other side, will make more and more difficult the recovery of good specimens.

Quartz—Two New Blues

Richard V. Dietrich

Abstract.—Most, perhaps all, blue quartz appears blue in reflected light only. The blue appearance has been found to depend upon the scattering of light rays by colloid-size inclusions of minerals—rutile, magnetite, or tourmaline and possibly apatite and ilmenite—or by trains of similar sized bubbles. Quartz from a gneiss in the Blue Ridge of southwestern Virginia is thought to appear blue in reflected light because of closely spaced micro-fractures and/or inclusions of colloid-size crystallites of zoisite within the quartz.

Introduction

Blue quartz has been reported from several different rocks at world-widespread localities, e.g., from granite porphyry of Llano, Texas (Iddings, 1904) charnockites and gneisses of Mysore Province, southern India (Jayaraman, 1939); Cambrian and Ordovician metasedimentary rocks of Norway (Goldschmidt, 1954); and granodiorite gneiss of the central Wind River Range, Wyoming (Parker, 1962). Jayaraman (op. cit.) and Frondel (1962) have given summaries dealing with the probable cause of the blue appearance of blue quartz. Briefly, it is thought that relatively closely spaced colloid-size inclusions selectively scatter light of the relatively short visible wavelengths to give the blue appearance. The blue is seen by reflection only; a complementary yellow-red is seen as the result of transmission of light through the quartz. The selective scattering of blue wavelengths of light is the well-known Tyndall effect.

Prior to Jayaraman's rather comprehensive review dealing with blue quartz, nearly all of the inclusions considered responsible for the scattering phenomena had been identified as rutile needles. Exceptional were those in the granite porphyry of the Llano District of Texas which Iddings (op. cit.) tentatively identified as apatite and ilmenite. Jayaraman echoed Iddings' conclusions and emphasized the likelihood that the opalescent blue color of quartz may very well depend upon inclusions of any of a number of diverse minerals—"the scattering is primarily a function of the dimensions of the included material and of the difference in the mean index of refraction of the inclusions and the quartz." In support of this conclusion he described blue quartz with its color apparently dependent upon the selective scattering of light by "minute dust like particles of unidentified" material *in addition to* rutile. Goldschmidt's (op. cit.) report of blue quartz with included magnetite particles, Parker's (op. cit.) record of blue quartz with inclusions of tiny tourmaline needles, and the blue quartzes described below substantiate this conclusion. The blue quartz, the color of which is attributed by Gordon (1946) to the inclusion of "blue needles" identified as trains of bubbles, may be additionally corroborative.

Blue Quartz in Virginia

Blue quartz in several diverse rocks of the Piedmont and Blue Ridge provinces of Virginia and adjoining states has been recorded numerous times (e.g., Robertson, 1885 and Watson and Beard, 1917). Probably the most thoroughly investigated occurrences within the region are those associated with the titanium deposits in the Roseland District of Amherst and Nelson counties, Virginia. In Robertson's report, he noted the presence of rutile in blue quartz from that district and suggested that "in view of the color of some of the varieties of titanic oxide, when seen by reflected light, it appears possible that the partial reflection of light by the surfaces of these microscopic crystals occasioned the color in question, or the latter may be in a measure due to the interference of light occasioned by these crystals." Subsequently, the second part of his suggestion has been accepted, reiterated, and elaborated upon in a number of reports (Watson and Beard, op. cit.; Ross, 1941; von Vultee, 1955). Ross, in fact, presented a fine photomicrograph of this quartz showing rutile inclusions (with diameters ranging between 0.3 and 0.5 microns) arranged in a hexagonal network nearly perpendicular to the *c* crystallographic axis of the enclosing quartz.

Significantly, Watson and Beard (op. cit.) stated that "this variety of [blue] quartz is characteristic of some rock types of the Blue Ridge Mountains and its outliers in Virginia" and that they had "examined microscopically many thin sections of blue quartz from different localities in the southeast Atlantic states, and in every case a substance of the quartz was found to be crowded with hairlike inclusions of rutile." This

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latter statement has led to several suggestions and thoughts which have characterized the region as a titanium metallogenic province. Such a province may or may not exist—in any case, blue quartz, much of which exhibits asterism as well as the characteristic opalescence, occurs at many localities extending from at least Maryland to South Carolina. A few of these localities are given in Dietrich (1970); several more are well authenticated (Peter McCreary, personal communication, 1970).

The writer first became interested in blue quartz within the region during his reconnaissance mapping of Floyd County, Virginia (Dietrich, 1959). His interest was enhanced chiefly on the basis of geological considerations: 1) much of the blue quartz of the Little River Gneiss of the county appears not to contain rutile; 2) other minerals of the gneiss, e.g., biotite, which are commonly titanium-rich in titanium-rich rocks do not appear to be so within this rock unit; and 3) Late Precambrian and Early Paleozoic quartz-rich sedimentary rocks, which were very likely derived at least in part from the Blue Ridge rocks, contain little or no blue quartz. In addition, even present day sediments being derived from the blue quartz-bearing Little River Gneiss contain few if any blue quartz grains with smallest dimenions less than about 0.5 mm.

Both kinds of blue quartz described below were collected from the Little River Gneiss unit within Floyd County. This Pre-cambrian unit contains up to 25 per cent blue quartz at some exposures. Typically, the quartz occurs as lens-shaped composite grains which range between 10 and 30 mm. in greatest dimension. The other major constituents of the gneiss are biotite and microcline. The unit is highly sheared throughout the county. For a more complete description attention is directed to the reconnaissance report by the writer (Dietrich, 1959).

Specimens of blue quartz from the unit were submitted to light transmission measurements; studied with polarizing, metallographic and electron microscopes; digested in hydrofluoric acid and the insoluble residues submitted to *x*-ray analyses; heat treated; and compared to other quartz specimens for specific gravity and physical stability determinations. The results of these investigations follow.

The Two New Blues

Most of the blue quartz of the Little River Gneiss is grayish blue and has a greasy to opalescent luster. Just as has been reported for several other blue quartzes, it has an appearance similar to that typical of blue-gray chalcedony. Light transmitted through specimens of this quartz is yellow-red (wavelength 6500-7000 Å) which is essentially complementary to the blue seen in reflected light.

Antler-shaped crystallites of zoisite with an irregular to a roughly radiating distribution can be seen to occur in some of this blue quartz (see Figure 1). Identification of the crystallites as zoisite has been proved by *x*-ray analyses of the bulk samples, utilizing specimen rotation to minimize preferred orientation, and of insoluble residues after digestion of the specimens in hydrofluoric acid. As can be seen in the Figure, the crystallites have dimensions that range up to 0.2 microns in their smaller dimension and up to 35 microns in their greatest dimension; this compares to von Vultee's dimension values of 0.02 - 1 micron thick and 1 - 500 microns long, previously recorded for rutile inclusions in blue quartz. Concentrations so far observed in the Floyd County specimens indicate as many as 3.5 - 4 million inclusions per cubic centimeter; this exceeds the 0.4 - 2 million rutile needles per cubic centimeter recorded by Frondel (op. cit.). In any case, at least the smaller dimensions of the described zoisite crystallites are within the size range arbitrarily set for collodial particles (0.2 microns to 5 millimicrons) and this combined with their concentration and distribution gives the relationships generally considered appropriate to produce the Tyndall effect.

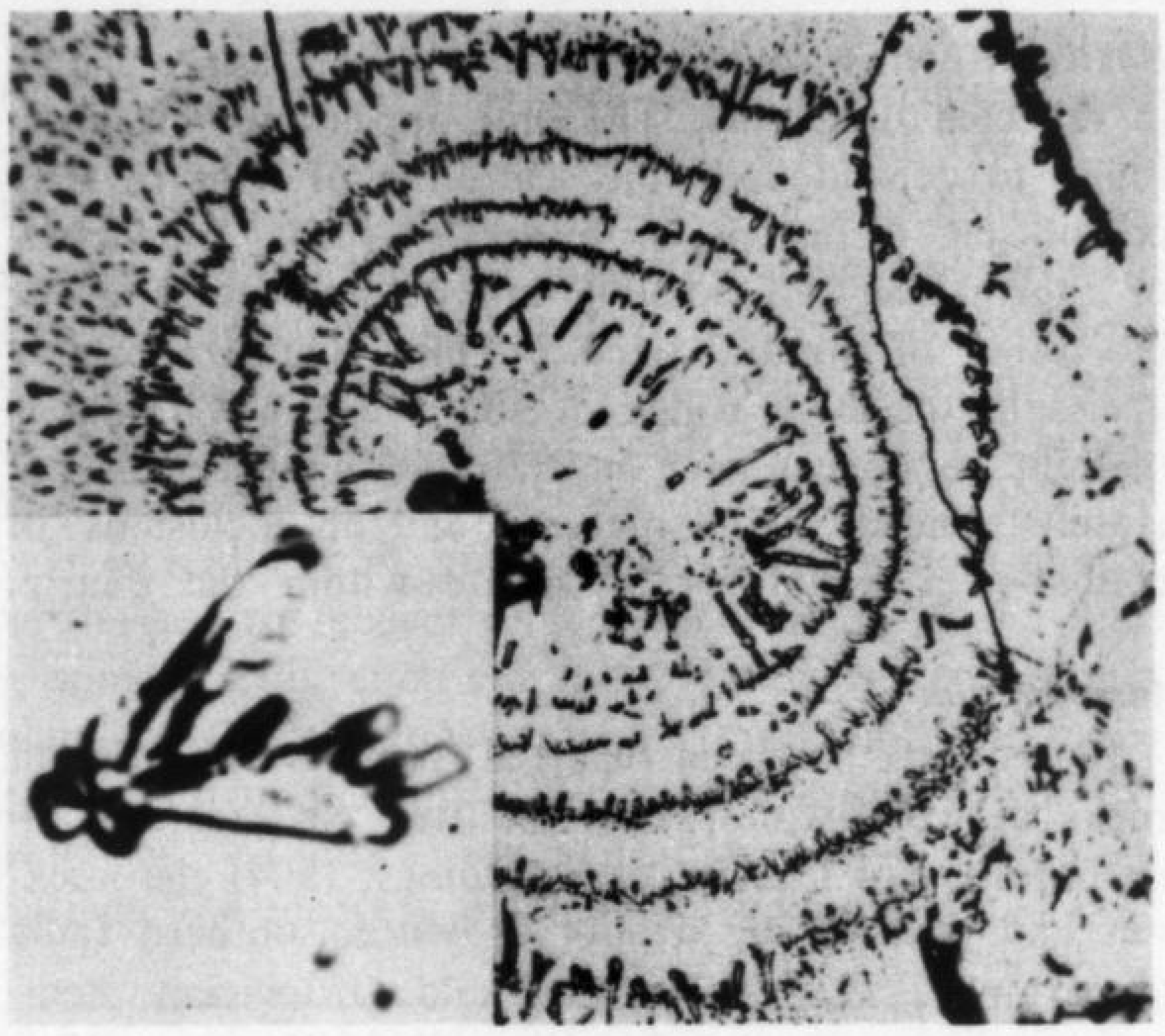

Fig. 1. Photomicrograph of zoisite inclusions in quartz: polished surface; magnification of main picture approximately 230x; inset in lower left is of an individual inclusion—length of nearly horizontal "wing" is approximately 20 microns.

Some quartz from the gneiss exhibits no inclusions when viewed with polarizing or metallographic microscopes even utilizing the highest magnifications possible with oil-immersion lenses. In addition, neither this quartz nor its residues give *x*-ray reflections indicative of mineral inclusions.

Both of these kinds of blue quartz have optical properties, such as indices of refraction, typical of those previously reported for strained quartz. When viewed between crossed nicols, however, both kinds may be seen to be extraordinarily highly fractured as well as strained (Figure 2). Numerous ***Boehm lamellae***[1] are

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[1] Fine lamellae, lines, or bands marked by dusty inclusions, subparallel to the basal plane (001) of quartz.

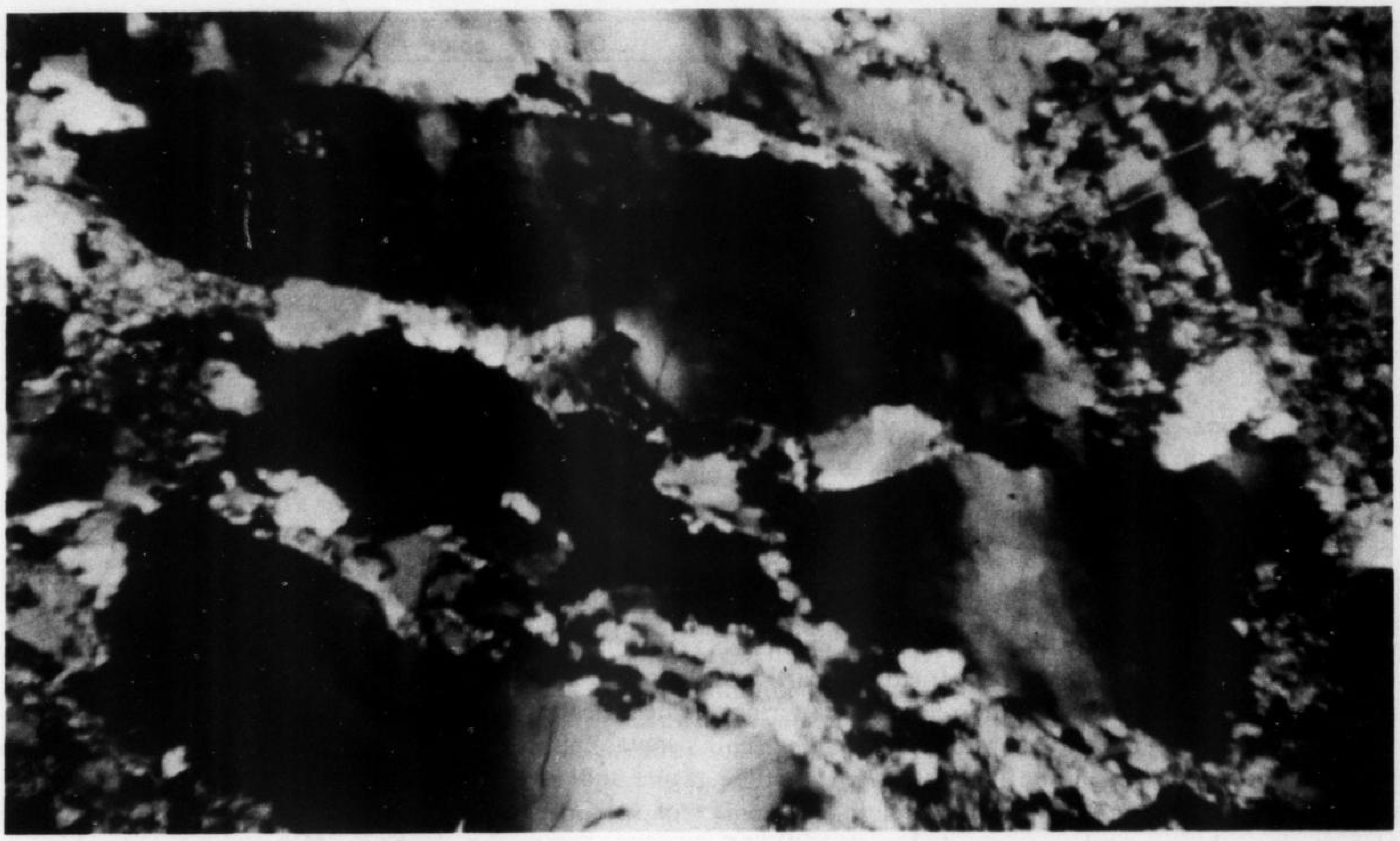

Fig. 2. Photomicrograph of microfractured and strained quartz: crossed nicols; longer, horizontal dimension of plate is approximately 18 mm.

evident and essentially all of the grains appear to be very near the point of fragmentation into nearly innumerable extremely small pieces. In fact, even the individually recognizable fragments, defined on the basis of having no well defined break in optical continuity, exhibit undulatory extinction which may manifest an even smaller scale (submicroscopic) of real or incipient fragmentation. In some cases, there is a readily apparent correlation between the degree of fracturing and/or strain and the depth of the blue color evident in reflected light.

The titanium content was determined for two specimens each of the zoisite-bearing and the zoisite-free quartz because of the suggestion (see, e.g., Frondel, op. cit.) that some titanium over and above that present as microscopic needles may occur and help account for the color of some blue quartz. The typical TiO_2-content is apparently 0.0X weight per cent (Frondel, op. cit.). The titanium content of the Little River Gneiss blue quartz specimens checked in this investigation is below the limit of detection by neutron activation analysis.

Specimens of each of the two kinds of quartz from Floyd County, along with rutile-bearing quartz from Roseland and specimens of amethyst, smoky, and rose quartz were heated in order to see if their color would be changed. As shown on Table 1, neither of these blue quartzes underwent any apparent change.

The specific gravities of representative specimens were investigated by comparison with colorless Brazilian quartz. Diiodomethane (methylene iodide) and an appropriate amount of carbon tetrachloride were mixed until the specific gravity of the solution was equal to that of the Brazilian quartz. For the specimens checked, the highly fractured, inclusion-free quartz floated in the liquid whereas the zoisite-bearing quartz sank. This may serve as a method to distinguish between the two for those who do not have polarizing microscopes or *x*-ray equipment available. In addition, it was determined that rutile-bearing quartz from Roseland sank in the liquid at an obviously more rapid rate than the zoisite-bearing quartz did.

Data relating to the physical reduction of the two kinds of blue quartz from Floyd County have been reported elsewhere (Dietrich, 1965). To summarize, both are reduced upon even relatively slight impact to extremely fine *colorless* grains.

Conclusions

On the basis of the known data it would appear that the blue color of both of these two kinds of quartz owes its existence to scattering of light by closely spaced micro-fractures manifest by diversely oriented extremely small segments of quartz. In addition, it appears that the described zoisite inclusions may also be responsible for selective scattering of light to give a blue appearance in reflected light. The first conclusion, of course, assumes an arrangement factor (see, e.g., Sanders, 1964) as well as a spacing of fractures such that either the fractures or the resultant particles present domains of the same order of magnitude as the wavelength of light. It neither requires nor pre-

Table 1. Temperature effects

Lapsed Time	Temperature, °C	Observed color				
		Blue #1a and 1b*	Purplish-Blue #2**	Amethyst	Smoky	Rose
72 hours	250 ± 20	same	same	same	slightly lighter	
30 hours	320 ± 10	same	same	slightly lighter	colorless	
14 hours	450 ± 10	same	same	colorless to white	colorless	colorless
48 hours	550 ± 20†	same	same	colorless to yellowish	colorless	colorless
72 hours	650 ± 10	same	less purplish	yellowish	colorless to white	colorless
1 hour	900 ± 30	same	less purplish	not run	not run	not run
1 hour	1000 ± 20	same	less purplish	not run	not run	not run

* #1a and 1b are Floyd County material.

** #2 is Roseland, Virginia, rutile-bearing quartz.

† Furnace may have exceeded high-low quartz inversion temperature (573 °C) once during this period.

cludes the possibility that air molecules, for example, may occur between some adjacent fractured particles and be in part responsible for the selective scattering.

Possibly the blue quartz from Rhode Island which was described by Emerson and Perry (1907) is another example of inclusion-free, highly micro-fractured blue quartz—they actually suggested that "a state of strain . . . probably produced a blue color."

Possibly corroborative to the writer's first conclusion is the observation that in artifically "highly crushed—generally at high pressures and low temperatures [—quartz] . . . a definite blue tinge characterizes some of the grains" (Neville Carter, personal communication, 1964).

An apparent discrepancy remains: In a previously published report which deals briefly with blue quartz from the Little River Gneiss it was noted that the quartz was found to contain microscopic and/or submicroscopic rutile (Dietrich, 1959). Restudy of the specimens upon which this original statement was based was not possible because the sections and hand specimens were apparently misplaced during a departmental move at V.P.I. Three main possibilities emerge as resolutions: 1) there was original misidentification of microscopic zoisite as rutile *plus* rutile contamination, or mixing (see alternative #2) of samples submitted to *x*-ray analysis; 2) there was mixing of specimens from the Little River Gneiss and specimens from the Amherst-Nelson counties district which, by the way, were being studied by a student at V.P.I. at the time of the original study of the Floyd County specimens; or 3) the Little River Gneiss contains blue quartz with rutile inclusions as well as the two kinds described in this report. The third alternative, although for many reasons the most appealing, has not been substantiated by examination of numerous specimens from the unit during this investigation.

Acknowledgements.—Drs. A. K. Furr and W. E. Foreman of V.P.I., R. G. Connell and D. A. Grey formerly of V.P.I., and Drs. L. D. Koehler, R. E. Kohrman, K. R. Lindfors, and F. M. Phelps of Central Michigan University aided with various laboratory studies. All these contributions are gratefully acknowledged.

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MINERAL NOTES

New Minerals

EVEITE

Eveite, $Mn_2(OH)(AsO_4)$, a new mineral from Langban
Paul B. Moore
Arkiv för Mineralogi och Geologi, **4**, 473-476, 1968

Eveite, $Mn_2(OH)(AsO_4)$, is the manganese analog of adamite, $Zn_2(OH)(AsO_4)$. It is found at Langban, Sweden where it occurs as an open-fissure mineral in apple-green warped tabular to barrel-shaped and sheaf-like crystals encrusting cavities and fractures in a slickensided fine-grained mass of banded hausmannite, Fe-Mn oxides and carbonates. The crystals are implanted on small brown flattened spears of akrochordite and do not exceed 2 mm in length. The powder is white, cleavage {101} is fair, and the mineral dissolves easily in cold 1:1 HCl leaving a colorless solution. The strongest x-ray lines are 4.39 (10), 3.058 (9), 5.09 (8), 6.10 (7) and 2.528 (6).

Eveite is a less dense dimorph of sarkinite (triclinic) and the two minerals, although both found at Langban, are not known to occur together. Eveite is in a distinctly different paragenesis since it is associated with high-hydrate and low-density arsenates in open cavities. The far more abundant sarkinite, on the other hand, usually occurs in filled narrow seams with adelite, tephroite, and sonolite—minerals which contain little or no water. In fact these latter minerals represent the more densely packed structures of the Langban fissure parageneses. It is not unreasonable to suggest that these fissure minerals formed under conditions of higher pressure, favoring the more dense dimorph, sarkinite, rather than eveite.

"Evite is named in light of its isostructural relationship with adamite. It alludes—in a serpentine way—to the famous couple in Christo-Judaeic mythology."

Orthorhombic—space group *Pnnm* or *Pnn2*

$a = 8.57$, $b = 8.77$, $c = 6.27$
$G = 3.67$(meas.) $Z = 4$
Biaxial (+) $\alpha = 1.700$, $\beta = 1.715$, $\gamma = 1.73$
$2V = 65° \pm 5°$, $r < v$ medium, birefringence moderately strong

DRESSERITE

Dresserite, the new barium analogue of dundasite
J. L. Jambor, D. G. Fong, and *Ann P. Sabina*
Can. Mineral., **10**, 84, 1969

Dresserite is found with weloganite (see *Mineral. Record*, **1**, 84, 1970) in cavities in an alkalic sill intruding limestone at St. Michel, Montreal Island, Quebec. Chemical analysis gave BaO 36.6, SrO 0.8, Al_2O_3 25.6, CO_2 22.2, H_2O 15.3, resulting in a theoretical formula of $Ba_2Al_4(CO_3)_4(OH)_8 \cdot 3H_2O$. This is the barium analog of dundasite.

(continued in next column)

Dresserite occurs in open cavities as white spheres and hemispheres averaging about 2 mm in diameter. Individual crystals comprising the spheres are bladelike. Dresserite has a sikly luster and a white streak, estimated hardness of 2 1/2 - 3, and it is readily soluble in dilute HCl with effervescence. Strongest x-ray lines are 8.09 (10), 6.23 (6), 3.66 (5), 2.73 (4) and 4.68 (3).

Closely associated minerals include weloganite, plagioclase, quartz, dawsonite, and an unidentified powdery hydrous aluminum oxide.

The name is in honor of J. A. Dresser (1866-1954) in recognition of his contributions to the geology of the Monteregian Hills.

Orthorhombic - space group *Pbmm, Pb2₁m, or Pbm2*

$a = 9.27$, $b = 16.83$, $C = 5.63$
$G = 2.96$(meas.), 3.06(calc.)
Biaxial (-) $\alpha = 1.518$, $\gamma = 1.601$
$2V = 30$ to $40°$ parallel extinction

New Data

LEADHILLITE-SUSANNITE

The leadhillite-susannite relation (abstr.)
Mary E. Mrose and Ralph Christian
Can. Mineral., **10**, 141, 1969

Mrose and Christian, through x-ray single-crystal, optical, electron probe, and infrared investigations, established that leadhillite and susannite are the monoclinic and trigonal dimorphs of $Pb_4(SO_4)(CO_3)_2(OH)$, and that susannite is the unstable high temperature form which reverts to leadhillite at room temperature.

LEADHILLITE (Tintic, Utah)
Monoclinic $P2_1/a$
$a = 9.08$, $b = 20.76$, $c = 11.56$
$\beta = 90°27.5'$ $2V \approx 10°$

SUSANNITE (Leadhills, Scotland)
Trigonal $R\overline{3}$
$a = 9.05$, $c = 11.54$
$2V = 0° - 3°$

Ed. note: *if leadhillite and susannite had been first described in recent years (instead of before the discovery of x-ray diffraction), they probably would not have been recognized as distinct species. Susannite is trigonal rhombohedral and leadhillite, while monoclinic, is strongly pseudo rhombohedral. It took very careful goniometry to reveal differences in morphology. Such goniometry is only rarely done today.*

(Continued from page 52)

Dear Sir:

Thank you for the Editorial Page in the Winter issue. I feel it helps point out some of the problems which are helping to stagnate Gem and Mineral Clubs. One point you failed to make is that most new (young) members are attracted to the clubs by some form of the Lapidary arts. These same members are usually sold on the idea of buying equipment, cutting material, mountings, etc., and as a result wind up with a large debt to that phase of the hobby. Unfortunately this debt has led to a genuinely mercenary attitude by the majority of club members which causes them to either overlook completely or take the wrong attitude toward mineral collecting.

This wrong attitude is fostered by the machinery of the Federations. Once I was in the trade (swap) room of a major show and two fellows came in with a bunch of nice minerals they had collected. Before I could make an offer to swap, several dealers were crowding around offering money. I made no swap with those gentlemen because of the dealers and when I complained about it to the show officials they pointed out that the dealers pay for the show and pretty much have their way. What effect did this act have on the youngsters who observed what happened?

Hope my comments don't offend anyone. I realize that the mineral dealer is an important part of the hobby, but then so are the enlightened amateurs.

Henry Barwood
Auburn, Alabama

Dear Sir:

Congratulations! The *Mineralogical Record* is just what both the professional and amateur need to be satisfied. For years I have been waiting for a magazine like that you have produced. I do enjoy all the nice photographs as well as the quality of paper and type of print—and not to forget the up-to-date information and excellent articles. Its a real contribution to both professionals and amateur.

Roy Kristiansen
Fredrikstad, Norway

Dear Sir:

Enclosed is cheque for $6.00 American funds. Please accept my sincere apologies for the delay in payment. I most certainly wish to continue this fine publication. Also, I assumed you would print only 4 editions as last year. Am extremely pleased you are graduating to 6 per year. It is the finest publication I have in my personal library.

Barbara A. Soth
Waterloo, Ontario, Canada

Dear Sir:

I have been delighted with the magazine—keep up the good work.

Veryle Carnahan
Whittier, California

On "Rings & Cylinders"

Dear Sir:

I've been pleased with the articles in the *Mineralogical Record* during the past year. Keep up the good work!

The article on Rings and Cylinders by Richard Bideaux is very interesting but contains a statement about iris agate that is wrong. The optical diffraction effects in iris agate are *not* caused by "parallel, closed spaced chalcedony fibers." The chalcedony fibers are *sometimes* twisted but this has nothing to do with the structure that gives the diffraction grating effects. I have explained the iris agate structure in publications:

Jones, F. T., *Amer. Min.*, **37,** 578 (1952)

Jones, F. T., *Lapidary Journal*, **20,** 34 (1966)

If any readers would like copies of these articles I can supply reprints.

Francis T. Jones
Berkeley, California

Micromount Dealers

Dear Sir:

In your response to a letter from someone in Lakewood, Colorado, you have stated that you "would appreciate recommendations from readers of dealers who offer first-rate micromount material." I have just become aware of the fact that there is a new dealership which is specializing in Micromounts and Micromount material. The two gentlemen who are running it have, for the past two years, done detailed x-ray diffraction and optical analysis of material from St. Hilaire, Quebec, and have identified many minerals previously not reported from the locality. Additionally, they have in preparation a book on the St. Hilaire minerals which is to be published in the not too distant future. The name of one of these gentlemen is David W. Richerson. The name and address of the new firm is:

Professional Mineral Services
Box 252
Greendale Station, Mass. 01606

Randolph S. Rothschild
Baltimore, Maryland

Dear Sir:

In reference to your request in the Winter issue for recommendations of first-rate micromount material dealers I wish to submit the following two dealers, who are well known for their choice micro materials of top quality:

1. Bideaux Minerals,
   111 W. Washington Street
   Tucson, Arizona
2. David New, Box 10
   Hamilton, Montana

(Mrs.) M. L. Scheffel
Royal Ontario Museum
Toronto, Canada

Dear Sir:

In the last issue of your publication, a subscriber asked for information concerning good dealers in micromount material. It is with pleasure that I recommend most heartily Mineralogical Research Co., 14770 Whipple Court, San Jose, California 95127, not only for micro material but for other fine specimens. This firm knows micromount material and strives constantly to list the best at reasonable prices.

I think that it should be emphasized that too many micromounters, and this is especially true of beginners, think that the prices of micromounts should be commensurate with their size. They will have to learn that good micro material, like specimens of larger size, will demand a price in keeping with quality and rarity.

In all fairness to the dealers, it should be pointed out that there is generally just as much work involved in labeling and packing the fifty cent specimen as there is in preparing for shipment one selling for ten times that amount. Their margin of profit on these small items, in most cases, is also micro in size.

Marvin H. Deshler
Phoenix, Arizona

Specimen Trading Through MR

Dear Sir:

A suggestion from a very admiring reader. Is there any plan to incorporate into the *Record* a section where collectors may purchase space for a classified ad for the purpose of TRADING MINERAL SPECIMENS? I can imagine full well that this thought may have already been considered and rejected for a good reason. I send it along anyway as it might be a good revenue producing section. I have really enjoyed the *Record* so far and wish you luck. I am pushing the magazine at local clubs and study groups held here at Boston University.

Pete J. Dunn
Boston, Massachusetts

Dear Sir:

I think a publication of this nature has been long needed to serve as a link between the technical journals and the amateur-oriented collector magazines. I am very impressed with the calibre of the articles presented and the color photos are superb. I hope the articles of this type will stimulate some of the "amateur" mineralogists to publish articles on new areas of mineralogical interest and on new finds of rare minerals so that material of this sort can be made available for research and similar investigations. I would also like to see the "Specimen Requests" column expanded to include a listing of rare and unusual minerals for trade and research.

J. F. Cooper, Jr.
Santa Cruz, California

In answer to the two letters above we are planning to initiate a section for mineral specimen exchanges in the near future. Thanks for the excellent idea. Ed.

(Continued on page 96)

Yedlin on Micromounting

There have been available at recent shows some fine muscovite clusters from Boiling Springs, Cleveland Co., N.C. (We've seen some from a locality noted as Cranford, N.C., same material, same county.) The mica crystals range from m/m size to 1 inch on an edge, and are quite beautiful in themselves, but are most interesting because they are studded with bright red needles, clusters and reticulations of rutile, some of which exceed 1-1/2 inches in length.

We bought a 2 × 3 piece of this stuff at last year's Franklin, N.J. show, and because of its locality studied it rather carefully. Some 12 years ago similar muscovite was coming out of Brooks' farm in Cleveland Co., and this material had been the host of superb crystals of anatase, brookite and rutile.

Better to observe the recently acquired specimen we "cooked" it in an oxalic acid solution to remove iron stains and loosen clay-like deposits in the interstices in the mica. This was done by making a solution of the acid powder until it just dissolved in a beaker of water, dumping the specimen into the liquid, and placing the whole into an ultrasonic cleaner. We were impatient and knew that the acid would not injure the specimen. (Soaking for a few days has the same effect.)

A rinse, a dry, a look, and we found that the muscovite was clean and sparkling, the rutile was clear and bright, and six crystals of golden monazite appeared, on the surface and edges of the mica—magnificent!

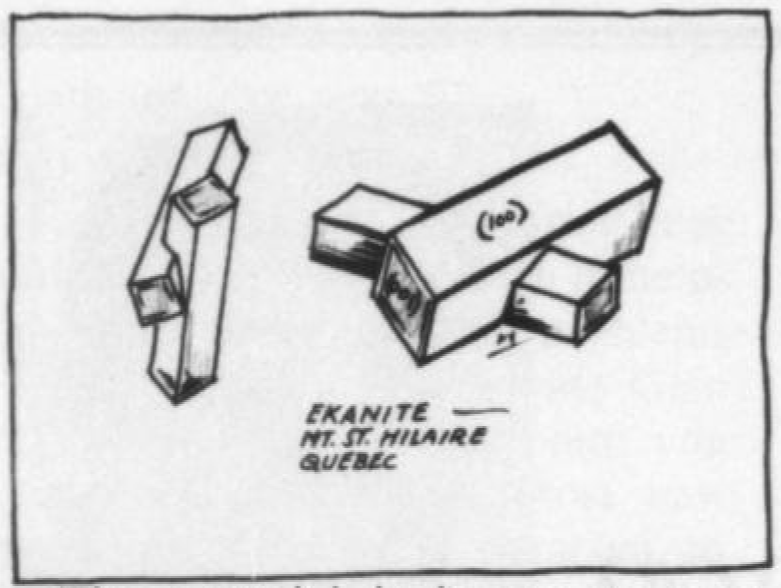
Checking back on our old anatase material from Brooks' farm we found that monazite appeared there, too, in fine yellow crystals, but sparsely. Our new material, from Boiling Springs, seems to be devoid of anatase and brookite, although this may only be the case in the one piece we have. We're looking for more information.

This muscovite is presently available on the counters of many dealers. Suggest you get some and play with it carefully. If you can "latch on" to any of the Brooks' farm stuff, do so. The anatase is as fine as any to be found.

Errors: Two of them cropped up in one item, one of omission and the other of commission. Like a shortstop failing to read a "pickoff" sign and then throwing wildly into right field. Anent the plastic box mentioned in the winter, 1970 edition of the *Record*, the distributor is Oceanside Gem Imports, (M. & H. Sklar) P.O. Box 222 (426 Marion St.) Oceanside, N.Y. 11572. Since Milt & Hilda Sklar are either in Brazil acquiring new mineral and gem specimens, or attending shows throughout the country distributing them, their mail may not be responsive enough for you. Try an evening (N.Y. time) telephone call, 516-678-3499. Error No. 2: Price is twenty cents each in lots of 100 (twenth-five cents each in lesser quantities) not ten cents, as previously stated. This is a fine box at any price.

New Data: Peter Tarassoff of Quebec has just sent a copy of a short paper by Perrault and Richard (Ecole Polytechnique de Montreal) anent Mt. St. Hilaire, Quebec unknown no. 4. The mineral has been identified as ekanite.

(continued on next page)



The material is brown to grey-brown, with the principal forms the tetragonal prism {100} and the pinacoid {001}. Chemically it is a silicate of thorium, calcium, sodium, potassium, etc. Out specimens are on albite, analcime, and aegirine, with many associated silicates. Once seen the mineral is readily recognized for its square prism, and right angled crystal habit, are dead give-aways, (See sketch.)

At one time we surmised that new minerals from this locality were being found faster than they could be identified, but the tide has turned. Chao, Gait, Harris, Hounslow, Mandarino, Perrault and Richard are but a few of those working on the mineralogy of this fabulous area. It should not be too long before complete cataloguing takes place—barring new and unusual finds. Mt. St. Hilaire! We feel that every micromount collector is obligated to visit this locality. No one has yet returned from it without at least a dozen speciments for mounting.

At the Tucson, Arizona convention (a fine meeting, by the way, the exhibits, available material, lectures and demonstrations were outstanding). Paul Desautels, of the Smithsonian, and this writer were privileged to judge the micromount competition. There were 11 entries and all the competitors were members of the Phoenix, Arizona Mineral Society. Each entrant displayed 10 m/ms, and it was our pleasure to look at each one of them, independently evaluating it numerically, totalling the score and subsequently averaging our results. The show directors left nothing to be desired, for 'scopes, light, tables, writing materials and a segregated area were all available—a professional job.

The m/m work was uniformly good. The specimens, for the most part, were carefully selected and were well mounted. It appeared that all contestants learned from the same teacher for there was a unanimity of technique that unmistakably indicated the modus operandi of one person. Many specimens were free of matrix. Most were mounted on *cactus* needles. Many were single crystals. Minuteness seemed to be in order, and it appeared that the collectors were intent on displaying as small a specimen as possible. Regional collecting was evident too, for most of the minerals were local and western, and perhaps indicated that the material was self-collected, an admirable thing. This regional situation is not unusual. The early collectors in the Philadelphia area—Jefferis, Boyle, Wills, Brinton, Trudell, Holden, *et al*—would collect, bring all their duplicate material to meetings, sit around a revolving table loaded with 'scopes, set up specimens, and at a signal give the table a short turn to the next 'scope. (We own that table, and use if constantly.) Thus most collections had the same minerals, and it was only when the Foote Mineral Co., or G. L. English (he, too, was a m/m hobbyist.), or Fiss, or Rakestraw disseminated foreign material that the collections became diverse. This is true today. New England collections are top-heavy with minerals from the Maine pegmatites, the New Hampshire phosphates, the minerals of the traprocks, the St. Hilaire suites, etc. The southeast collectors specialize in things from North Carolina, from the Alabama phosphate area, from Georgia, etc. Many west coast collectors exhibit suites of the minerals of the lithium pegmatites, borates, etc. They do not preclude others, in fact they strive to obtain them, but availability is the keynote. Good. Such assemblages are necessary for the science of mineralogy.

Interestingly, one of our early precepts was carried out. It has been our contention that it is not important that your work is better than your neighbor's. It is important, we think, that your work is better today than it was yesterday, and that it will be better tomorrow than it was today. At Tucson a set of standards was established, and these varied with the status of the contestant. For the novice, a 75 point total merited a blue ribbon. For the master, the line of demarcation was 90 points. This, then, permitted more than one blue ribbon in each class, and detailed the value of the work as compared to a mean. We feel that such technique in judging is a proper step in the educational process. At Tucson there were 11 blue ribbons, attesting to the fine quality of the work done.

The crystals of rose quartz from Plumbago Mt., Newry, Maine, are quite frequently associated with eosphorite in individual tan flat crystals, and clusters of blades, attached to the albite matrix which is the basic ground mass. Eosphorite is orthorhombic, in bladed terminated crystals, and is one end member of the eosphorite-childrenite series, where eosphorite has a manganese content in excess of iron, and childrenite an iron content over manganese. The Maine material was once called childrenite, and where the crystals were a dark chocolate brown rather than tan, it was casually referred to by early collectors as the latter species.

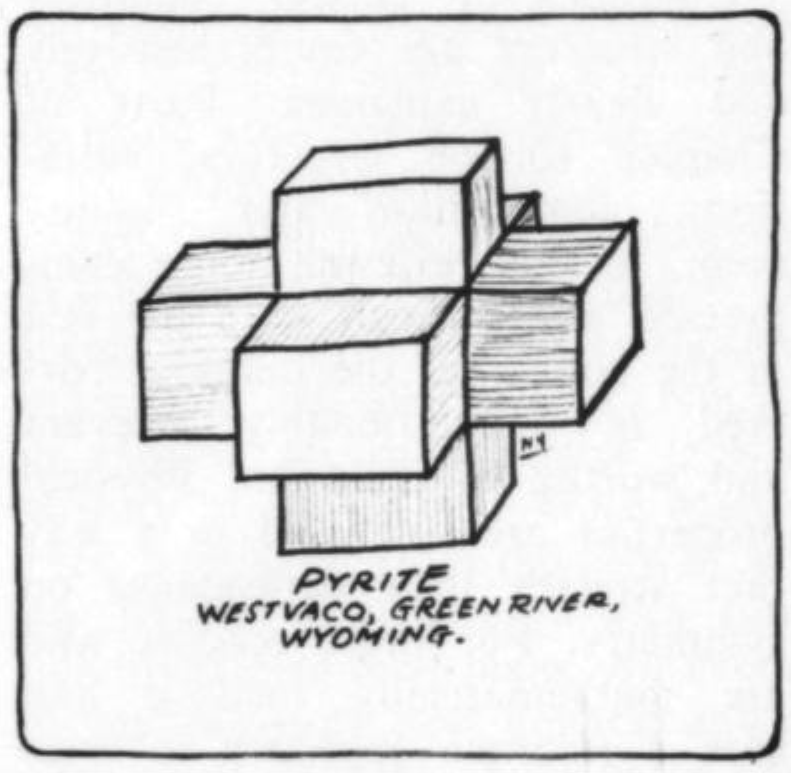
The dealers now have rose quartz in fine crystals from Taquaral, Minas Gerais, Brazil, and associated with much of the quartz are clusters of rather dark brown eosphorite. Some of this makes superb m/ms, and where Maine and Brazilian material are exhibited side by side, together with childrenite from Cornwall, England; and Llallagua, Bolivia; an interesting study suite is presented. Try this for m/m competitions.

An old friend is again heard. Ten years ago, and prior thereto, Hatfield Goudy (now of 2303 Russ Bldg, San Francisco, Cal. 94104) supplied the collector with fine m/m material and mounts. One vivid recollection is the uvarovite that he furnished, from near Jacksonville, Cal., usually on a lavender kammererite matrix. He attended the Pacific M/M conclave at Santa Monica this year, and we dined together and "jawed" over old times. He has issued a new price list, available for a stamp. The latest ***American Mineralogist*** has a cross section, in its ads, of the things he has available.

In an early catalog Mr. Goudy gave a brief and informative outline of his conception of m/m mineralogy. So closely does it conform to our own ideas that we plan to include portions of it in future columns. It clearly tells "what it's all about."

Some years ago, when Dr. Charles Milton was at the Geological Survey in Washington he showed us some pyrite crystals, extracted from the drill cores of the Westvaco mine, Green River, Wyoming. These pyrites were most unusual, looking like children's iron "jacks," played on a flat surface with a rubber ball. At first they were thought to be "trillings," and were described as "triaxial" crystals.

This occurrence has just been fully detailed by A. Pabst in the *American Mineralogist*, Vol. **56**, 133, 1971, in an article entitled "Pyrite of Unusual Habit Simulating Twinning, etc."



The photographs and sketches indicate weird crystals. We were fortunate in acquiring a few. We strongly suggest you read the article and become familiar with these pyrites. It will help in determining true twinning in some of your own specimens. For those to whom the publication is not available we've sketched one crystal—rather idealized, as are most line drawings of minerals. Our thanks to Dr. Milton for permission to do this. Imagine not being a micromount collector and being deprived of the chance to see such things!

Meanwhile, buy and use a good mineral book. ■

Neal Yedlin

The Record Bookshelf

Crystal Growth in Gels, *by Heinz K. Henisch, Pennsylvania State University Press, University Park, Pa., 1970, 111 pp., ($6.95)*

Few aspects of laboratory science remain that can be pursued by scientists and nonprofessionals alike, without generous funding. Crystal growth is this kind of endeavor, since it is generally acknowledged to be both an art and a science. Gel growth is especially stimulating; remarkable results can be attained with minimal apparatus, impure reagents and a spark of intuition. The techniques of crystal growth in gels have been cogently summarized in this delightful little book by Heinz Henisch.

A text that is both informative and readable is a rare and highly desirable item. When the same book also stimulates the inception of ideas for experiments and new lines of thought its acquisition becomes imperative. *Crystal Growth in Gels* is such a book. After a brief historical introduction, Henisch discusses gel preparation and characteristics of crystal growth and nucleation, and current problems. The beauty and perfection of gel-grown crystals, illustrated by numerous high-quality photographs, provide constant stimulation for the reader to dash off to the nearest hardware store for a can of water-glass (sodium silicate solution, which gels when acidified). But this is not even requisite since many types of crystals can be grown easily in household gelatine.

The book may seem a bit expensive considering its size. The information it contains, however, is well worth the price, and the lucid and entertaining style of writing Henisch employs is an added bonus. *Crystal Growth in Gels* should be read by anyone interested in an unusual method for growing crystals, a method that may be responsible for the growth of many natural materials by relatively unstudied processes. ■

Rocks and Minerals, *by Richard M. Pearl, Barnes and Noble (Everyday Handbooks, No. 260), N.Y., 1956, 275 pp., ($1.95)*

One might argue that the fields of mineralogy and crystallography, geology, gemology, economic geology and meteoritics could not possibly all be treated in a single book. After reading Pearl's text, however, one is convinced that a comprehensive survey of all these fields in a single work is possible. With the additional advantage of a low-cost paperback, Pearl's *Rocks and Minerals* is an ideal introduction to the panoramic scope of earth science.

Pearl does not waste words. Each chapter is brief and to the point, but remarkably comprehensive. The style of writing is lucid and compact, yet entertaining and easy to read. One has to go back and study the text page by page in order to realize that it consists of one fact after another, in logically developed sequence. A first reading conveys a far greater sense of narration and explanation than of bare, factual condensation. The book contains a comprehensive glossary and index, but is far more useful as armchair reading material than as a reference work. It is too enjoyable to waste only on specific inquiries. A small section of color plates is included, but they are of such poor quality that they cannot be factored in weighing the merits of the book, and are best ignored.

No one book, of course, can be considered an educational panacea. Every author brings his own special insights to his subject, and every book will be "the most suitable" for a certain group of readers. *Rocks and Minerals* is, however, an excellent gateway to a broad spectrum of geologic knowledge, and is written for readers of all ages. Furthermore, it will continue to be informative every time it is consulted, and more can hardly be asked of any technical popularization. ■

The Curious World of Crystals, *by Lenore Sander, Prentice-Hall, Englewood Cliffs, N.J., 1964, (6th printing: 1970), 64 pp., ($3.25)*

Crystal enthusiasts come in all sizes and shapes, and range in age from sub-teens to octogenarians.

(continued on next page)

But all of these eager devotees rely for understanding of crystals on the same basic facts. These can be presented in various formats and with varying degrees of sophistication, but the facts remain the same. Sander's book treats them lucidly and directly and therefore is a fitting shelf-mate even for the most advanced text.

The Curious World of Crystals is written specifically for the elementary school student (about 5th and 6th grade level). But it could well serve any interested adult whose introductory chemistry and physics courses remain obscured in mistily-forgotten past trauma, or who simply needs review of such things as states of matter and the nature of atoms and molecules. After all, one might argue, if a 10 year old can know about atoms why can't you? And the stimulus to learn about these things is given by the author on page 1, with the reminder that "crystals are everywhere." The remaining pages are devoted to such subjects as patterns in crystals, solutions, growing crystals, crystal shapes, and techniques for growing sugar crystals. This reviewer found the mention of certain topics, such as screw dislocations and p- and n-type defects (transistor theory) perhaps a bit too much to expect a 5th grader to assimilate in one bite; certainly exposure to the terminology cannot hurt, especially when one considers that transistors and dislocations affect all of us every single day of our lives.

Sander's book definitely fills a gap in the literature of crystals, and fills it well. This gap is caused by the increasing sophistication of young people, and their ever increasing capacity and demand for technical information. In an age when grade school children play with computers and learn to count in binary via the "new math," *The Curious World of Crystals* is a welcome addition to any school or home library. ■

Crystallography and Crystal Chemistry, by F. Donald Bloss, Holt, Rinehart and Winston, New York, 1971, 545 pp. ($15.95).

The excellence of this latest work by F. Donald Bloss will come as no surprise to those already familiar with his superb ***Introduction to the Methods of Optical Crystallography*** (see *Min. Record*, **1**, 129). The circumstances involving marketability and timing of publication are the same for both books; both have been published at a time when several good texts were already currently available in their respective subject areas. It is a tribute to Prof. Bloss that his optical crystallography book immediately rose to a top position among works in its field. The current offering, *Crystallography and Crystal Chemistry*, should follow the same pattern.

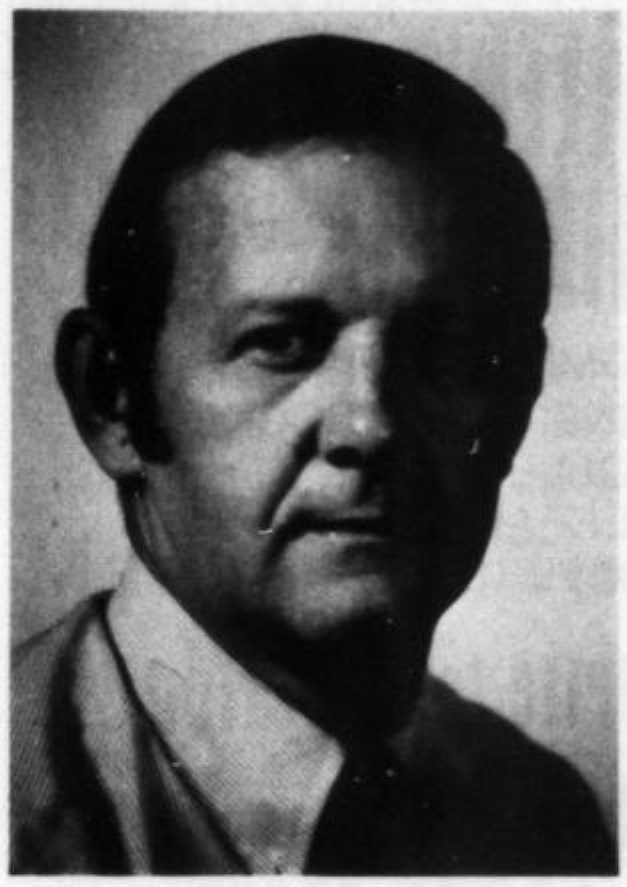
As with the optical book, *Crystallography and Crystal Chemistry* is noteworthy in two respects: clarity of presentation of text, and masterful and ingenious drawings and figures. The contents of the latest work are not much different from those to be found in numerous other texts. No one book can cover all the various aspects of crystallography and related areas of materials science, mineralogy, X-ray diffraction and physical chemistry. The reader must therefore carefully select the book that contains information most relevant to his work and/or interests. Bloss has included a range of subjects that will be of interest to mineralogists, ceramists, chemists, solid-state physicists and metallurgists. This selection is aimed at the student just beginning to study crystallography; but it is an excellent overview for the mineral collector who may not realize exactly how wide a diversity of disciplines uses crystallography as a working tool, and how many of these studies relate directly to minerals.

Bloss treats external symmetry of crystals first, rather than internal symmetry; this "debatable decision", as he puts it, assumes that operations of external symmetry are simpler and grasped more easily by the beginning student. The first 150 pages of the book cover crystal classes, crystal systems and axes, symmetry, nomenclature, forms, lattices and projections. The chapter on projections is detailed and rigorous, and will prepare the student adequately for discussions of graphical representation of crystallographic measurements. Such background and training are invaluable to any serious student of earth sciences. The drawings and analogies in the first few chapters are especially lucid. Concepts of plane, axial and inversion symmetry are illustrated by a football field, a world globe, and a room containing a table and chair (the inversion operation produces duplicates of these that hang from the ceiling). Rotation and inversion axes are illustrated by showing the positions of a human hand after rotations and reflections. The text is extremely readable, almost conversational, and tends to be wordy where more words seem necessary to explain a difficult point. The presentation of space group symmetry operations (glide planes, screw axes) is especially well illustrated. The chapters on crystal chemistry and structural variations, composition and stability will be useful to the college student as well as to the serious mineral collector.

Concepts of crystal chemistry and structure are comprehensively and clearly explained. Parts of Chapter 10, on structural variations, composition and stability seem, to this reviewer, more compressed and difficult than the rest of the book, but the material covered is unquestionably relevant and worthy of inclusion. Physical properties are discussed in a way that stresses their dependence on symmetry. For those readers who are mathematically inclined and seek a rigorous approach to crystallography, a section on tensors should prove challenging. The final chapters, on crystals and light

■

Reviews By Joel E. Arem



The Museum Record

Paul E. Desautels

Bigness in mineral museums doesn't necessarily mean wealth. As a matter of fact, it is often much more costly to keep going when you have a big establishment. It is always surprising to me, then, when I see one of the big, old-line museums of the East raise sufficient resources to update its physical plant or public exhibits of minerals. The Smithsonian went through the process of reviving its mineral and gem exhibits more than ten years ago. Already showing age, they need to be done again. Accordingly, I try to keep up with what is being done elsewhere in order to be ready when our turn comes again. I find at the moment that there is quite a bit going on elsewhere.

Ted Downs from the Los Angeles County Museum recently stopped in Washington for some discussion about mineral exhibits. Something big seems to be stirring at his establishment at least and we should hear much more from that quarter later. Not too long after his visit I had the pleasure of another one of my quick trips to the American Museum of Natural History in New York. Vince Manson was there with his exhibit designer Fred Bookhardt from the firm of W. F. Pederson, architects. Putting aside my feelings of jealousy—with some difficulty—I found myself greatly impressed with their plans. An overall model and some arthitect's drawings of the proposed new mineral and gem exhibit were paraded before me. The whole concept—both as to architecture and content—is a departure from anything that has been done before. If the finished product turns out as good as the plans we all have a treat coming up.

The latest of the big collections to complete a renewal project is the one at the Royal Ontario Museum in Toronto. We've already heard much about the new mineral and gem exhibition galleries there. If you've missed their show and can't make the trip I suspect that the curator, Joe Mandarino, or one of his colleagues can arrange to supply you with their very attractive descriptive brochure.

At the time these new exhibits were being constructed I was interested enough to do a little investigating into the history and development of the mineral and gem exhibits at the Royal Ontario Museum. Interestingly, the mineral collection predates the Museum itself. Its origins arise in the mineral collections of the University of Toronto, the Victoria University and the Ontario Provincial Museum.

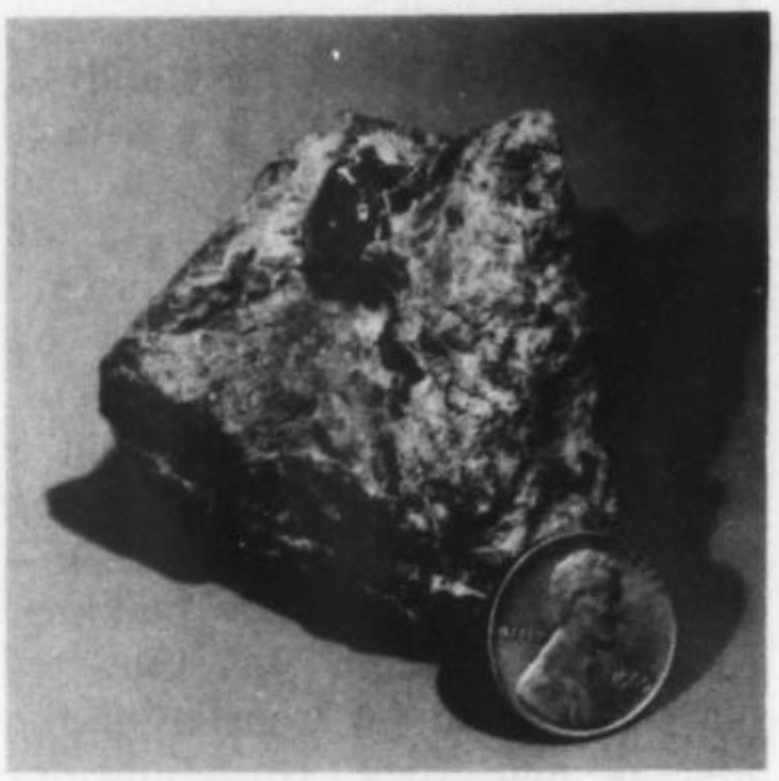
In 1894 the University of Toronto purchased a large private collection belonging to Dr. W. F. Ferrier of Ottawa (for whom ferrierite was named). This collection was displayed in the Biology Building which then housed the Department of Mineralogy. Under Professor T. L. Walker's leadership from 1901 to 1937 the collection was constantly improved as it was later in succession by Vic Meen and lastly Joe Mandarino. By 1912 the west wing of the new museum building had been completed on the edge of the University campus. The minerals were moved from a basement room of the Mining Building—their home at the time—to the top floor of the new building. The public museum was thus begun, augmented by transfer of the mineral and rock collections of Victoria University. Specimens of this new addition were in generally miserable condition from fire damage. These were the years of the first recognizable presentation of the Royal Ontario Museum mineral collection to the general public.

(continued in next column)

By 1932 another new museum wing was completed and once again the collection was moved. It came to rest in a very much larger and better equipped display gallery, of the old style, on the ground floor of the new section. A complete refurbishment and rearrangement of the exhibit was again the order of the day but there was no great breakthrough in concept. It was possible by now to mount a really fine systematic mineral exhibit because the collections of William Morris, Henry Montgomer, Andre Dorfman, Culbert, W. Hamilton Merritt, Dillon Mills and others had already been absorbed. There had also been numerous gifts, purchases and exchanges.

It was not until 1969, three quarters of a century after purchase of the Ferrier collection, that the first real change in direction materialized. The only thinkable public exhibit up to this time had to be centered about a comprehensive systematic collection. Under Dr. Joseph Mandarino, who appreciates a good mineral specimen as much as anyone I know, the new exhibit was planned to develop a series of concepts about minerals and mineralogy. The systematic collection was very firmly de-emphasized.

What is so interesting about this development is its similarity to the one now proposed at the American Museum of Natural History. The trend seems to be toward paying serious attention to communicating



Sperrylite from Poltgietersrust, Transvaal, South Africa. A matrix specimen of one of the very few extraordinarily large (1/2 inch) crystals ever recovered. Smithsonian Institution.

Zoisite (tanzanite) from near Arusha, Tanzania. Perhaps the finest of the larger gem crystals, 2 x 1 x 1 inches, transparent, blue. Smithsonian Institution.

to the general public some ideas about minerals—what they are, how they got that way and what they mean to all of us. The systematic collection is there, of course, but in decidedly lesser prominence.

This wind of change is blowing and I find myself less horrified at the thought than I might have been years ago. Prospects of a Smithsonian exhibit with accent on communicating mineralogical facts and principles is appealing. However, one danger possibly resulting from this approach makes me want to resist the trend rather strenuously. Without the certainty that a superb exhibit type specimen is destined for public show if acquired by the museum the incentive for acquiring such pieces is lost. As I see it, one of the primary objectives of museums is to preserve these unique natural objects for posterity—a sort of archival function. Few museums, in times of shrinking budgets, will want to struggle for marvelous but expensive specimens to be stored away somewhere, surfacing at infrequent intervals for public view.

In recent years, communication has been improving rapidly among mineral museum curators and their customers. This means that my fellow curators have a better chance of convincing me that my concerns are baseless—and vice-versa.

Speaking of struggling to acquire fine specimens, two of the most recent, extraordinary acquisitions for the National collection are shown here. Has your museum added some mineral treasure lately that you are proud of. You may show it in this column and I promise not to attempt talking you out of it.

The Clay Minerals Society and The Mineralogical Society of America

Announce:

The 20th Annual Clay Minerals Conference with joint participation by the Mineralogical Society of America, will be held in Rapid City, South Dakota from August 8th to 12th, 1971. A field trip to Black Hills pegmatite localities, and a symposium on the phosphate minerals associated with them will occupy August 8th and 9th, General Sessions for both Societies will be followed by an excursion through the Wyoming bentonite producing areas on August 12th.

FRIENDS OF MINERALOGY

Meeting in Tucson, 1971

Joel E. Arem

On Feb. 13, 1970, twenty amateur and professional mineralogists met in Tucson, Arizona to found an informal group dedicated to promoting better appreciation and preservation of minerals. High on the list of the goals of the new group was the creation of closer ties between amateurs and professionals in advancing the science of mineralogy, and to encourage among amateurs a greater appreciation of mineral specimens for their educational and scientific, as well as their commercial, value. The concept of such a group, originally called the Mineral Preservation Society, had been created by Arthur Montgomery and Raymond Grant, both of Lafayette College, Easton, Pennsylvania, and soon joined by Richard Bideaux of Tucson, Arizona and Joel Arem, then at Harvard University. The concept was nurtured by the ideas and enthusiasm of a small number of highly motivated and deeply interested people, and finally was officially "born" in Tucson in Feb., 1970. The group would henceforth be known as the Friends of Mineralogy.

The formative year of FM was one of flexible attitudes among its supporters, combined with cautious idealism. Many problems had to be faced, chief among them the expansion of membership and the formulation of clear-cut goals. It is significant to note that very early in the history of FM, its membership was equally divided among amateurs and professionals. As time passed it became clear that cooperation between these groups was both natural and productive. The positive accomplishments of these early months laid a strong foundation for later projects.

FM was originally intended to be an organization of, by and for mineral collectors, educators and professionals, formed to promote all worthwhile aspects of the science and hobby of minerals. Yet bringing awareness of the existence of FM to potentially interested people seemed to present difficulties. Without a formal structure, FM was, of necessity, a "bootstrap" operation. The people involved were those invited to participate by the founders, usually by personal note. New members in turn recommended others who might be interested in joining. There was, as yet, no way to know how the organization might evolve or even how it might function. In a sense there was no organization to join, but rather a loose alliance of enthusiasts, and membership, by invitation, was necessarily selective. No guidelines for membership had been set, and many highly qualified amateurs and professionals could find no apparent access to what seemed like a worthwhile and vitally needed endeavor. Certainly many omissions in FM roles were overlooked, and recognized and regretted later on. In spite of these shortcomings, tremendous enthusiasm was generated among FM members and many projects were begun. One of these culminated in a highly successful educational exhibit competition in Tucson in 1971 (see report by Bob Jones following this article). Great support was given to *The Mineralogical Record* in its first year of publication. Informal groups were created to set numerous projects in motion. Yet by the time of the 1971 Tucson Show, lack of organization was proving to be a handicap. FM, for all its achievements and good intentions, was creating among some the image of an elite, closed group. The time had come to formalize the organization, and put the idealism on a firm structural foundation. In Tucson in Feb., 1971, the outline for such a working base was drawn.

It was decided at Tucson, by about 50 FM members present, that FM would have an executive committee of 6 elected members, with the current President of AFMS (American Federation of Mineralogical Societies) a seventh (voting, but ex officio) member. Two new members would be elected each year, with 2 dropping off at the same time. Of the original 6 elected, 2 would be elected for 3 year terms, 2 for 2 years, and 2 for one year each, thus assuring continuity. The committee members would elect, from among themselves, a President, Secretary and Treasurer.

In Tucson an 11-man slate was nominated, consisting of: Joel Arem, Richard Bideaux, Raymond Grant, Millard Groben, Robert Jones, Michael Kokinos, John Medici, Arthur Montgomery, Mary Mrose and John Sinkankas. The election for FM executive committee was held between Feb. 25 and April 1, with 58 ballots counted, and one ballot arriving late. The 6 committee members elected, by majority vote, are: Joel Arem, Arthur Montgomery (3-year terms); Richard Bideaux, John Sinkankas (2-year terms); Robert Jones, Mary Mrose (1-year terms); the seventh member, representing the AFMS, is its current President, Paul Seel. The FM officers elected by this committee are: President: Bideaux; Secretary: Arem; and Treasurer: Montgomery.

The executive committee's next job is to design membership procedures, and establish committees to nominate future officers, to handle membership and to draft by-laws. The present membership procedure, however, was approved in advance. This will allow the organization to grow, even while it is being formally constituted.

Membership is to be tied to *The Mineralogical Record,* since the *Record* serves as the primary information vehicle for FM news and activities. FM dues will be $12.00—

the same figure currently applicable to membership in the Mineralogical Society of America. Of this sum, $6.00 is applied to a subscription to MR, and $6.00 to support FM activities. It has been the unanimous consensus of all those involved with FM to date that the single most vital purpose of FM is to assure continued publication of the *Record*. Without the *Record*, FM would have no effective means of communication. Even more important than this is the highly significant role the *Record* plays in current mineralogical literature. The very aim of the publication is to bridge the gap in outlook between amateur and professional mineralogists. FM, an organizational union of these two groups, could have no better purpose than to maintain issuance of the *Record*, to insure that the gap does not open.

The bond between FM and MR is far stronger than merely overlapping interests. The launching and success of the *Record* have been possible only through the support and encouragement of FM members. The effectiveness of MR itself in promoting FM goals, both through the FM columns and through the very orientation and outlook of the publication, can be considered the greatest of FM accomplishments thus far. Both the *Record* and FM have benefited enormously from their association; for this reason a powerful link between the two must be maintained.

Some discussion was raised in Tucson regarding the inclusion of a questionnaire among membership applications for FM. The justification for this is that anyone, amateur or professional, truly interested in promoting FM goals should not be ashamed to say so, and to be able to state how and why. If an applicant cannot at least form a viewpoint in his own mind, how likely is he to actively work toward the goals of the organization? For these reasons, the idea of a questionnaire was adopted. In addition to asking for a statement of attitude, the questionnaire was designed to build a talent-pool file by including a space for the applicant's specific interests and skills. Such records would provide an invaluable data bank for exchange of information and ideas, and for forming project groups.

Some projects already organized, but in need of active support and interest are: specimen registration file (R. Bideaux); educational exhibit guidelines and competition (R. Jones); reports on collections (A. Montgomery) and preservation of key localities (D. Lapham).

A broad statement of FM goals, drafted prior to the 1971 Tucson meeting, was accepted unanimously by those present and later condensed and refined. These goals are:

1. To protect and preserve mineral specimens, especially those used for teaching, study and display, and to promote conservation of designated specimen localities and mining deposits by publicizing their historic, scientific and educational usefulness.
2. To further a more generous spirit of cooperation and sharing of specimens and collections among mineral amateurs and professional scientists, also to encourage the collecting and acquisition of minerals for their research and educational, rather than commercial, value.
3. To advance mineralogical education, especially in academic programs of mineral study and research, educational activities of amateur mineral organizations, and wider appreciation of mineral specimens in terms of their esthetic, scientific and economic importance.
4. To support publications, such as the journal *Mineralogical Record* which communicates FM activities and is an educationally-oriented affiliate, and those programs initiated by individuals or groups whose activities coincide with FM goals.

We must learn to think of FM with a long-range viewpoint. It will, with continued support, evolve into an international body devoted to the preservation of minerals and promotion of FM goals. The only way this can come about is through the active support of both amateur collectors and professional mineralogists, on ALL levels of proficiency and experience. The only valid requirement for admission is *interest*. FM is, one might say, "open for business". If interested in participating, please contact:

Dr. Joel E. Arem
Department of Mineral Sciences
Smithsonian Institution
Washington, D.C. 20560

FM has come of age, but is still very young and immature. It is up to all who profess an interest in minerals to decide whether or not it will grow to maturity as a force in the advancement of mineralogy, as both a science and a hobby. In a sense, these two aspects cannot really be separated if mineralogy is to advance and thrive.

Report On Educational Exhibit Competition Tucson, 1971

Robert W. Jones

The aims of this activity are to promote and improve educational displays for the hobbyist and the public. The immediate aim is educational exhibit competition. A long range aim is to develop a public program of educational mineral exhibits. Results of the Tucson "try-out" of our new guidelines have indicated we are a little closer to realizing our aims.

Six exhibits were placed at Tucson, four adult and two junior. Thanks to the Tucson Gem and Mineral Society things went smoothly. Some problems with case dimensions and organizational omissions by this reporter were overcome and all went well. We extend a special thanks to the TGMS people who helped so much.

Winner of the Adult Division was Mr. Dean Wise, Albuquerque, New Mexico. His exhibit was entitled "Minerals Serve Man". Following the Tucson Show the exhibit was slated to be displayed at the musuem of the University of New Mexico as a part of our effort to get educational displays placed publicly.

Runner-up in the Adult Division was Mr. Paul Seel, whose display of crystallography will be seen in competition at all the regional shows this year.

Two other adult displays were very well done. Though they did not win any prize money these excellent displays will be placed before the public at the museum of the University of Arizona, where both Stan Keith and Les Presmyk, the exhibitiors, attend school.

The winning Junior Exhibit was placed in competition by Byron Brandon, President of "The Explorers", the junior group of the Tucson Gem and Mineral Society. The winning display, "How to Identify Minerals", will now be placed on public display at the County Administration Building, Tucson, Pima County, Arizona.

The runner-up Junior Exhibit, by Chris Presmyk of Phoenix, was on "The Bowen Reaction Series". This display will be exhibited at the Arizona State Mineral Museum in Phoenix, after some regional science fair competition.

As you can see, we have not only attempted to get educational displays into competition but are making efforts to see that they do not gather dust. In addition, a card file has been started on these exhibits so we can keep track of them for future use. Hopefully, we can do this with all exhibits entered under FM guidelines, building a reservoir of excellent displays for many uses.

It is difficult to assess the success of our first guideline "try-out". However, if response and interest are any criteria, we've gotten a good start. Several museums and club groups have shown interest in the exhibits or the guidelines. We hope to have this type of competition developed for a number of shows in the coming months. Naturally, FM cannot carry the financial burden of increased and frequent competition. We must make an effort to involve the Host Club in the financing. Tucson people generously split the costs with us. We look forward to the time when clubs will bear the entire cost while FM provides the skill and organizational guidelines.

Now that the guidelines have been tested we can begin the task of refining them. Those of you who attended the show can be of considerable service in this matter. Let us know your ideas for improvement. A constructive dialogue can be most valuable now.

The First Annual Get-Together

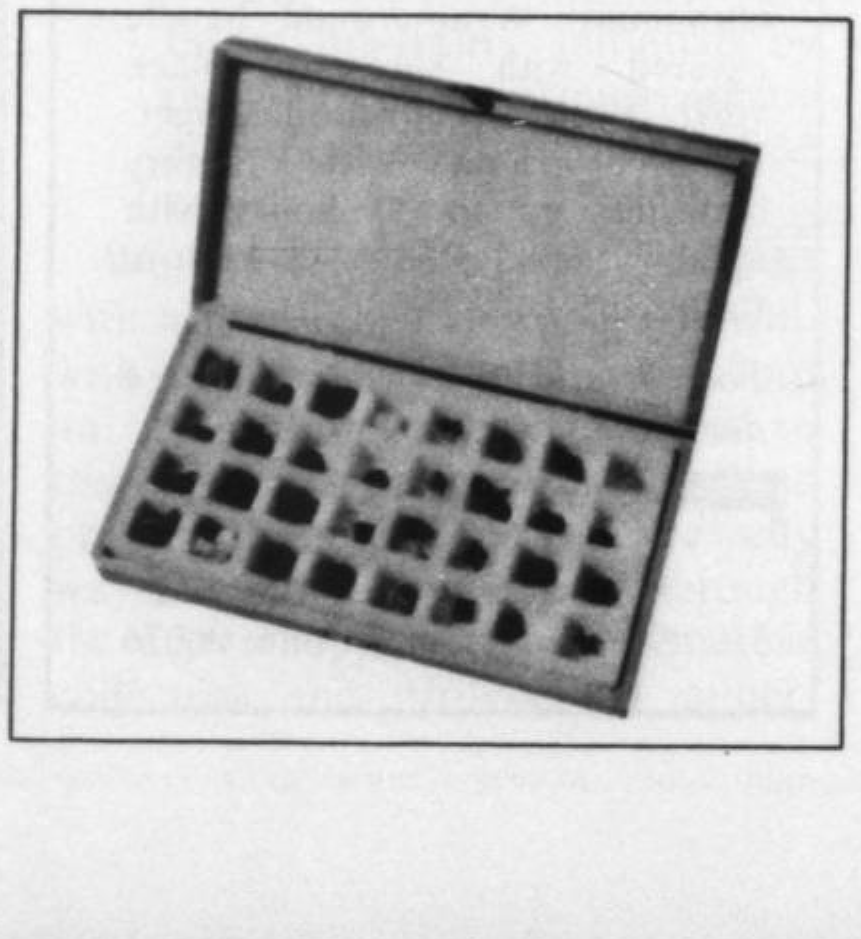
John S. White, Jr.

The Tucson Gem and Mineral Show (Feb. 12-14, 1971) afforded an excellent opportunity for the MR to gain additional exposure and to initiate an informal annual get-together for many of its readers and supporters. The Tucson Show al-

(continued on page 95)

MEETINGS & SHOWS

WHO & WHAT	WHEN	WHERE	CONTACT
The Middlesex County Mineral Club, Inc. Gem and Mineral Exhibition and Rock Swap	**June 6**	Middlesex County Agricultural Center Haddam Conn.	**Randy Hale, Jr.**, Plains Rd. Haddam, Conn. 06438
Eastern Federation of Mineralogical and Lapidary Societies, annual show	**June 11-13**	Olympic Arena Lake Placid, N.Y.	**M. F. Witherell**, Bristol, Vermont 05443
South Dakota State Gem and Mineral Show	**June 25-27**	Rapid City, S.D.	**Scott C. Moses**, P.O. Box 492, Deadwood, S.D. 57732
Calif. Fed. of Min. Societies, annual convention and show	**July 2-4**	Ventura Fairgrounds Ventura, Calif.	**Bruno Benson**, 207 S. Pueblo Ojai, Calif. 93023
Midwest Federation of Mineralogical & Geological Societies, convention and show	**July 22-25**	Richland Co. Fairgrounds Mansfield, Ohio	**B. F. Parr**, 1488 Marion Ave. Rd. Mansfield, Ohio 44906
The Gem & Mineral Society of Syracuse, Inc. Annual Rock Swap & Show	**July 24-25**	Syracuse Auto Sales, Inc Lafayette, N.Y.	**Richard Gildersleeve**, 718 Maple Drive, Fayetteville, N.Y. 13066
Mineralogical Soc. of America, summer mtg. (Pegmatite Phosphate Symposium), jointly with Clay Minerals Soc., ann. mtg., and North American Clay Minerals Conf.	**Aug. 8-12**	Rapid City South Dakota	**D. H. Garske**, S. D. School of Mines, Rapid City South Dakota 57701
Amer. Fed. of Min. Societies & Northwest Fed. of Min. Societies, annual show in conjunction with Seattle regional show	**Sept. 3-6**	Seattle Coliseum Seattle, Wash.	**Ed Messerly**, 3017 N.E. 97th. Seattle, Wash. 98115
Conference, Physics & Chemistry of asbestos minerals	**Sept. 6-9**	Louvain University Belgium	**G. Poncelet**, Laboratoire de Physico-Chimie Minerale, Institut des Sciences de la Terre de Croylaan 42, 3030 Heverlee, Belgium
Rocky Mountain Federation Show	**Oct. 1-3**	Topeka, Kansas	**R. C. Roderick**, 2106 East 6th. Topeka, Kansas 66607
Geological Soc. of America and Mineralogical Soc. of America, annual meeting	**Nov. 1-3**	Washington, D.C.	**GSA Headquarters**, Box 1719 Boulder, Colorado 80302
Michigan Mineralogical Society Greater Detroit Gem & Mineral Show	**Nov. 5-7**	Detroit Light Guard Armory, Detroit, Michigan	**Mrs. Charles Towle**, 22114 Allen-A-Dale, Birmingham, Michigan 48010
1972			
Geological Society of America *Northeast Section*, ann. mtg.	**Mar. 9-11**	Buffalo, New York	**E. J. Buehler**, Dept. of Geol. Sci., State University of New York Buffalo, N.Y. 14207
Geological Society of America, *South Eastern Section*, annual meeting	**Apr. 15-17**	Tuscaloosa, Alabama	**T. A. Simpson**, Geological Survey of Alabama, Drawer O University, Ala. 35486
Geological Soc. of America and Mineralogical Soc. of America, annual meeting	**Nov. 13-15**	Minneapolis, Minn.	**GSA Headquarters**, Box 1719 Boulder, Colorado 80302



FRIENDS OF MINERALOGY
(continued from page 93)

ways attracts an extraordinary number of devoted collectors. Thus, by providing table space for us to show the magazine and thereby take new subscriptions during the show, the Tucson Club gave us a tremendous assist and they are to be commended for it.

On Saturday evening all who cared to attend met in the Desert Inn for our short but interesting program. We started with the showing of the 35 mm slides entered in the contest to select a cover photograph for a future issue of the MR. Due to short notice there were only 10 entrants, each permitted to enter 2 slides, so there were 20 slides to pick from. All in attendance were given ballots and allowed to vote for their favorite. The winning slide was of rhodochrosite from Nassau, Germany, taken by Joel Arem, for which a $25.00 prize was awarded. The second place was won by Lou Perloff for his slide of cyanotrichite from Lemhi County, Idaho, and third place by Joel Arem (again!) for a photograph of topaz from the Thomas Range, Utah.

Following this, prizes were awarded to the winners of the competition for the best educational exhibits at the show.

The feature of the program was an illustrated talk by Richard Thomssen about his experiences collecting epidote at Prince of Wales Island, Alaska in the summer of 1967. The talk, about one of the most intriguing mineral localities in the world, was directed toward collectors and was very well received.

Except for a forced delay when the projector broke down during Dick's talk, the evening was deemed a great success and the Tucson Club is now interested in making such a meeting an annual event—thereby supplanting the usual party on Saturday night of the show weekend. The size of the show now precludes having a party in the home of any club member. It is hoped that FM will adopt this meeting—undertake the planning for it and the management of it—with the cooperation of the Tucson people. ■

NOTICE TO MINERAL DEALERS AND COLLECTORS

Over the weekend of April 24 and 25, many valuable gemstones and a few fossils were stolen from the geology department at the University of Vermont. It is believed that the person(s) who took them knew something about the mineral hobby and may try to sell them in the near future. Readers of this magazine are asked to be watchful in case these specimens should turn up somewhere. A brief description of the more valuable items is given here for reference. Anyone having knowledge of their whereabouts should contact Dr. Rolfe Stanley, Chairman, Geology Dept., Univ. of Vt., Burlington, Vt.

Amont the missing pieces are: a large red and green tourmaline crystal from Paris, Maine; a large rough opal and some opal cabochons; a 1 inch cluster of gold crystals; a cut star of clear quartz; several small faceted diamonds; a violet jade cabochon; an enraved tigereye; a large Jurassic ammonite lined with calcite crystals; numerous faceted tourmalines, zircons, garnets, etc.; cabochons of moonstone, emerald, agate, zoisite, and others; a very large segment of a petrified log; a clear quartz sphere (small); and quite a few others.

Sincerely,
Woodrow Thompson

To The Editor

(Continued from page 85)

WINGSTARS DEFENDED

Dear Sir:

Thank you for reviewing my book THE DISCOVERY OF THE WINGSTARS in the Jan-Feb issue of *the Mineralogical Record.*

As I said in my book: 'There are no authorities who can judge in the field of discovery". It is pitiful that you should have tried. It is unfortunate that such a misguided blast was printed. But then, YOU DID NOT INVESTIGATE, and therefore could not know what you were talking about.

You have taken the liberty to advise the world NOT TO INVESTIGATE my disclosures. I wonder why. What are you afraid of?

You disqualify yourself when you insinuate that I am unqualified since I am an inventor—not a scientist. It is appalling when a scientist gets to believing that others cannot see things in a rational manner. Webster's dictionary says a scientist is a "scientific investigator". Note it says *investigator.*

YES! Let's stick to the facts. You say: *"Facts, such as the impossibility of melting limestone and dolomite in the atmosphere."*

And you boldly say: *"It is an erroneous assumption . . . atmospheric friction melting."* Here—denying what almost everyone else knows: that atmospheric friction melts meteors—you pretend to be qualified to pass upon Wingstars!

You also say: *"The entire* (Wingstar) *theory is based on a glaze, a superficial polish."* This absolutely false statement is made while no mention at all is made about FUSION glaze, FUSION crust, FUSION flow textures, FUSED "bullet" scars, FUSED drip-deposits caused in a meteor shower, nor other markings as are prominently mentioned in the book.

Now, who was talking about FACTS?

You have done a great disservice to the name of science.

I keep repeating: There are no authorities in the field of discovery. I would admit, if I were you, that I stepped out of my field.

I was drawn into this venture by a chance discovery which was too great to ignore; have no need for profit from it, and will be surprised if I break even on the risk taken. I had felt that I was doing a service in advancing a great new field of knowledge.

You say: *"Wishes, whims and unproved declarations have no place in the real world, and reality is the last court of appeal."* How true, *how true!*

Is your failure to investigate, and your derogatory advice to others founded on the *fear that I might be right?*

You have the right to criticize the book for many things, *but when you denounce its claims without investigating and then reporting exactly what was found,* you have committed a grave error.

For many years professors had taught that the world was flat and that it was the center of the universe, with the sun, moon and planets captured and submitting to its great influence. Then a man with the vision and the originality of a *true inventor* proved otherwise. His name was Copernicus. And of course, he too had his troubles with the professors.

It has been very costly per unit to produce only 1000 books in 4 colors. And I have no intention of bringing out future editions. But since I know my subject and something about what it portends—and seem to be the only one who does—I believe that the books will become greatly treasured by the few who obtain them.

The price has now been set at $19.95. Perhaps enough to allow dealers to take their regular discounts, and enough so that I can get the world started in a completely new science: *Earth Orbited Meteorites.*

While your fearful and capitalized recommendation cries: *"DO NOT BUY,* my reply is: *BUY . . .* Then if you do not like it, or do not believe it, get your money back. *The book is unconditionally guaranteed.*

This letter will be circulated as a right of rebuttal, unless you wish to play fair and publish it in full and as prominently as the original review.

Let your readers use the common sense that you *should* believe they possess.

Thank you again for the mention. Perhaps now there will be more people who will wonder, and will dig and investigate, and determine the truth for themselves.

Russell T. Wing
Excelsior, Minnesota

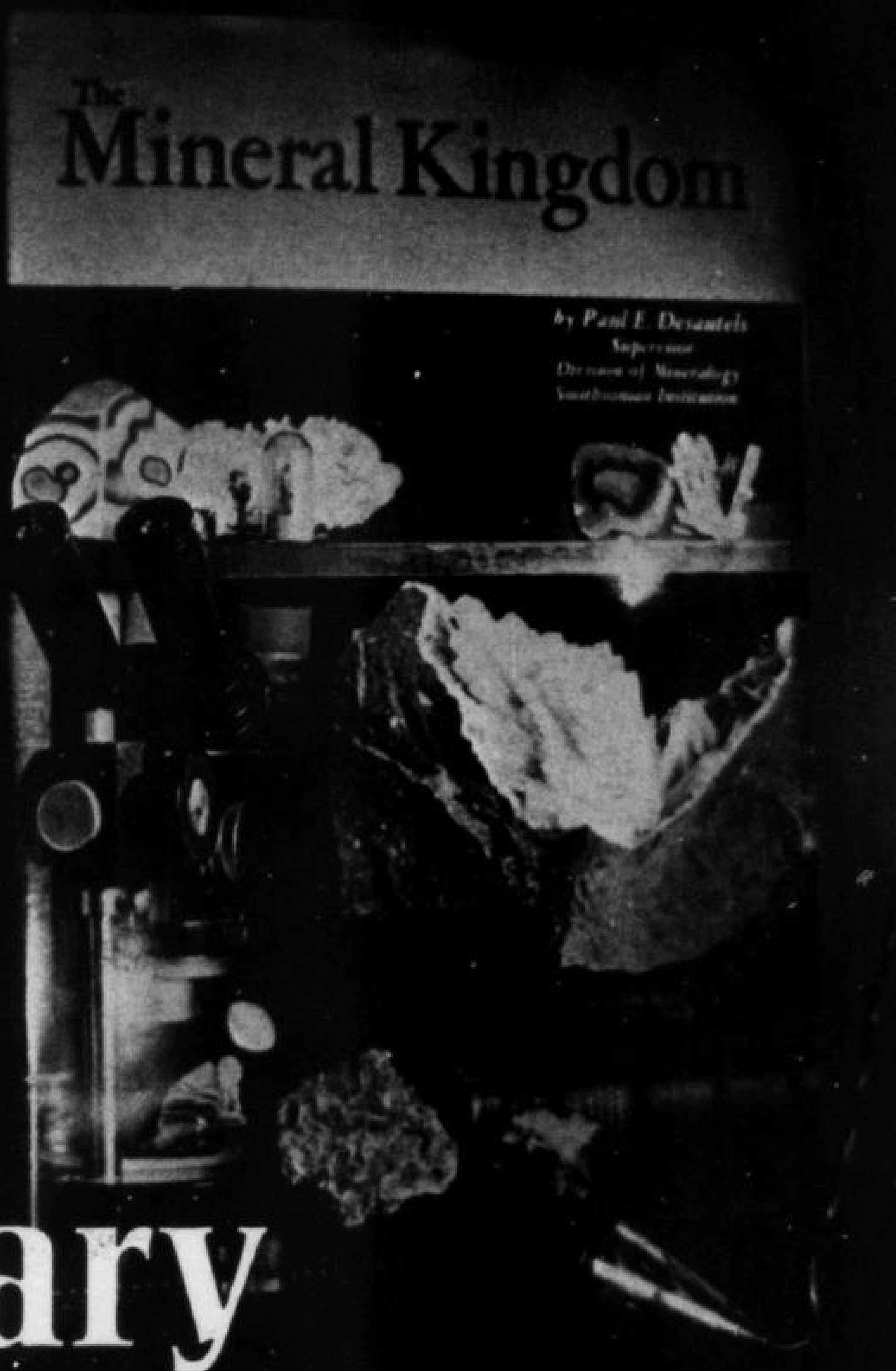
Dr. and Mrs. Werner Lieber, of Heidelberg, Germany visit with Paul Desautels at the Smithsonian Institution, Washington, D.C. Dr. Lieber is the former editor of *DER AUFSCHLUSS* and has just retired as President of the German Association of Friends of Mineralogy and Geology after more than 10 years of service. The Liebers are touring the United States for the first time, their 45 day vacation will take them from coast to coast with many stops in between.

New Micromounters Group

The first meeting of the Northwest (Federation) Micromount Minerals Study Group was held in Forest Grove, Oregon on the first weekend of last November. Approximately 40 people attended with 18-20 scopes in use. Program features were headlined by Dr. George W. Williams narrating his slide program on micromounting; Mr. Ford Wilson shared tips on techniques, labeling, and cataloging and led a discussion shared in by all present. Mr. Norman Steele presented and narrated a program of mineral slides in stereo photography with discussion on microphotography. Our group elected Mr. Bob Hagglund, 2412 Chestnut Street, Everett, Washington 98201 as our first President; Mrs. Lee Kendall, P. O. Box 5, Glenwood, Oregon 97120 was chosen Secretary-Treasurer. We hold our 2nd meeting this coming April 24-25 in Richland, Washington; a field-trip meeting is scheduled for the last weekend in May; and we expect to "man" a booth with scopes and specimens for viewing at the coming combined Northwest and American Federation convention this Labor Day weekend at Seattle, Washington.

ERRATA . . .

from Vol. II, no. 1
p. 28 *Minerals of Greenland* is a single volume, "octavo" size, not 8 volumes.



The Mineral Kingdom
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