the Mineralogical Record

Volume 3/Number 5
September/October 1972

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GYROLITE

- basic hydrous calcium silicate, one of the rarer zeolites
- Grant County, Oregon
- tiny crystals with a striking pearly luster in vugs in basalt, an unusual mineral to find in discernible crystals, not spectacular in any sense, good M/M potential
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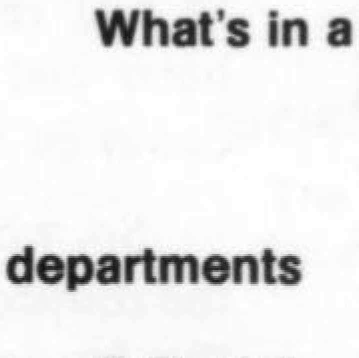

TWINNED CINNABAR CRYSTALS from Hunan, China. This specimen is an "old-timer" in the mineral collections of the Smithsonian Institution. The photograph, by Joel E. Arem, was the winner of the 35 mm slide competition in Tucson this past winter.

Editorial

Mineral Shows— Are They Worth the Effort?

We all probably tend to take mineral shows more or less for granted, at least those of us who have never been directly and heavily involved in putting one together. It came as a considerable surprise, therefore, to see the motivations behind shows, the goals, and the rewards all questioned in a mineral club bulletin following a recent major show. Queries such as "Is the considerable expenditure of time and effort worthwhile?", "Who are we working for?", "Has our 'hobby' become a job?", "Is the 'fun', the 'satisfaction' and the 'glory' worth the effort?", "How big do we want our Show to get?", "Do we have any choice (about size)?", "Is there a danger of the Show getting too large and becoming unmanageable?" were made but no answers were given.

This invitation to analysis was made shortly after the show closed and the writer was still feeling the fatigue following an exhausting stint as show chairman. Thus the pessimistic nature of the questions is understandable. But let us hope that such a pessimistic attitude does not become so prevalent that enthusiasm for producing mineral shows goes into a decline.

There are two dominant contributors to the growing size and health of the mineral hobby in this country — mineral dealers and mineral shows. Without these the hobby would not have grown a fraction of the amount that it has in the last ten years. The number and variety of specimens available to the majority of collectors would be but a pale shadow of the volumes now being sold and traded. Regular meetings of mineral clubs alone could never stimulate or sustain the growth of the hobby the way mineral shows can, and much of the excitement generated by a coming show is due to an eagerness to see what the dealers will have on their counters.

There are other ways in which shows stimulate the collector. For one, he looks forward to seeing friends and fellow collectors he probably hasn't seen for at least a year. The social rewards, therefore, count heavily. The mineral show has, perhaps, become somewhat of a field trip substitute since field collecting is often less rewarding than it used to be (from the specimens collected point of view, at least). It offers an opportunity to exchange ideas, to learn new techniques (from displaying minerals to faceting), to examine new products, to discover new mineral specimen material, for club officers to get together to discuss common problems, and it gives the people who are responsible for the productions a sense of fulfillment and purpose once they have recovered from their exhaustion. The benefits of and reasons for supporting mineral shows have just been touched upon here, the lists could be much longer.

So, while in sympathy with the attitude that the rewards come not to those who have worked the hardest to produce the show, I feel this attitude may be largely attributed to a temporary depression growing out of post-show weariness. As in so many other aspects of life, the "rewards" need only to be recognized, they are always there but too often not seen — just as in the familiar expression of "not seeing the forest for the trees." The show, after all, has entertained thousands of people. How often in life do most of us have an opportunity to play a major role in such an accomplishment? Most shows make profits that can be used to support worthy programs such as scholarships or providing specimens and displays to schools. Again, the list may be extended.

One of the unfortunate developments one often observes in the production effort is that only a few people are burdened with the bulk of the work. Those of us deriving manifold benefits from the shows do not often take the time to express our gratitude to the chairman and sponsoring organization. Showing our appreciation will go a long way toward paying our debt to those who have worked so hard on the show. Naturally we cannot expect the same individuals to perform the same labors year after year but, human nature being what it is, this is a common phenomenon. I heartily endorse the practice of selecting both a chairman and a vice chairman with the explicit understanding that the vice chairman for one show will be expected to become the chairman for the following show.

The problem of a show becoming too large to suit its sponsors is not one with which many groups have to contend. However, in certain areas a combination of factors may conspire to make a show "catch on" and grow to giant proportions regardless of the counter wishes of the sponsoring club. Nevertheless, I can't believe that a serious effort to cut back on the size of a show would fail. It is hard to imagine runaway growth that can't be checked and I don't see this as a widespread problem. The real problem is the club that collectively wants a large show but individually will not work for it, so that the lion's share of the work falls upon the shoulders of a few. This is a difficult problem to resolve because chairing a *major* show requires considerable management talent, and few mineral clubs can boast of having many members who can handle the job adequately. Clubs facing this problem may have to resort to actively recruiting new members who possess such management skills.

In spite of all this, I think we can take heart because mineral shows appear to be improving continually. Even though shows, as we know them today, have not been with us very long, they have evolved a very satisfactory format offering something for virtually every element of the "rock hobby."

John S. White, Jr.

The Museum Record

by Paul E. Desautels

Sooner or later every museum must come to grips with the question of "exchange" policy. Of course, the easy way out is to adopt the position that there won't be any exchanges of specimens — everything that comes in stays and nothing at all goes out. With sufficient patience over the long run — spanning the tenure of several curators — this has been a good way in the past to accumulate large and varied collections especially in regions where there were few competitive museums. However, things have changed in recent years and the museum with an active exchange program is getting not only the long range accretions but some of the cream of the current specimen crop as well. This obviously puts such an institution in a position of definite advantage for improving its collections.

The dangers involved in an exchange program for a museum collection are serious and there are several of them. Primary among these is the chance that irreplaceable specimen material may somehow get away through oversight, lack of knowledge on the part of the curator, pressure from collectors and other institutions, biased preferences of a curator toward certain kinds of specimens (which may not be appreciated by his successors), etc. One thing certain is that large numbers of private collectors have made a serious study of museum collections, curators, and the necessary procedures for promoting exchanges. If the curator or his establishment is not equally prepared to cope with these skilled exchangers it is better to stay out of the game. Naturally even when prepared there are bound to be some errors of judgement in exchanges by a curator but a long series of faulty decisions can be disastrous.

In my experience the smaller museums, unless totally devoid of direction and common sense, or unless they are lucky enough to have a dedicated, knowledgeable and able curator of minerals, tend to avoid exchanges completely or to encumber them so badly with red tape that most collectors are discouraged from trying. The large museums participate more or less freely in exchanges because they feel the necessity. Even so, I don't know of a single curator who enjoys the experience. Universally it is looked on as a distasteful, onerous, time consuming, nerve wracking chore.

An encyclopedia of the art and science of specimen exchanging would be a thick one. With no hope of covering all of it, a look at some of its aspects here might be illuminating.

Proposition A — The rule of "exchanging in kind" is probably good basic insurance. When a museum collection is mixed; i.e., contains minerals, gems, meteorites, rocks, ores, fossils, and miscellaneous natural curiosities, it is best to exchange only gems for gems, fossils for fossils, meteorites for meteorites, etc. Also, considering only minerals, it is best to exchange top quality for top quality, medium for medium, etc. Of course, any such rule of thumb must be applied with some judgement across the barriers. The need for such a rule is almost obvious and it is based on the disparity in values of various kinds of objects. One gemstone accepted in exchange can easily wipe out a large suite of desirable mineral specimens. For the value in a handful of gems an entire mineral collection could be bought. All of the minerals in the Smithsonian are probably of lesser intrinsic value than a selected half dozen of its gems.

Proposition B — Exchanging specimens with dealers may be an entirely different kind of game. When a private collector has something to offer he usually wants in exchange something of similar or somewhat better quality that appeals to him more strongly, or for which he has greater need in his collection. That doesn't mean he won't try for higher stakes! In money terms it is more likely to end up a nearly even trade unless there are complications. This is where judgement comes in. What complications? Perhaps it is more important to the museum collection to maintain the collector's good will even if it means unbalancing the exchange to give him a super-satisfied feeling. Perhaps the specimen offered is of no immediate value to the collection but the curator has in mind a second exchange, to which it is perfectly suited, which will work out very well to his advantage. Perhaps the museum needs the specimen far more than it does one which is more valuable but in excellent supply in the drawers. The complications can be numerous and significant.

A dealer, unlike the private collector, when he has something extraordinarily good to exchange needs to be enticed into the action. A truism in today's mineral specimen market is that "anything good can be sold quickly". The dealer can sell the specimen he has acquired and does not need to go through the troublesome process of exchanging with a museum for specimens of equal value which must then be sold before he can recover his money

continued on page 234

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In lieu of quarterly lists we are planning full page specimen listings in future issues of the Mineralogical Record. Please contact us for specific requirements in minerals, reference material or cut gemstones. Please include a check with your order and postage consideration. Any specimen may be returned for cash or credit if you are not satisfied. Refer to list M-5. See us at the following 1972 shows: Tucson; Cincinnati (Midwest Fed.), Oklahoma City (Rocky Mtn. Fed.). Hansen's Minerals, Inc. Dr. Gary R. and Maurine Hansen. Ph. (314) 432-2882. (Showroom: 149 N. Meramec, Clayton, Missouri).

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Gary R. Hansen

TOPAZ. Minas Gerais, Brazil. (1961). Two complete, transparent, terminated gem crystals. A.) 2.5 x 2.5 x 1.2 in., **$125.00**; B.) 3.9 x 3.5 x 2.2 in., attractive orange inclusions. **$200.00.**

RHODOCHROSITE. Travonia Mine, Butte, Montana. A very lustrous group of rose-pink 0.3 in. crystals. The sharp faces appear to be cleaved rhombohedrons but are natural terminations. Minor damage to one crystal. 3 x 2 in., **$60.00.**

GROSSULAR Garnet. Wilui, Siberia, USSR. Eight yellow-green complete crystals. 0.5 - 0.8 in. diameter. 5 @ **$10.00**, 3 @ **$15.00.**

ELBAITE, Schaitansk, Ural Mtns., USSR. Seven rose-red terminated crystals. 5 x 10 mm. to 10 x 15 mm. **$15.00** each.

COPPER, Kaiserstimel, Daaden, Westerwald, Germany. A beautiful crystallized leaf of native copper. 35 x 12 mm. Excellent miniature. **$40.00.**

STIBNITE, Ichinokawa, Province of Iyo, Shikoku, Japan. An attractive, bright, terminated crystal 1.2 x 6 in. Complete, with minor side damage at base. **$185.00.**

STIBICONITE. San Luis Potosi, Zacatecas, Mexico. A doubly terminated clean crystal, 8.2 x 0.7 in., attractive color. **$35.00.**

CHLORAPATITE, Japan. Four white terminated crystals, 0.5 x 0.4 in. **$7.00** each.

APATITE on Adularia. Zillerthal, Austria. Two pale pink crystals of Apatite up to 0.5 x 0.4 in. on Adularia w. Chlorite. 1.7 x 1.0 in. **$55.00**

APATITE. Pearidge, Missouri. Bright, chocolate brown terminated crystal (1.2 x 1.2 in.) on matrix of Hematite stained Calcite w. Chalcopyrite. 3.5 x 3 in. **$20.00.**

QUARTZ w. Chlorite Inclusions. A.) Kremnitz, Hungary. A group of 1 to 2 in. free standing crystals, w. half of the verticle axes coated w. Siderite. 3.5 x 2.5 in., very attractive. **$50.00.** B.) Holland Mine, Washington Camp, Arizona. Two crystals, 3 x 0.6 and 2.5 x 0.4 in. penetrating at a 90° angle, with small crystals growing out of attachment point. Unique. **$40.00.**

CALCITE. Cumberland, England. Fourteen terminated, translucent TN-crystals. Hexagonal with trigonal termination. Approx. 1 x 0.6 in. **$5.00 each.**

PYROSMALITE. Nordmarken, Sweden. Two tan 5 x 3 mm. hexagonal crystals on matrix. 1.6 x 1.3 in. A fine, rare miniature. **$85.00.**

WOLFRAMITE w. Quartz. Tong Wha, Korea. A 1.7 x 0.8 in. crystal of Wolframite attached to the base of a 2.8 x 1.0 in. crystal of quartz at a 30° angle. Both crystals are terminated and half coated with Dolomite. **$75.00.**

QUARTZ v. Japan Twin. Kurasawa, Kai, Japan. A beautiful transparent twin with crystals, 2.5 x 2 x 0.5 and 1.3 x 1.2 x 0.5. Exhibits classic form. **$185.00.**

ELBAITE (Tourmaline), Bicolored. Himalaya Mine, Mesa Grande, California. A very attractive doubly terminated (basal and pinacoidal) crystal 2.2 x 0.7 in., color bands of green to pink to green to dark pink. **$150.00**

AZURITE. Lavendar Pit, Bisbee, Arizona. A lustrous, deep blue, crystallized group of small crystals on matrix. 3 x 1.5 in. **$65.00.**

NEPTUNITE. San Benito County, California. A fine matrix specimen with six major, black, lustrous crystals up to 1.0 x 0.3 in. Displays well. 2.5 x 1.5. **$75.00.**

DIOPSIDE. De Kalb, New York, A group with two major intersecting, green crystals, 1.2 x 0.8 and 0.7 x 0.4 in. Attractive miniature, 1.8 x 1.8. **$70.00.**

Native **SILVER.** Freiberg, Sachsen, Germany. Five TN-crystallized, wire groups. Very attractive. **$10.00** each.

ARTINITE. San Benito County, California. A selection of twelve specimens, beautiful white, tufted matrix specimens. The nicest material we have seen from any locality. Specimens approximately 3 x 2 in. **$15.00** each.

SMOKY QUARTZ (Gwindel). St. Gottard, Switzerland. A very clean, transparent smoky crystal, exhibits classic twinning, 2.2 x 2.2 x 1 in. **$45.00.**

ELBAITE (Tourmaline). Minas Gerais, Brazil. (1961) A bright, sharply terminated, deep green crystal, stands upright on base. 3 x 1.5 in. **$85.00.**

SPHALERITE w. Calcite. Trepca, Yugoslavia. A group of two large, twinned, brilliant black Sphalerite crystals with 0.3 in. balls of translucent Calcite and minor Arsenopyrite. **$70.00.**

Native Crystallized **COPPER.** Lake Superior District, Keweenaw Peninsula, Michigan. Two specimens, fine crystallized heavy "wires", 0.5 x 3 in. **$25.00** each.

THE COLLECTOR

by Richard A. Bideaux

In 1955, the Sunrise Mining Company began to sink an exploratory shaft at the Glove mine, east of Amado, Arizona. These claims had been located before 1910, and a little early production of lead reported; a minor occurrence of wulfenite in the upper workings was known. Thus there had been little anticipation when the new shaft and the lower workings developed from it uncovered one spectacular pocket of wulfenite after another. The first of these, narrowly missed by the shaft, was about 6 by 10 feet, and 4 feet high. Opaque brown to brilliant yellow transparent crystals encrusted the walls, in some places as isolated singles and groups, in others as masses to over a foot thick. These crystals were only up to 1/8 inch thick, but of unprecedented size; the largest I have from this first pocket is 3 1/2 inches from edge to edge.

As exploration and mining proceeded over the next several years, bonanza grade orebodies of anglesite and cerussite were found in the limestones, and other wulfenite pockets found nearby. Most of the pockets were smaller than the first, but each contained distinctively different types of crystals. The last major pocket was the largest found; it was about 35 feet long and 10 feet wide. Two domes at one end, each about 5 feet in diameter and 15 feet high, were covered with orange crystals, opaque, and rounded in outline, averaging around 1 inch, but up to nearly 3 inches across.

The largest wulfenite crystals I have ever measured, in terms of maximum dimensions, are from the Glove. One specimen, now in the National Museum of Natural History, consists of two crystals, olive-green in color, and 109 mm. between opposite edge terminations - over 4-3/8 inches across. On other specimens, some plates measure nearly 7 inches from the upper termination to where they were broken from the matrix.

After the impact of the first pocket, the mine management permitted contract collecting, so an unusually high percentage of the wulfenite discovered was preserved. After exhaustion of mineable reserves and a period of idleness, the mine is presently being reexplored by drilling, but the optioning company does not permit access.

An equally spectacular discovery was made in 1957 at the Defiance mine, Gleeson, Arizona. A series of connected caverns in limestone was encountered in mining operations. Two of these were about 40 feet long, 10 feet wide, and 4 feet high. They were thickly lined with wulfenite on all sides, nearly all of the same character. Brown, with overtones of orange in the best pieces, and averaging around 1 inch, these crystals are lozenge-shaped and of a composite character. Each crystal is usually made up of a number of smaller individuals, variously misoriented to give saddle shapes or crenulated edges. One such crystal was 2-3/4 inches across.

Most of these crystals were destroyed in mining, but not before some hundreds of pieces had been collected. Mining ceased shortly after these pockets were removed, but some material of lesser quality has reached the market since. The owners have backfilled the principal mine entrance at this time.

The North American wulfenite province we have been discussing continues well on into Mexico. The mines at Villa Ahumada, Los Lamentos, Chihuahua, Mexico, have rather consistently provided many thousands of pieces of a very characteristic wulfenite over the last several decades. These familiar brownish-yellow thick tabular crystals on limestone are collectors' favorites, often compared to caramel candy. Crystals usually range from 1/2 to 1 inch, and rarely reach the range 1-1/2 to 2 inches. A common associate is arsenian vanadinite, usually mislabelled end-

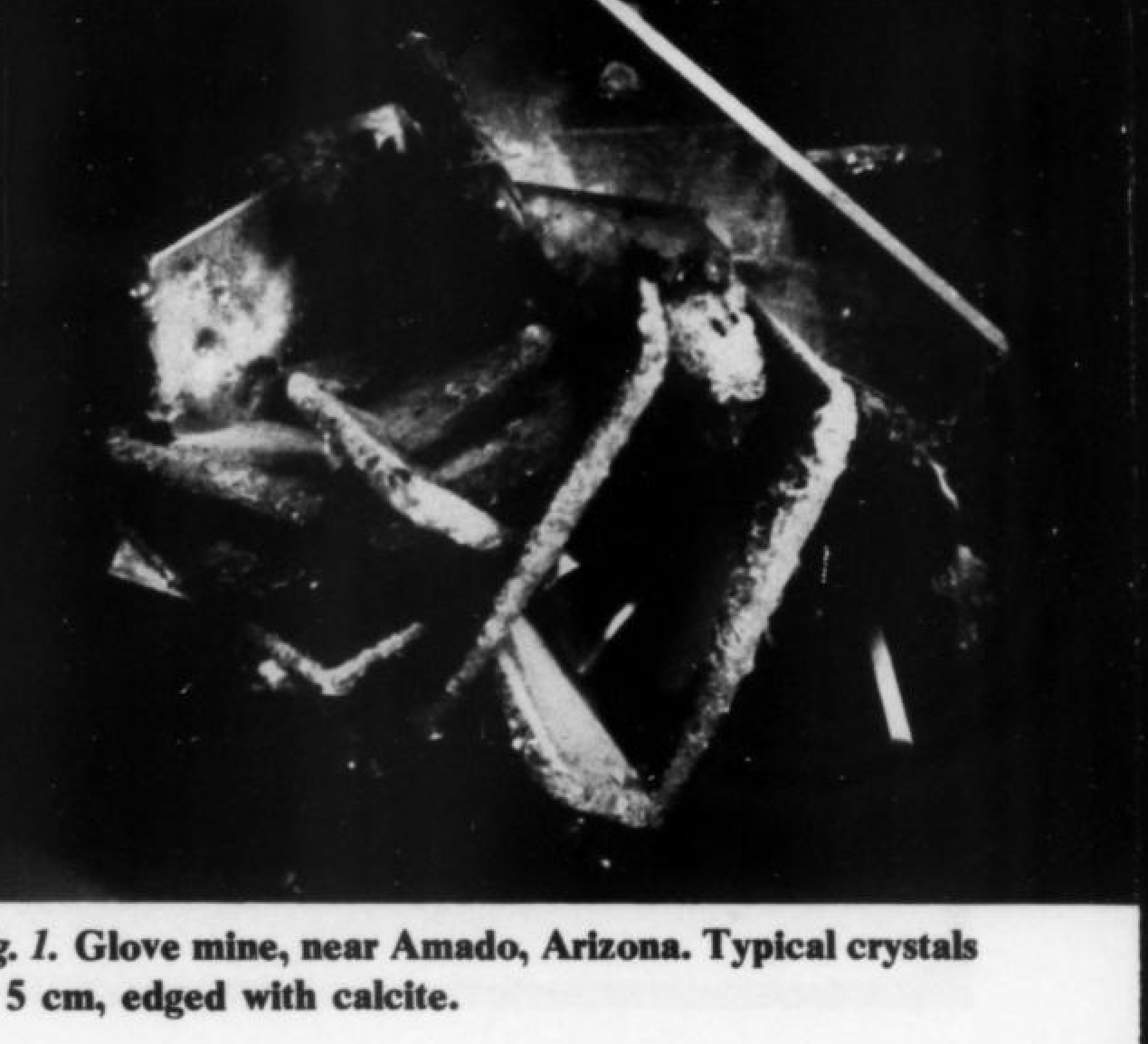


Fig. 1. **Glove mine, near Amado, Arizona. Typical crystals to 5 cm, edged with calcite.**

lichite. Steep pyramidal crystals of the same color and luster are not infrequent, while thinner tabular light brown to yellow transparent crystals are much rarer.

Mexico's greatest specimen producing mine, the Ojuela, at Mapimi, in Durango, is her other prominent wulfenite locality. This mine has supplied moderate amounts of a wide variety of types of wulfenite, mostly in the late 1940's through the early 1960's. The most characteristic and beautiful are thin, square, transparent pale yellow-green crystals, usually around 1/2 inch, but occasionally over 1 inch, on limonite with mimetite microcrystals.

Several years ago, a few striking wulfenites were imported from the San Carlos district, Chihuahua, Mexico. This district used to provide rich vanadinite specimens, but without evidence of associated wulfenite. These recent wulfenites are a fine orange-red color, and occur as isolated individuals imbedded in white calcite rhombohedra.

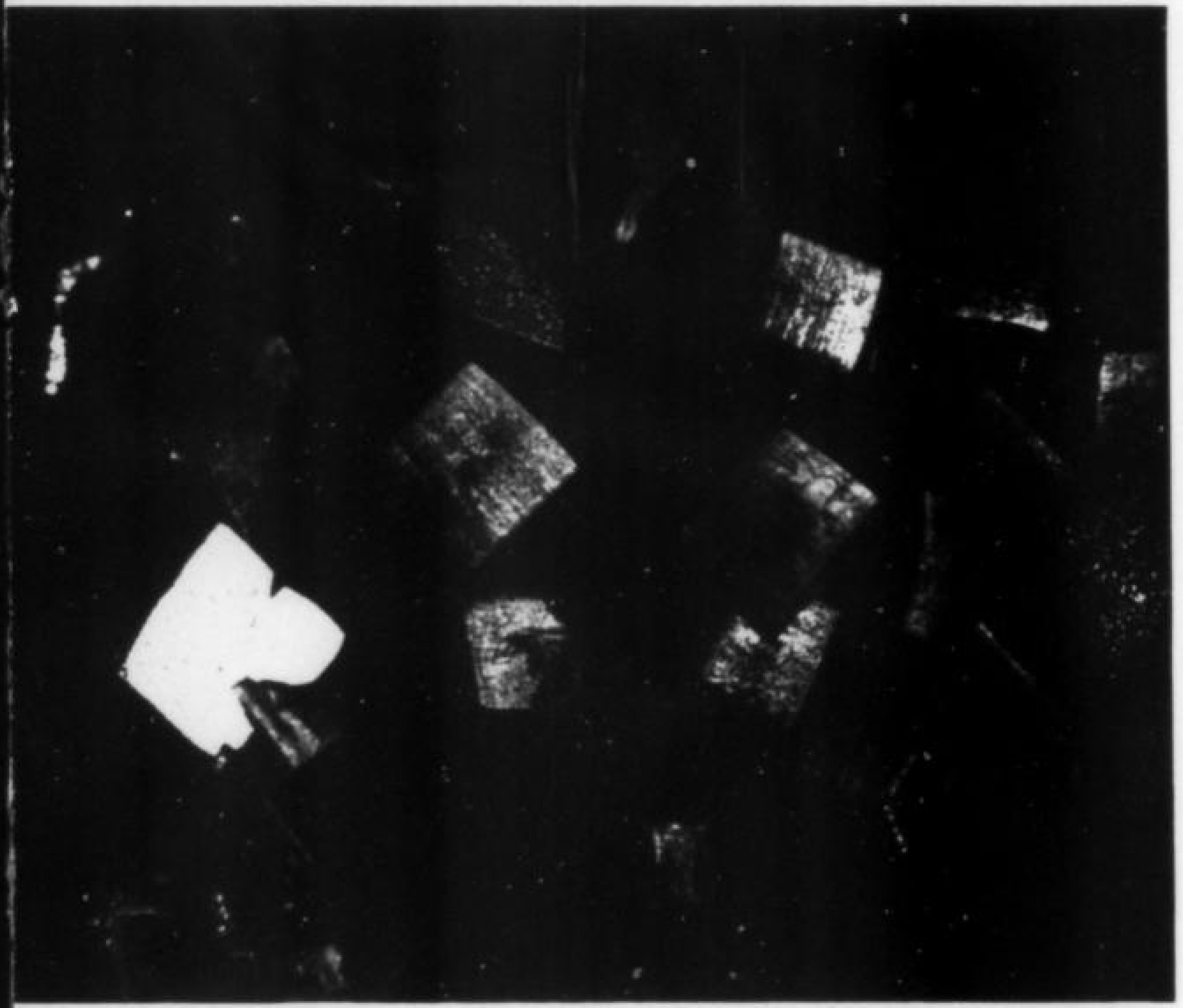


***Fig. 2.* Glove mine, near Amado, Arizona. Stocky 2-3 mm crystals, an atypical habit.**

***Fig. 3.* Defiance mine, Gleeson, Arizona. The specimen is 8 cm across.**

At about this same time, but continuing over a period of several years, some wulfenites were brought in from a mine at San Pedro Corralitos, also in Chihuahua. Crystals were on the small side, perhaps 1/4 to 1/2 inch, but were richly varied in habit, color and association. Sharp, flat pyramidal yellow crystals were distintive, as were yellow tabular crystals on a matrix of drusy azurite. One of these was pictured on the cover of the last issue of the *Record.*

I have seen a few specimens from a number of localities in Sonora, Mexico over the years, but no quantity of material ever seemed to be available. This past year, however, several thousand pieces have been collected at a centuries-old mine at Cerro Prieto, near Magdalena, Sonora (*Mineralogical Record,* **3**, 4, 180-181, 1972). This locality seems to be a mimic: a wide variety of types was found, each remarkably like older material from other mines. Rosetted yellow crystals, like Tombstone; transparent yellow-orange crystals with yellow tufted mimetite, like Tiger; orange crystals with orange mimetite balls, like the Rowley mine; and yellow masses of crystals like early Glove specimens have been seen.

All are handsome pieces, some with crystals up to 2 inches across. Unfortunately only a few pieces were carefully collected and are essentially undamaged. Mexico in general, and Sonora in particular, can be expected to produce major wulfenite finds in coming years.

On other continents, Africa has the most notable localities. Morocco, Algeria and Tunisia have undoubtedly had some fine specimens, but few have apparently been saved as have the outstanding cerussite, anglesite and vanadinite

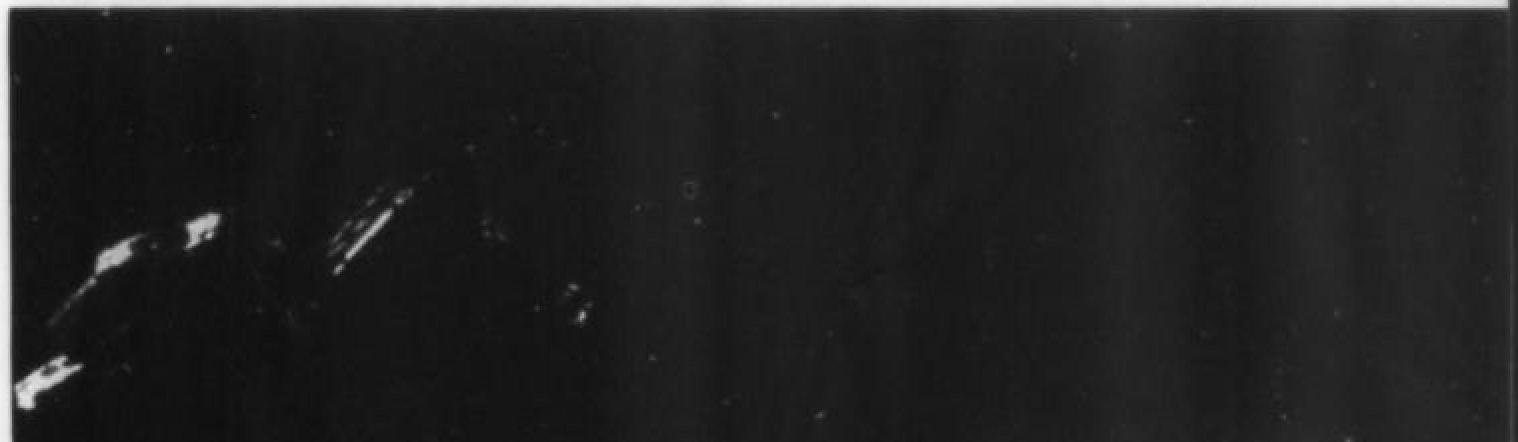


***Fig. 4.* Villa Ahumada, Los Lamentos, Chihuahua, Mexico. The crystals are 3 x 3 cm.**

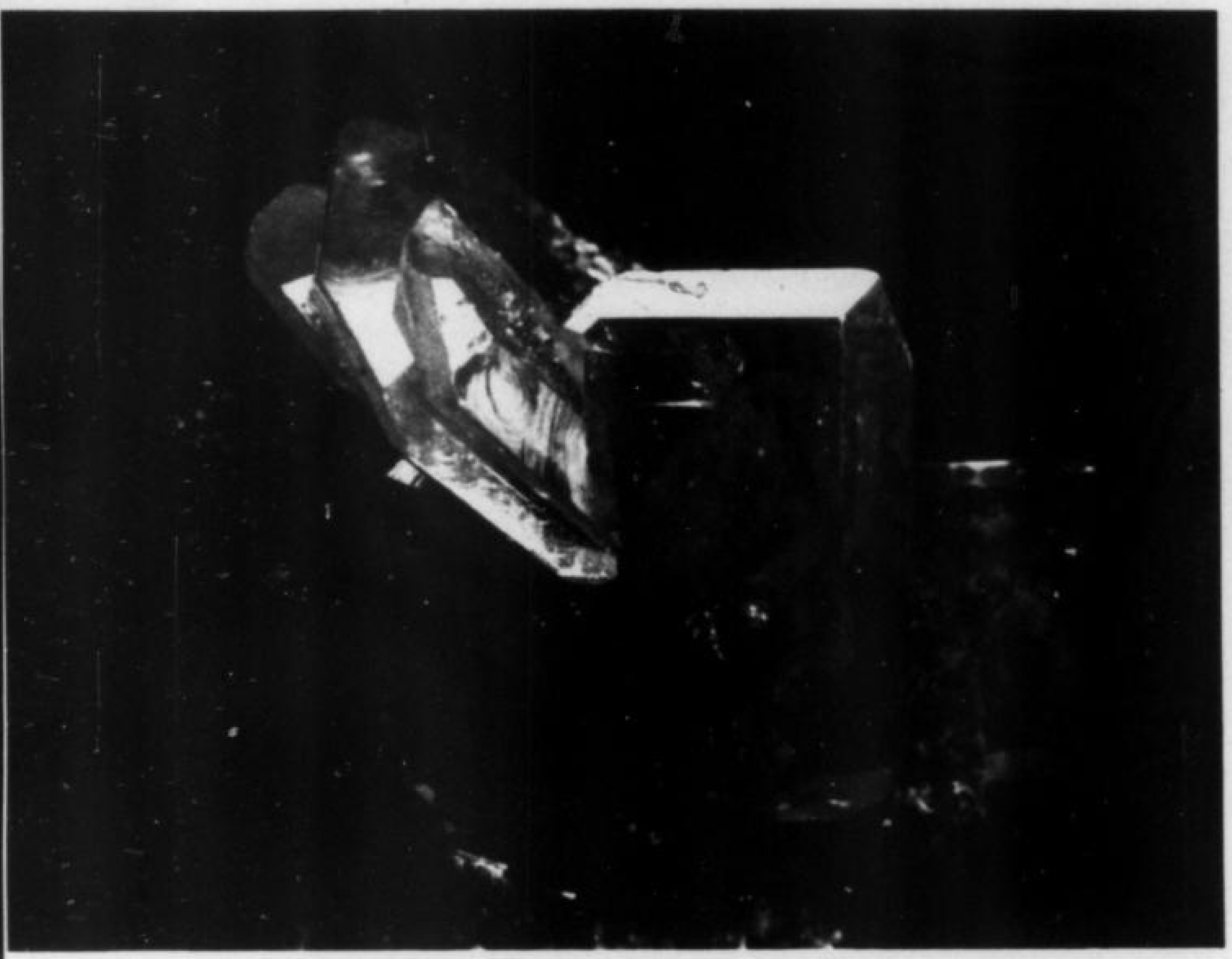


Fig. 5. **San Pedro Corralitos, Chihuahua, Mexico. The large crystal is 2 x 2 cm.**

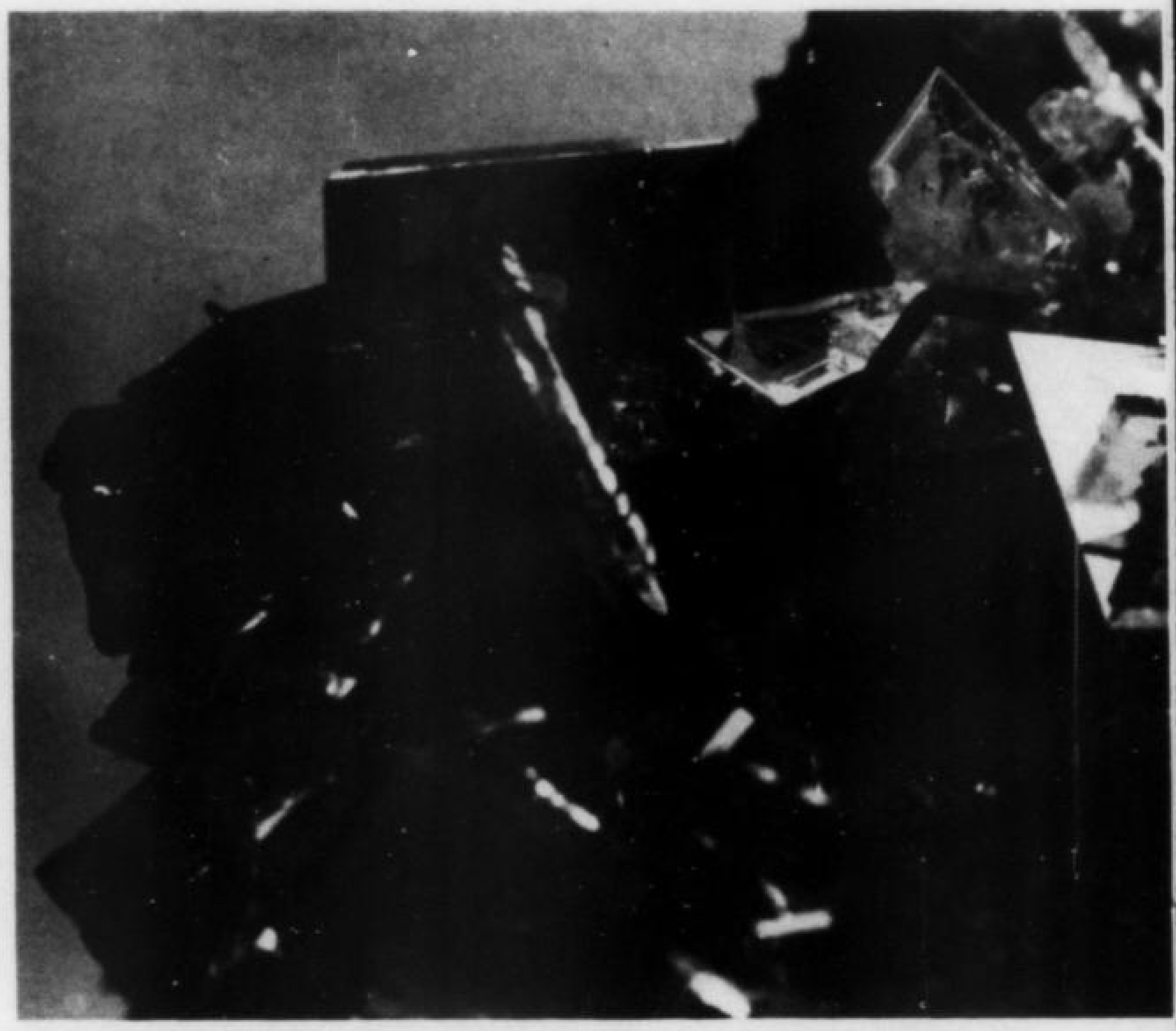


Fig. 7. **Cerro Prieto, near Magdalena, Sonora, Mexico. Maximum crystal edge length is 2 cm.**

Fig. 6. **San Pedro Corralitos, Chihuahua, Mexico. The large crystal is 1 cm across.**

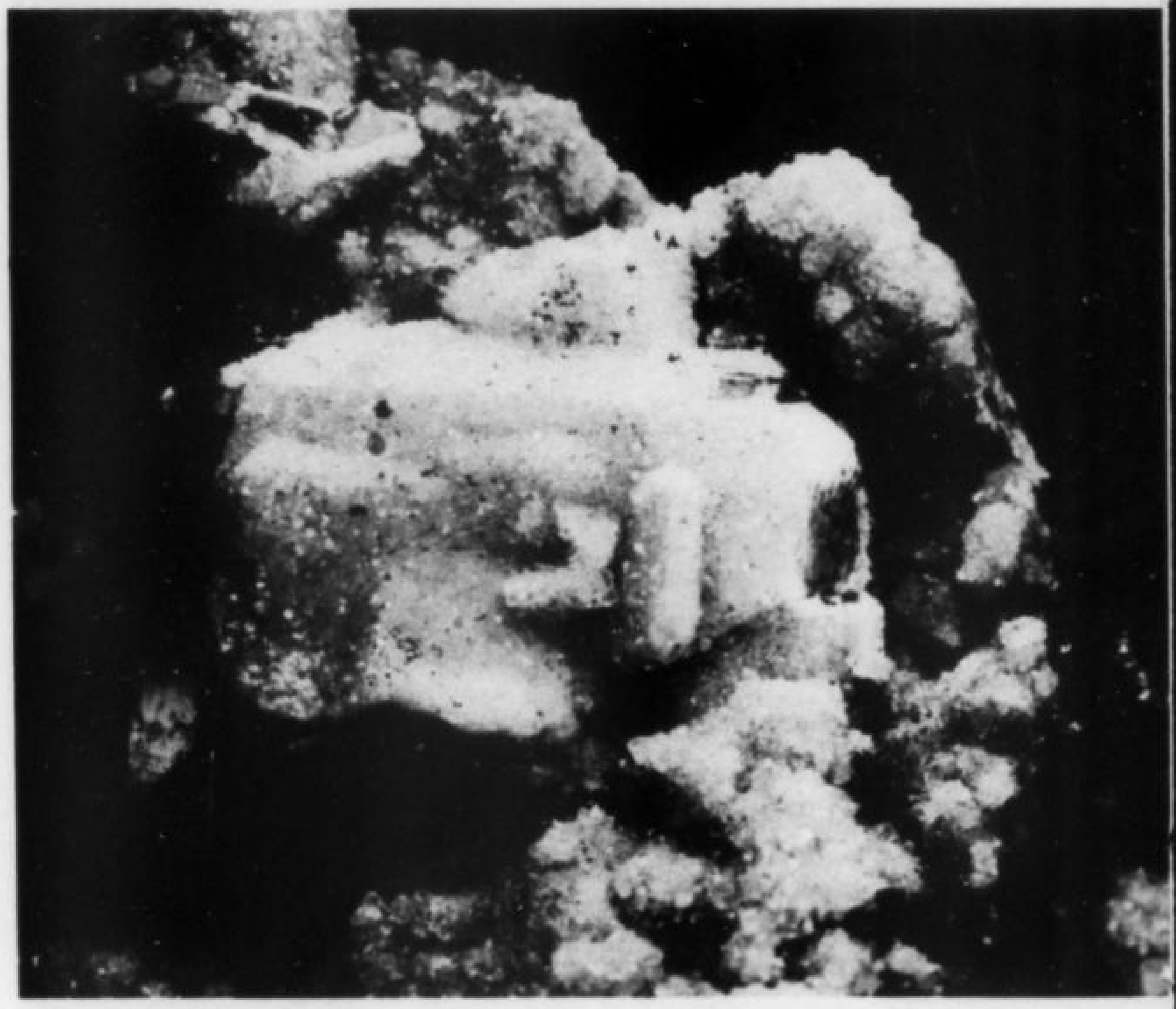


Fig. 8. **M'Fouati, Congo (now Zaire). Drusy quartz partially covers this 5.5 cm-long crystal.**

specimens. Some localities in central Africa, especially in the Congo, show minor but interesting wulfenite occurrences. M'Fouati had a pocket with immense crystals up to fist-sized, undoubtedly the largest in the world by weight for single crystals, but tightly encrusted with drusy quartz. Occasionally large wulfenite crystals occurred with the dioptase specimens for which this region is so famous. Fine examples are on display in Paris museums.

Tsumeb, South West Africa, has had some exceptionally large crystals and masses recovered during mining, although the mineral is a minor constituent of the ores there. White, gray, pale yellow and grading to a rich brown, some crystals are over 3 inches on an edge. The largest piece of wulfenite I have seen is from Tsumeb, now in the American Museum. This broken, platy mass of deep orange crystals must weigh well over a hundred pounds, and appears absolutely devoid of any other species.

Wulfenite forms when oxidizing lead-bearing deposits are exposed to ground water carrying molybdenum in solution. Williams (*Amer. Min.,* **51,** 1212, 1966) has found a connection between crystal habit and conditions of formation. Tabular crystals generally form under mild conditions, with an increasing tendency to becoming equant, then finally steeply dipyramidal at extremes of acidity and oxidation.

Synthetic, chemically pure $PbMoO_4$ is white, but naturally occurring white crystals are a rarity, especially if trans-

Fig. 9. **Tsumeb, South West Africa. A 3.5 cm square crystal nested in malachite.**

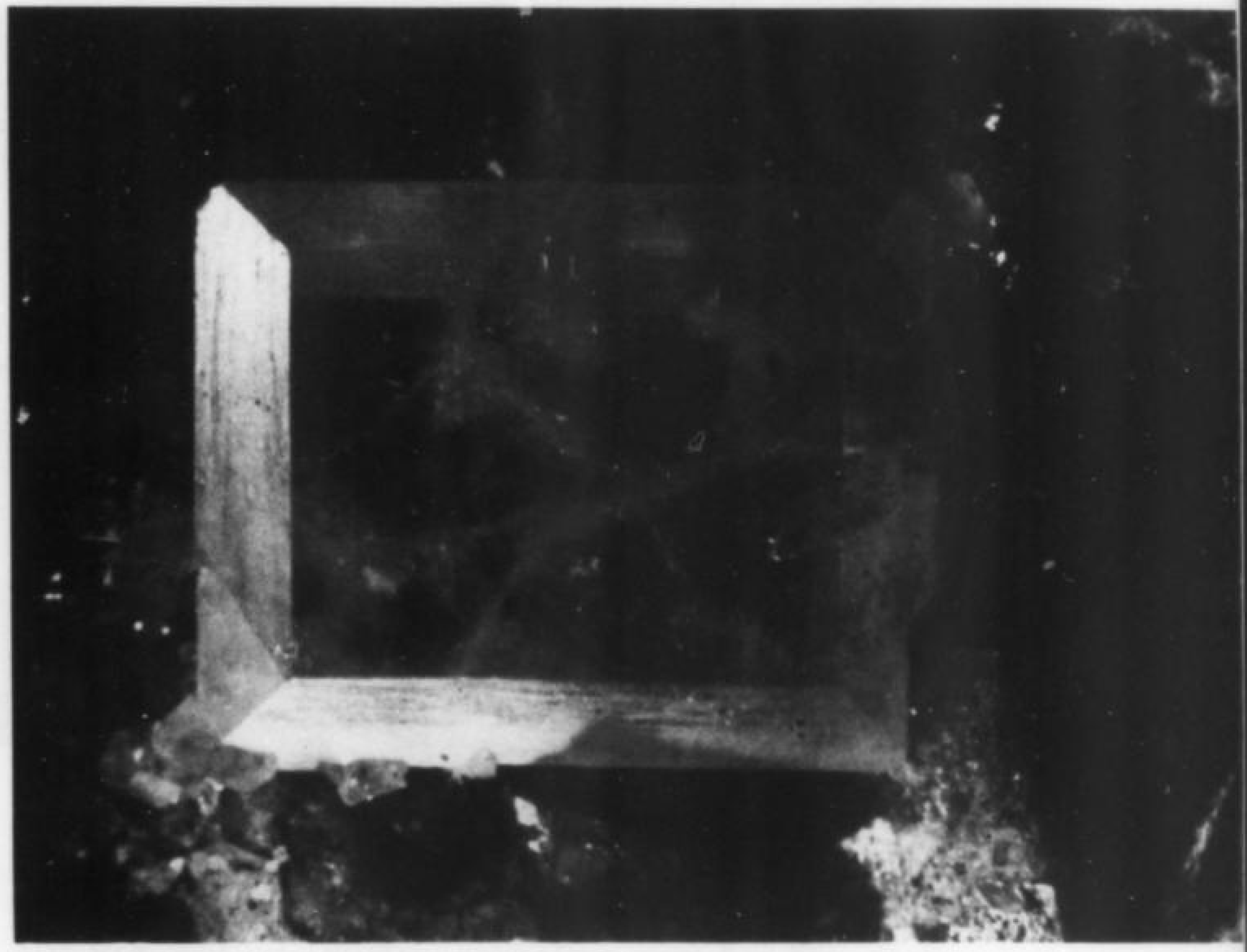


Fig. 10. **Tsumeb, South West Africa. A creamy-white crystal 1.3 cm long.**

parent. A few such crystals have been found at the Glove mine; some other localities show crystals grading to colorless at the edges. Tsumeb especially is noted for opaque white crystals. Probably the most frequently occurring color is brown, followed by orange, yellow, green, red and black. Williams (loc. cit.) found maximum impurity levels in an analyzed series of samples to be: WO_3 greater than 10%; V_2O_5 1.10%; Cr_2O_3 0.85%; and As_2O_3 0.75%. While correlations have not been exhaustively tested, tungstenian material can be orange, yellow or white; vanadian and chromian, orange and red; and arsenian, brown, orange and yellow. Members of the series vanadinite-mimetite-pyromorphite are nearly always associated with wulfenite, and are usually of identical color.

Red wulfenites are especially attractive; those from the Trigo Mountains and the Mammoth mine, Arizona have already been mentioned. Some crystals from the Chah Kharboze, near Anarak, Iran are even somewhat deeper in color, but the reddest I have seen are from the Florence mine, Arizona. These microcrystals are in direct association with the chromate minerals hemihedrite and vauquelinite, and contain 0.83% Cr_2O_3 (Williams and Anthony, *Amer. Min.,* **55,** 1088, 1970).

Note that the blue end of the spectrum is unrepresented. I have seen only a single fragment of patchy blue authenticated wulfenite, from Tsumeb. This color is due perhaps to included ilsemannite or other molybdenum oxide.

All specimens figured are from the collections of the Smithsonian Institution, and the photographs were all taken by Wendell E. Wilson.

PURFIELD KENT

Purfield Kent, President of the New York Mineralogical Club, passed away at the age of 58 on September 1, 1972 after a brief illness. He was a mineralogist in the classical sense, his interest in geology going back to his high school days in New York City. He graduated from the College of the City of New York in 1938 and while there became a protege of the late Dr. Daniel O'Connell who sent him down to a professional lapidary to learn how to make a thin section. On his own he decided he would learn to make a cabochon. After a five year stint in the Army in World War II, he returned to become a member of the faculty of the Department of Earth and Planetary Science for the next 26 years, and incidentally the first lapidary teacher in the City of New York. He spent only a year at this before turning the classes over to a regular lapidary instructor, but in that year he started three future instructors of lapidary and gemology and one future grand master and national champion of the American Federation of Mineralogical Clubs. For years he was the member of the faculty whose opinion was sought after when it was a question of mineralogy. The same thing applied to members of the club. After a heated discussion all heads would turn in Purfield's direction. If the evidence supported a conclusion, it would be quietly given. If there were doubts, these would be stressed. But always, whether it was his colleagues at City College or his fellow club members on a field trip, he was listened to with respect. His friendship was given just as quietly. A talented educator, he will be missed by the faculty and students at City College. A discerning collector and fine mineralogist, he will be missed by the New York Mineralogical Club. He is survived by his wife, Irma, and two daughters, Mrs. Carol Natoli and Gale.

Yedlin on Micromounting

We have a new adjunct to our mineral interest — labels. Our recent discussion of George L. English and his various places of business was the start of a search for mineral tags, old and new; collectors, dealers, colleges and museums. Presently (9/1/72) some 300 in our collection, some singles, and some with changes in address, style and modernization. These include English (13), Foote (10), Wards (9), U.S.N.M. (13), Kunz (10), Amherst (10), Yale (7), and Cahn (5).

From these labels we've learned that Cahn first sold minerals at Staten Island, N.Y., in New York City at two establishments, and then at Colorado Springs, Colorado. That George F. Kunz built collections and sold them in the regular course of business, printing different styles of labels for each. That Amherst College had many donors, including Shephard, author of one of the first mineral books in the United States, part of whose collection reposes, too, at the Smithsonian. Amherst graduated many who became missionaries in the early days (100 or so years ago) and they sent specimens back to their alma mater. There were so many of these missionaries, and so many specimens, that all were lumped into a group, and a universal card was printed — "Missionary Collection".

Richard Bideaux, too, collects old labels, but with the actual specimens appended (we've put the tail to wagging the dog on this one.) Dick collects superb specimens, and when they're old-timers, and the original label comes along, he treasures both. He added a couple to our G. L. English assemblage. During the transition stage when English's business moved to New York from Philadelphia, his labels carried both addresses. English exhibited at the World's Columbian Exposition at the turn of the century, and when he disposed of a particularly choice item he included this label as part of the sale: *"This specimen is sold on condition that we shall be privileged to borrow it for display in our exhibit at the World's Columbian Exposition."* Dick has the specimen. He says it's not that good.

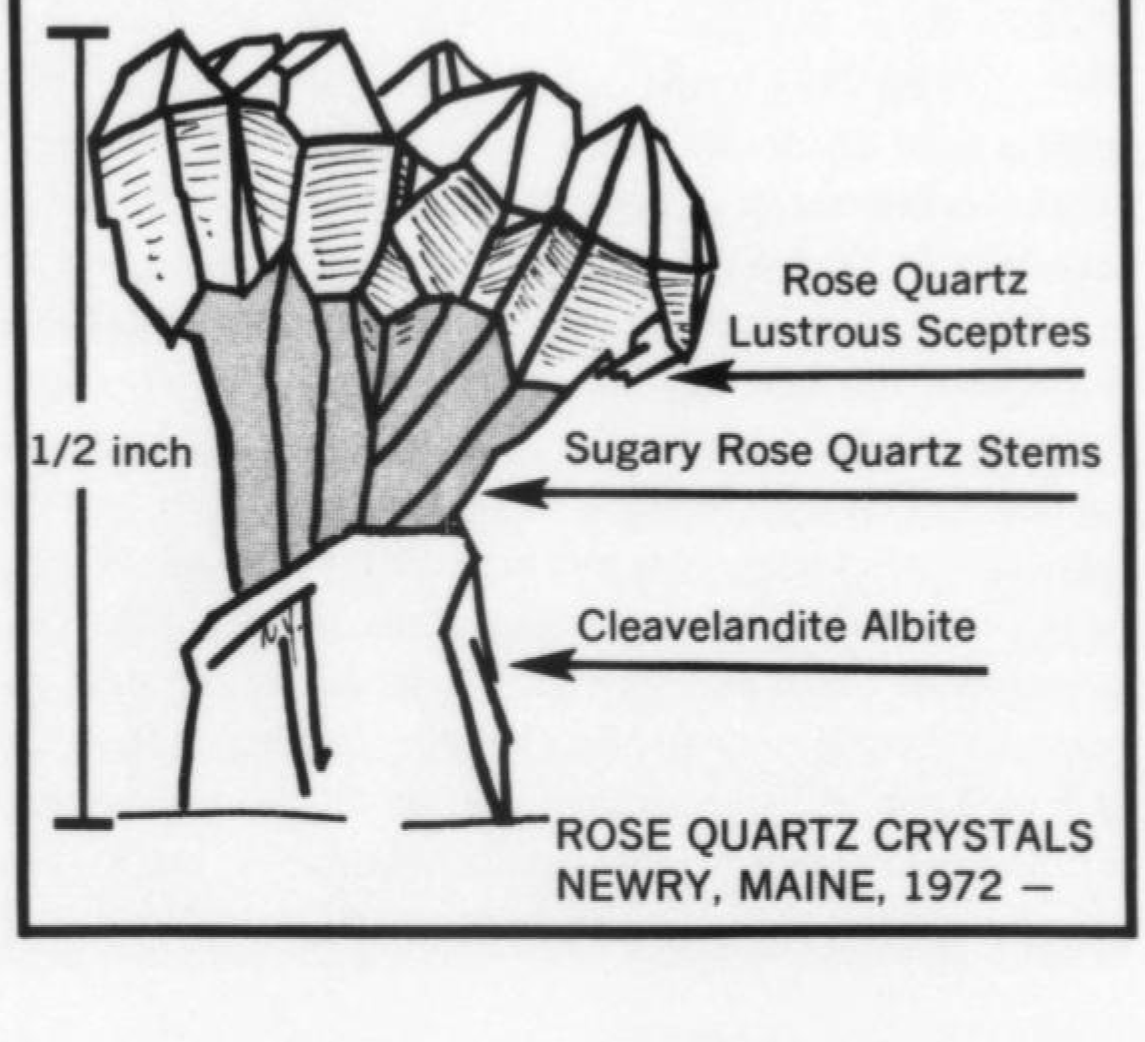
One last thing: *The Mineral Collector,* a defunct monthly publication (more about this later) in its March 1905 issue, contains a full page advertisement by Ward's. In the middle of the page is the following: "To our customers: Having this day sold our entire stock, goodwill and fixtures to Ward's Natural Science Establishment of Rochester, New York, we take pleasure in bespeaking for them the favor of your continued patronage. Thanking you for past favors, we remain, George L. English & Company. Dated January 5, 1905."

Sic Transit Gloria Mundi.

Quote: "The largest aluminum works in Great Britain are at Battersea, where it is produced by a certain process from cryolite and sodium, — the former mineral being brought from Greenland, where it is to be obtained in 'inexhaustable quantities'." From *Minerals, a Monthly Magazine* dated May 1893. In this case "inexaustable" meant 78 years.

In August we attended the Sunapee, New Hampshire mineral show and exchange. It was in beautiful country, in a beautiful setting, and was an excellent New England show, with an entire floor devoted to sales and another to exchanges. Among other things we acquired some fine Newry, Maine rose quartz, some of which had associated eosphorite in tan flat crystals. This material was collected in the spring of 1972 and, in miniature, appeared like the specimens from Taquaral, Minas Gerais. One was unique, a cluster of sceptre points, with fine artistic symmetry. Roughly, we've sketched it and show it. The whole thing is about half an inch in size and fits into a micromount box.

Some good babingtonite crystals, with associated epidote and datolite, were available; the locality on the label was "Lane Quarry, Westfield, Massachusetts (R.I.)" Now this place is noted for its babingtonite, from micromount to immense crystals, but the quarry has been solidly closed



ROSE QUARTZ CRYSTALS
NEWRY, MAINE, 1972 —

to collectors for some fifteen years. "Where" we asked John Marshall, who had a number of them in his sales display, "did these come from? And why the inclusion of '(R.I.)' at the bottom of the label?" A most interesting answer was forthcoming. "During the 1938 hurricane in New England a section of the right of way of the New Haven Railroad was washed away near Providence, Rhode Island. In the emergency eleven carloads of traprock in large sizes were dumped on the spot to replace the missing ballast. The rock came from the Lane Quarry in Westfield, Massachusetts. I've been collecting it for years."

From this, and from the collecting that's been done in the New Jersey meadows near East Rutherford of rock dumped there from excavations in New York City, we can postulate another theory of collecting: "When a locality is off limits to mineral gatherers, find out where the waste is being dumped. It may provide a good source for specimens."

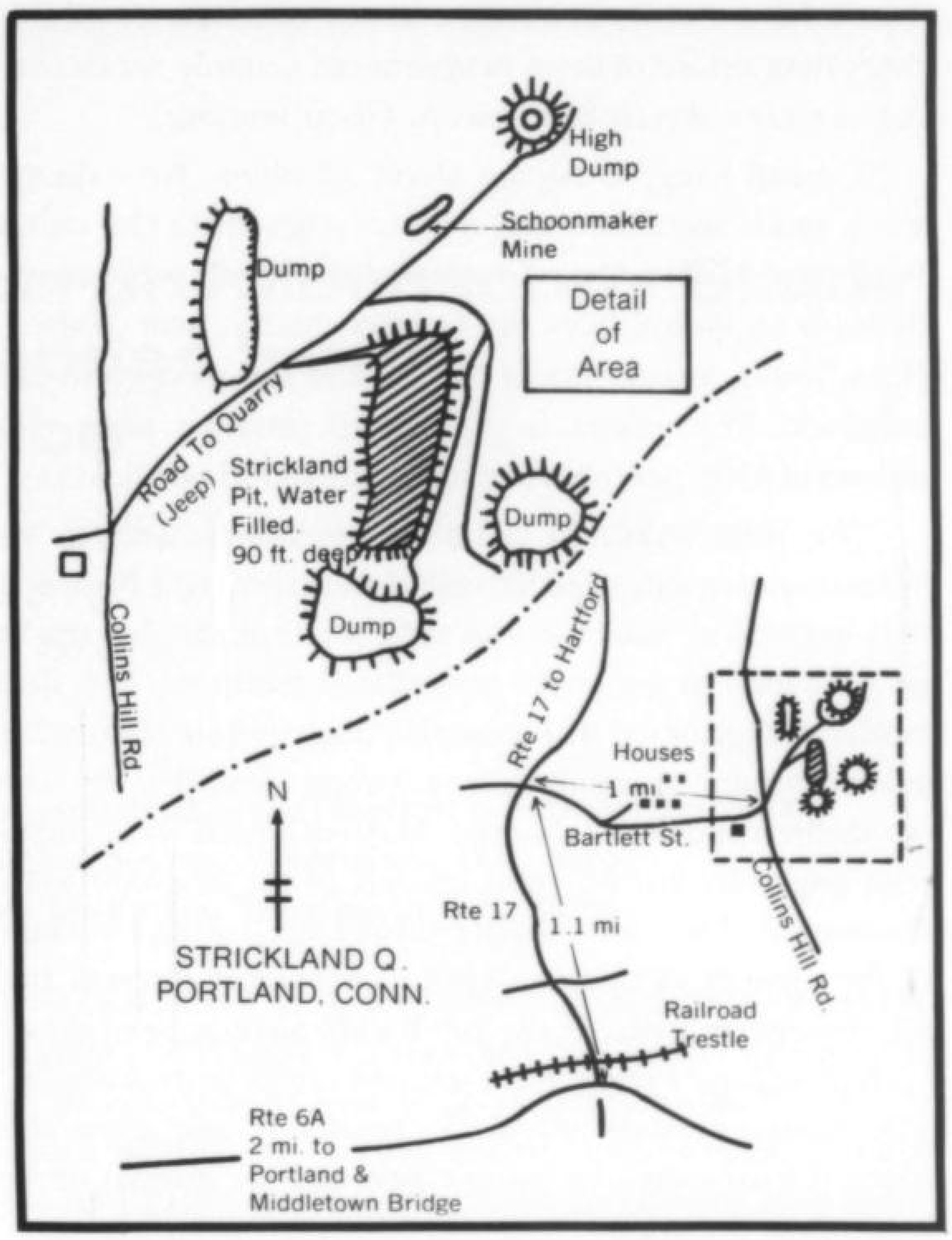
Notes: Dona and Wayne Leicht, P. O. Box 2514, Costa Mesa, California 92626 have decided to share their plethora of duplicate material with other collectors. They're advanced micromounters, interested in acquiring fine specimens and have things of superb quality. They've issued a bulletin of availables which is yours for the asking (and a stamp).

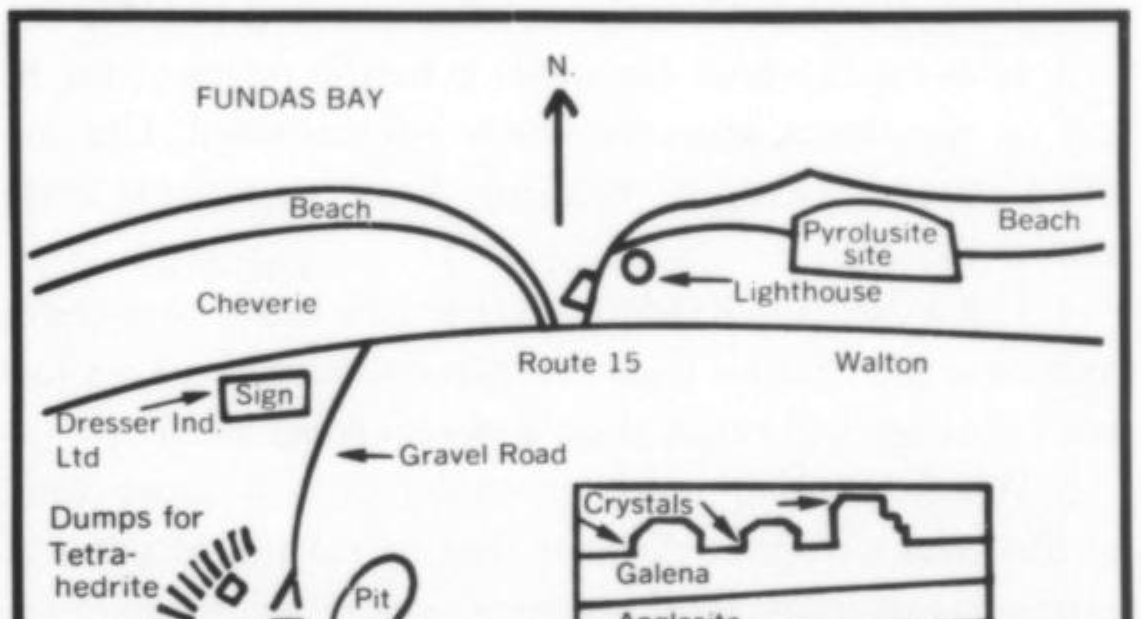
W. F. Erichsen, 2078 Landsdown Road, Victoria, British Columbia has some of the friable dolomitic limestone from the Lengenbach Quarry, Binnental, Switzerland. "I got these in exchange from a university in Geneva.... They vary in size up to two inches. All show some of the lead sulphosalts, along with pyrite and (some) realgar. I doubt that any would show more than crystal faces rather than complete crystals, although some may be buried in the dolomite. It is difficult to put a value on them, but if any of your readers are interested I'd be pleased to hear from them."

A Note from Mildred Watson, of Stratford, Connecticut anent "minerals are where they're supposed to be" which we discussed in a prior column. "Sometimes," she says, "they're where they shouldn't be. While cleaning tri-state specimens I spotted some black, minute crystals. Looked like enargite. Could it be? Dana's Seventh says 'rarely found with chalcopyrite, sphalerite and galena on dolomite in the Joplin district of Missouri.' This occurrence is also mentioned by Sinkankas and Pough. A subsequent check revealed several pieces had some enargite, and one was covered with the crystals. There must be a lot of this around, unrecognized by collectors, who take the tri-state material for granted."

We have some of these shiny black prismatic crystals on dolomite. The source of our material was F. A. Pough, mineralogist and author, while he was curator at the American Museum of Natural History in New York.

A visit to the famous Strickland Quarry, Portland, Connecticut was in order in July last, more or less as a Survey. Jules Bernhardt, of the Nassau Mineral Society, was along. He'd never been there and was working up a trip for his micromount group. After avoiding swimmers and scuba divers, and digging on some of the old dumps, we decided that there was a good deal to be found. Strickland, a lithium pegmatite, was worked for mica, beryl, and on occasion, for the accessory minerals. A half hour's casual digging and breaking up of the albite produced fluorite, apatite, lepidolite, almandine, pyrite, cookeite, quartz, brown tourmaline and muscovite, all in minute crystals. We went to our files and located an old field trip notice of the Boston Mineral Club, describing the locale. Reference is made to Strickland (and nearby quarries) in *Rocks and Minerals,* Vol. XII, No. 5, May 1937, which gives a pretty good description and bibliography of the area. The Boston club notice lists fifty-one minerals





found there, but we doubt that at any one time you'll find more than a third of them in specimens suitable for mounting. An area sketch is herewith. Good hunting.

Vandall King, 43 Alpine Street, Gorham, New Hampshire, sends specimens and a seven page letter (he writes large and spaciously.) Extracts: "Enclosed some tetrahedrites on barite, from the Dresser quarry, near Walton, Nova Scotia, just off Route No. 15, and always open to the collector. The galena is reputed to produce some 800 ounces of silver per ton; ruby silvers are found on occasion."

"We were returning from the pyrolusite locality at Walton, and saw the sign 'Dresser Industries Ltd.'. Knowing that barite was mined in the area we thought this might be a chance to get some crystallized material. The first barite was sprinkled with complex chalcopyrite. Extended search produced small galena cubes, modified by the octahedron and dodecahedron. Massive galena was banded with anglesite, but no good crystals of the sulphate were discovered. Then tetrahedrite turned up. I wasn't certain of the identity of this one until I checked it through the microscope at home. If the sun hadn't already been down for half an hour I might have secured much more material. The minute crystals are black, sparkling, and show the trigonal tristetrahedron on one side and the normal tetrahedron on the others."

Here are some suggestions lifted from the *Mineral Mite*, a publication of the Micro Mineralogists of the District of Columbia which, in turn, lifted it from a paper by Rudy M. Tschernich, presented to the Micromounters of the Northwest Federation. Some good advice here, and it may apply:

"1. Use cotton swabs (Q-sticks) in place of brushes to paint the insides of plastic boxes black. Use flat black paint or enamel, not lacquer, which ruins the boxes. (Al Keen).

2. Round sawblade of steel, with tungsten carbide bonded to it (advertised extensively and available at most hardware shops) to notch specimens so that a trimmer or nippers can bite into the specimen. Best hold the mineral in a wood vise while filing the notches into it. (Ford Wilson).

3. In areas in which the water is hard a residue may be left on specimens after they have been washed. Use distilled water or "Calgon" softener. Some detergents leave similar deposits.

4. Use a dampened 000 or 0000 artist's brush to transfer minute single crystals from one place to another. Less loss and breakage will result than if tweezers are used.

5. When isolating small crystals found in loose sand or dirt, run a magnet through first to rid the mixture of magnetic materials. Steel tweezers, which become magnetized in a short while, work more efficiently if there are no clinging grains. Conversely, when separating magnetite crystals from such mixtures, a magnet picks them readily from the assemblage.

6. Want a micro-meteor? No guarantee, but try placing a magnet at the bottom of your roof downspout. There are an awful lot of them bombarding the earth, and a thousand square foot rooftop is a fine catchall for specimens.

7. When a specimen is so uniformly good that it must be viewed from all sides, mount it on the COVER of a plastic box. Use a clear box, so that proper care may be exercised in opening it for viewing." (Ed. note. When cardboard boxes were in vogue, we mounted the pedestal on the end wall of the box, cut the bottom out of it, and used two covers. Thus the specimen could be viewed from either side, usually more than adequate. There are yet a few of these mounts around, some of them ours.)

Quoting the *Mineral Mite* again — "At the Roundup (Annual Spring meeting in Washington, D.C., this year in May.) two questions were asked: 'Where does one get corks, and how do you prepare them for pedestals?'

Corks are usually sized by number, and those usually used by micromounters are, in descending order, 0,00, 000,0000. First try a hobby shop catering to many hobbies, then a drug store. The owner may be able to help you but may want to sell you a large quantity. (Ed. note. If you live in a city of considerable size, go to the yellow pages of your telephone directory under corks. Usually a chemical supply house will carry corks in half pound or pound lots. The quantities may be large, but the prices are correspondingly low.)

Most hobbyists prefer to blacken the corks before using. An easy method is to prepare a solution of India ink and water, in which the corks placed in it for a few minutes reach the desired color. It is best to start with a light colored solution and add ink until the right color is reached. Also, if you are dipping a number of corks ink may be added to the solution. Place the corks on a blotter to dry."

We have a number of suggestions. Put the solution into a mason jar. Put a fistful of corks into the jar, cover, and shake vigorously. Use a metal strainer, and empty the jar, through the strainer, into another container, saving the liquid for later use. The strainer has all the corks. Rap the end of the sieve a couple of times against the inside of a carton to free drippings, and leave to dry,

continued on page 227

A Scanning Electron Microscopy Study of Minerals in Geodes from Chihuahua, Mexico[1]

by Robert B. Finkelman, John J. Matzko*, Ching Chang Woo*, John S. White, Jr.†, Walter R. Brown†*

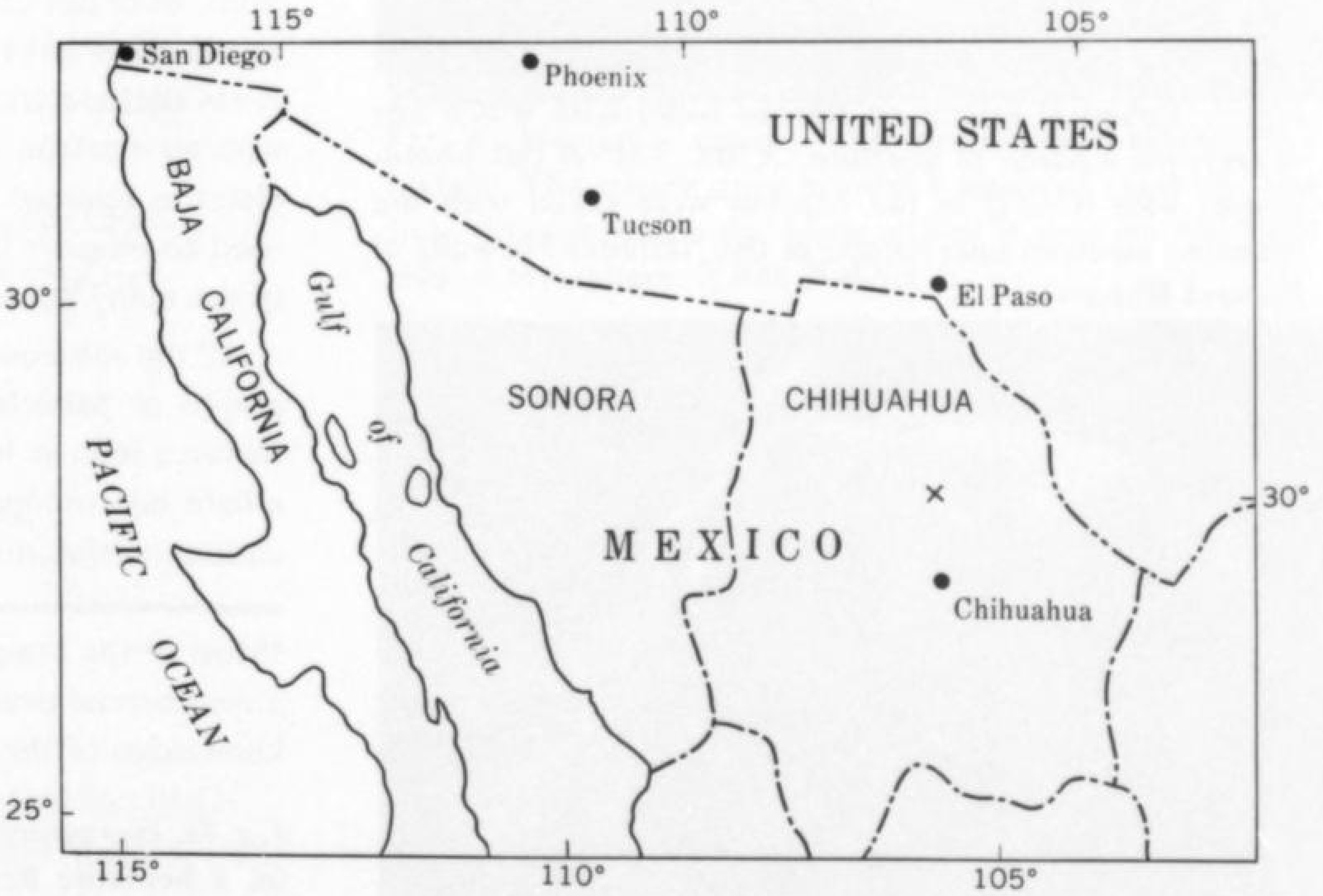
* **U.S. Geological Survey, Washington, D.C. 20242**

† **Smithsonian Institution, Washington D.C. 20560**

In recent years hollow nodules (sometimes referred to as "coconuts") from Chihuahua, Mexico (Figure 1), have been seen in increasing numbers in almost every rock shop and museum in the country. Although these nodules originate in a rhyolitic ash, they have been referred to as geodes. Older definitions describe geodes as hollow bodies with inward-projecting crystals lining the interior of the cavity. These descriptions restricted the occurrence of geodes to sedimentary rocks (Twenhofel, 1950, p. 605) or to limestones (Pettijohn, 1949, p. 151). More recent definitions, however, have not applied this constraint but have emphasized the fact that geodes are easily separated from the enclosing rock (Sinkankas, 1959, p. 626). Zeitner (1967) suggested that the reference to crystals in the cavities be dropped so that hollow nodules lined with chalcedony or opal may be included in the definition. Sinotte (1969) suggested that the term "geode" be extended to include objects that were at one time hollow but in which subsequent crystal growth has completely filled the cavity. We feel that both these suggestions have merit.

Recently one of these geodes from Chihuahua, Mexico, was brought to our attention. Many microscopic crystals and inclusions were observed under a binocular microscope. It was obvious that the mineralization of the geode was quite complex. Few attempts have been made to unravel the sequence of mineralization in geodes, and, to our knowledge, no comprehensive study of the mineralogy of geodes from Chihuahua has appeared in the literature. Therefore, a study of the mineralogy of these geodes was initiated.

Fig. 1. **Index map of northern Mexico. X, source area of the geodes.**



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[1] **Publication authorized by the Director, U.S. Geological Survey**

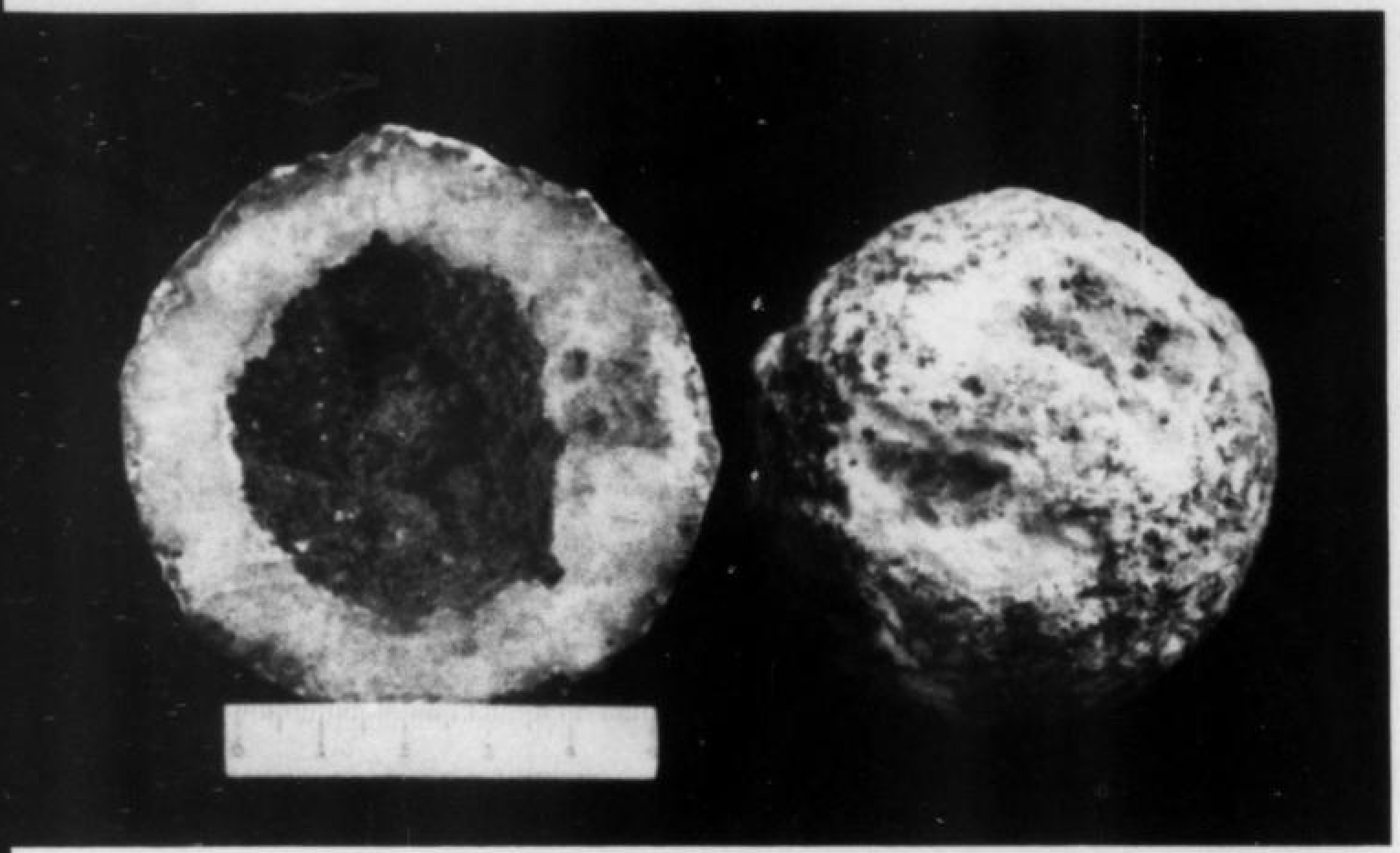

Fig. 2. **Geode from Chihuahua, Mexico. The geode has been cut in half so that the interior cavity and exterior surface may be seen simultaneously. Scale in centimeters.**

Fig. 3. **Euhedral quartz on fibrous todorokite which has overgrown a blade of goethite. X300. NMNH (all photographs with NMNH in the caption were taken with the scanning electron microscope at the National Museum of Natural History).**

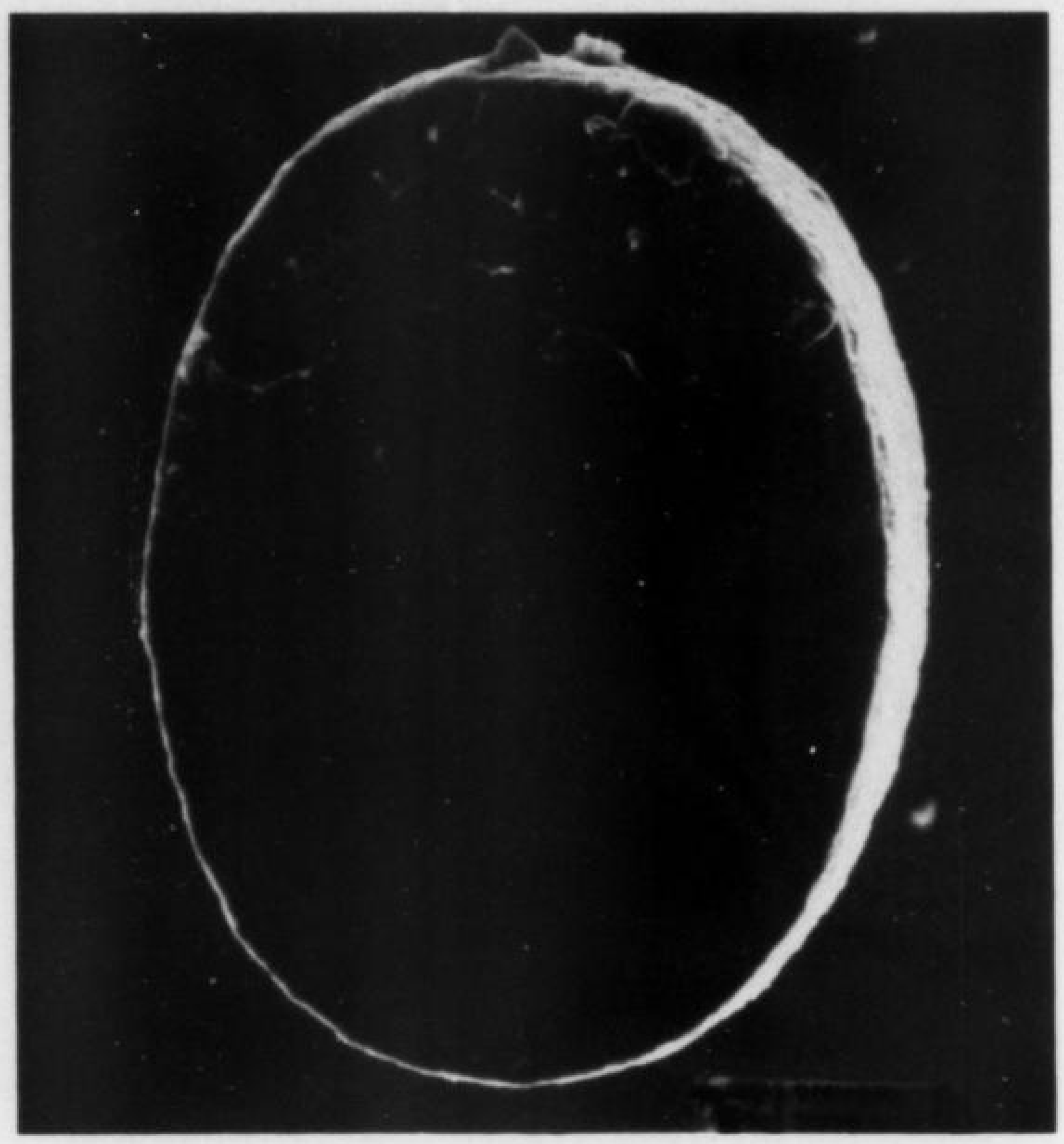

Fig. 4b. **Underside of a hematite hemisphere similar to the hemisphere in Fig. 4a. Note the concentric bands. X420. BRC.**

The geodes from Chihuahua (Figure 2) range in size from less than 2 inches to more than 8 inches in diameter. About half of the more than 150 specimens* we have examined were hollow. The size of the cavities varied greatly, ranging from about 90 percent of the volume of the geode down to about 1 percent.

The minerals found in the cavities (Table 1) consist primarily of quartz with subordinate calcite and trace amounts of several iron and manganese oxides. Crystals of kaolinite, gypsum, and the carbonate apatite, dahllite, have been found in only a few of the geodes examined. Sulfide minerals, found in geodes from some other locations, were not observed. The minerals removed from the geode have been identified by their optical properties, X-ray and electron diffraction, and by elemental analysis with an electron microprobe X-ray analyzer. A scanning electron microscope (hereafter referred to as SEM) was used to observe in more detail the intimate intergrowths of the many microscopic crystals in the geodes.

All the subsequent illustrations in this report are photographs or particles observed with an SEM. Some of the features seen at low magnification may be observed with a light microscope, but the SEM's wide range of magnification (useful magnification X15-X20,000), great depth

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*Most of the samples were purchased in a 100-lb lot from a commercial dealer. Unfortunately, we therefore have no knowledge of the field relationships between the geodes.

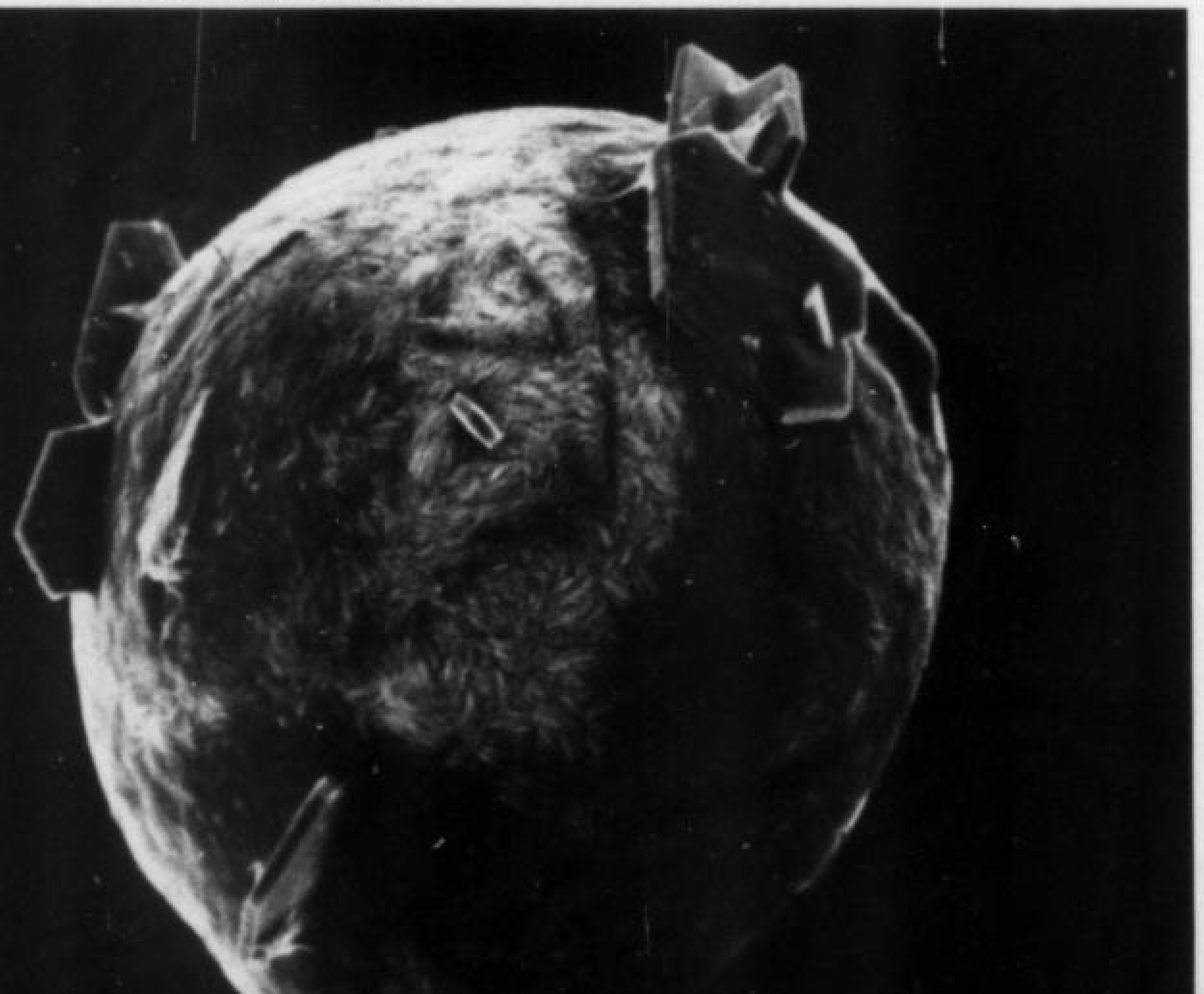

Fig. 4a. **Hexagonal plates of apatite on, and partly embayed in, a hematite hemisphere. X420. BRC (photographs 4a and 4b were taken by Dr. Anastasios J. Tousimis at the Biodynamics Research Corporation).**

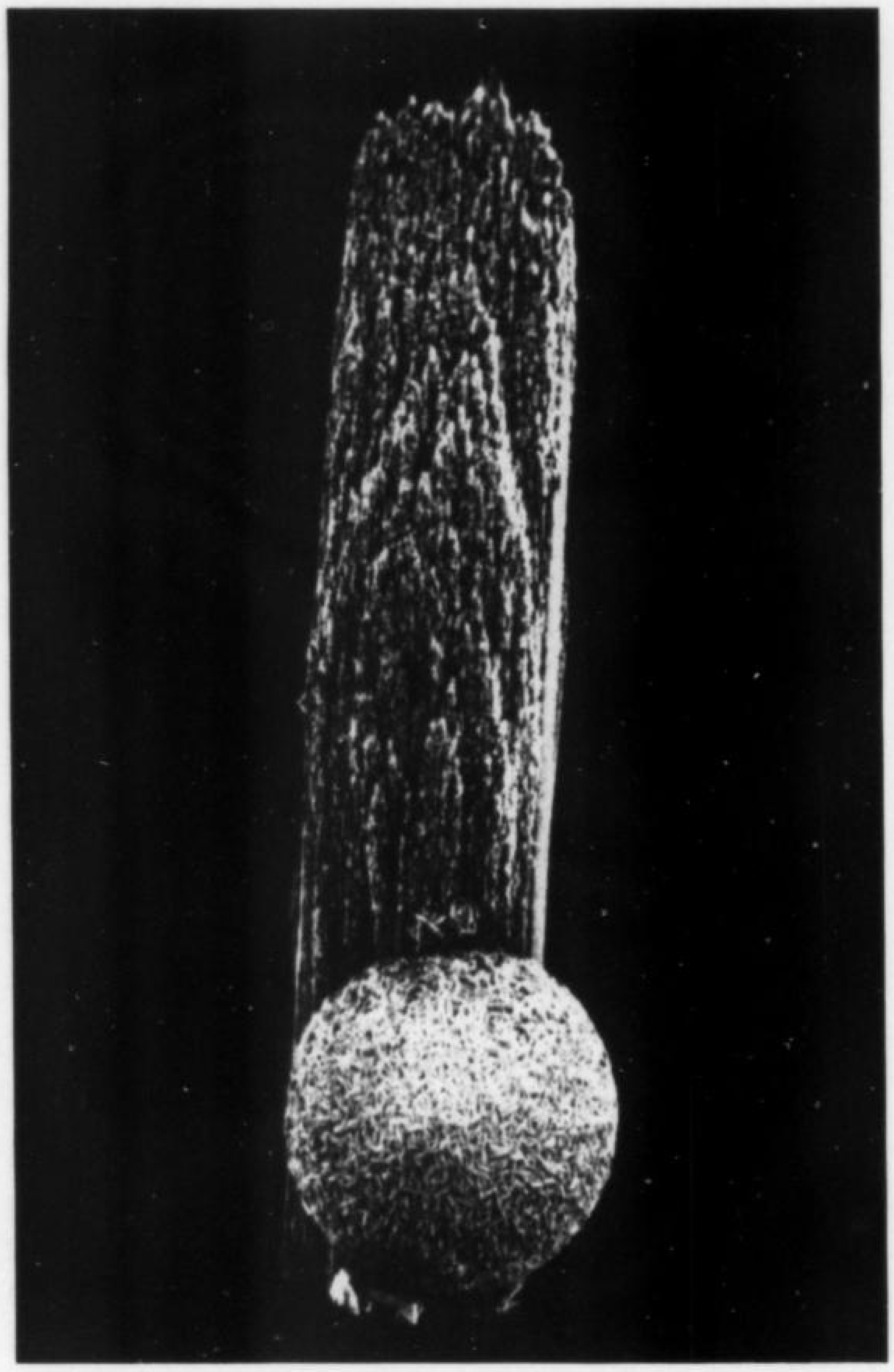

Fig. 5a. **Hematite hemisphere growing at the base of a stack of goethite blades. X40. NMNH.**

TABLE 1. MINERALS OBSERVED IN THE GEODES FROM CHIHUAHUA, MEXICO

*Minerals illustrated in this report. +, minerals not previously reported from geodes.

Apatite, carbonate *+	$Ca_{10}(PO_4)_6(CO_3).H_2O$
Birnessite +	$(Na, Ca)Mn_7O_{14}.3H_2O$
Calcite *	$CaCO_3$
Chalcedony	SiO_2, cryptocrystalline
Cryptomelane	$K(Mn^{+2},Mn^{+4})_8O_{16}$
Goethite*	$Fe_2O_3.H_2O$
Gypsum	$CaSO_4.2H_2O$
Hematite *	Fe_2O_3
Kaolinite	$Al_2Si_2O_5(OH)_4$
Opal	$SiO_2.nH_2O$
Pyrolusite	MnO_2
Quartz *	SiO_2
Ramsdellite *+	MnO_2
Rancieite +	$(Ca,Mn^{+2})Mn^{+4}_4O_9.3H_2O$
Todorokite *+	$(Mn^{+2},Ca,Mg),Mn^{+4}_3O_7.H_2O$

Fig. 5b. **Enlargement of the hemisphere in Fig. 5a. X2000. NMNH.**

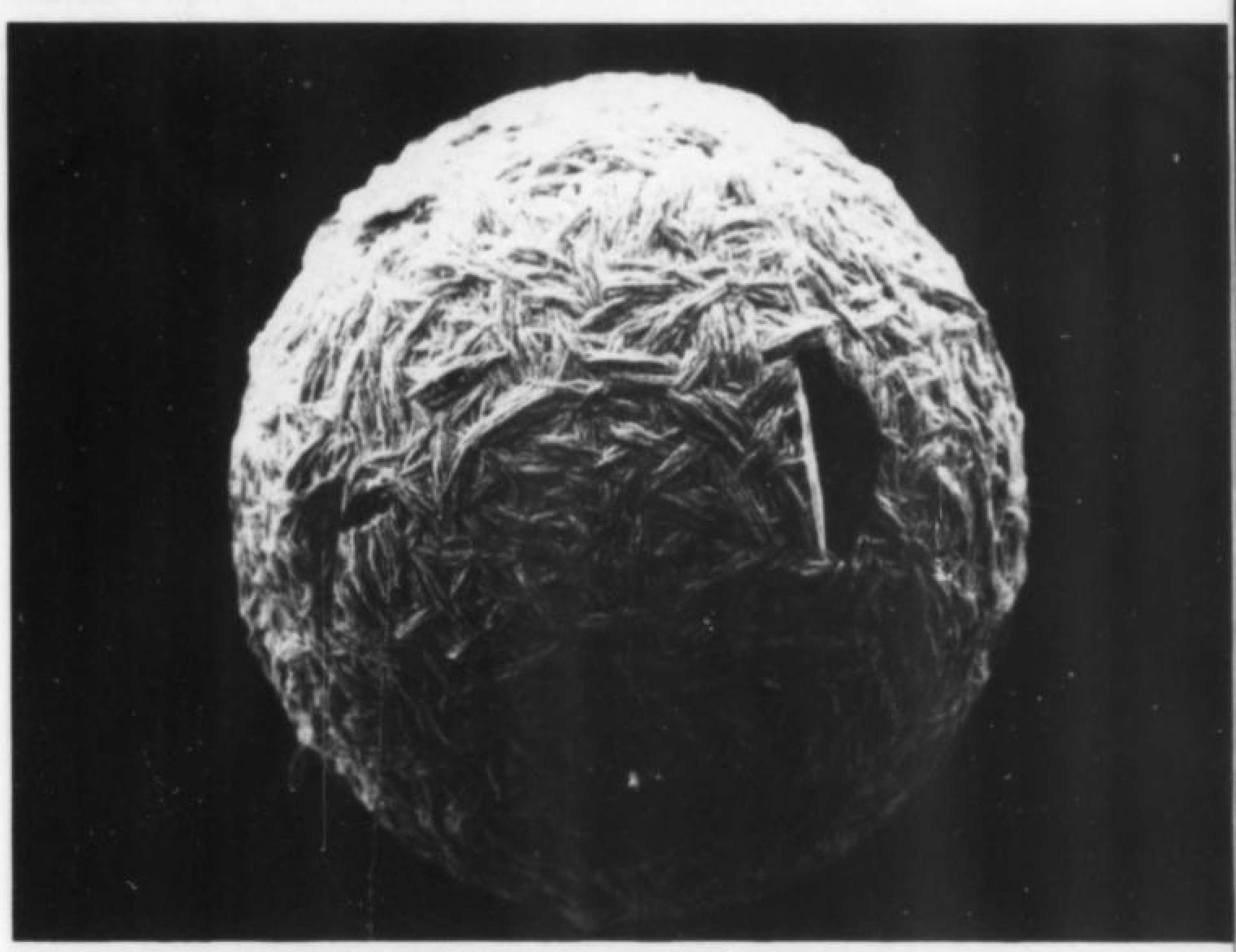

Fig. 6. **Hematite sphere with prominent basket-weave texture. The sphere grew around a blade of goethite. The hole through which the blade exited is seen on the right side of the sphere. X200. NMNH.**

Fig. 7. **Hematite rosette on a goethite blade. X460. NMNH.**

Fig. 8a. **Quartz crystal partly enclosing goethite needles which are overgrown by lenticular hematite. X33. NMNH.**

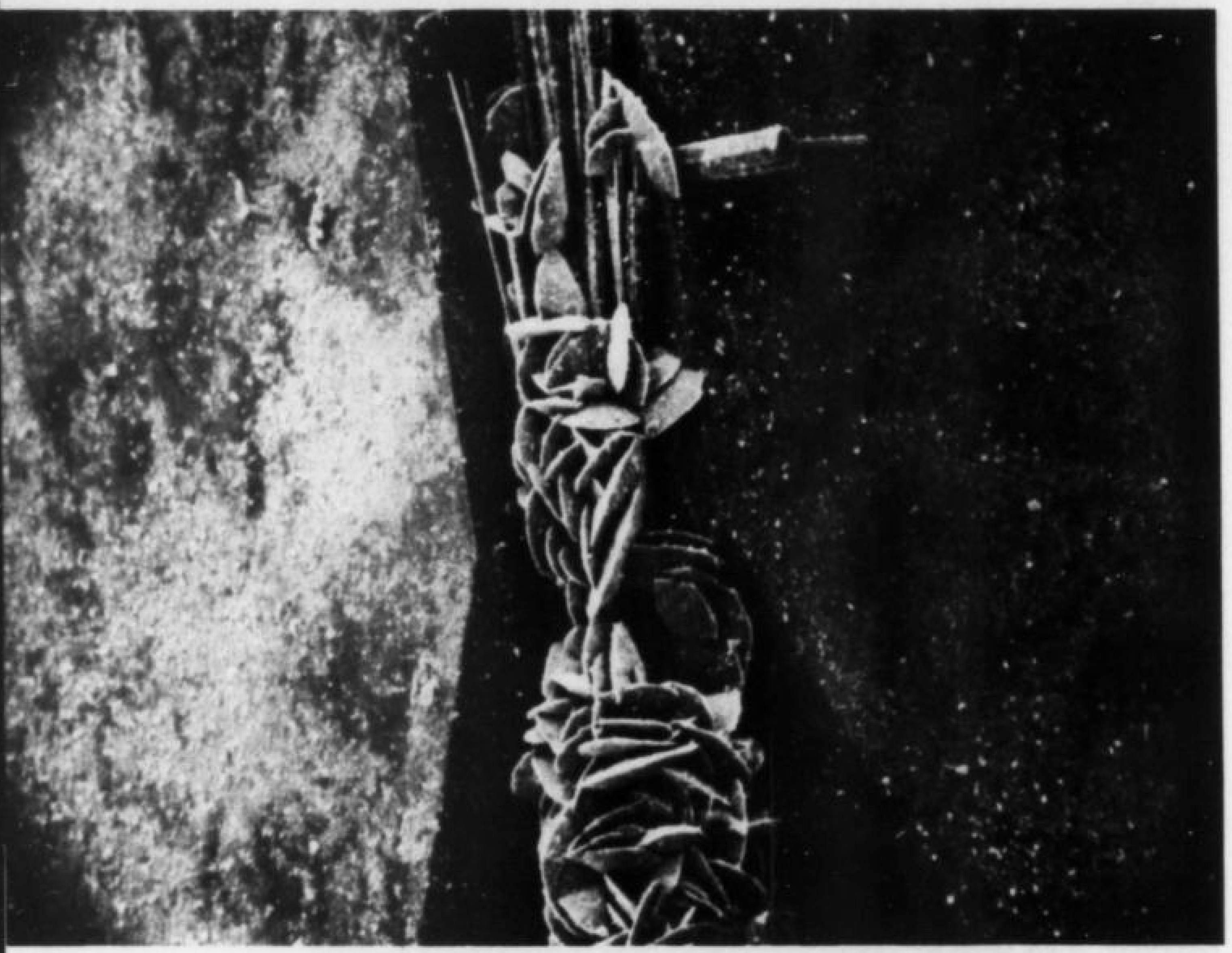

Fig. 8b. **Enlargement of Fig. 8a. X160. NMNH.**

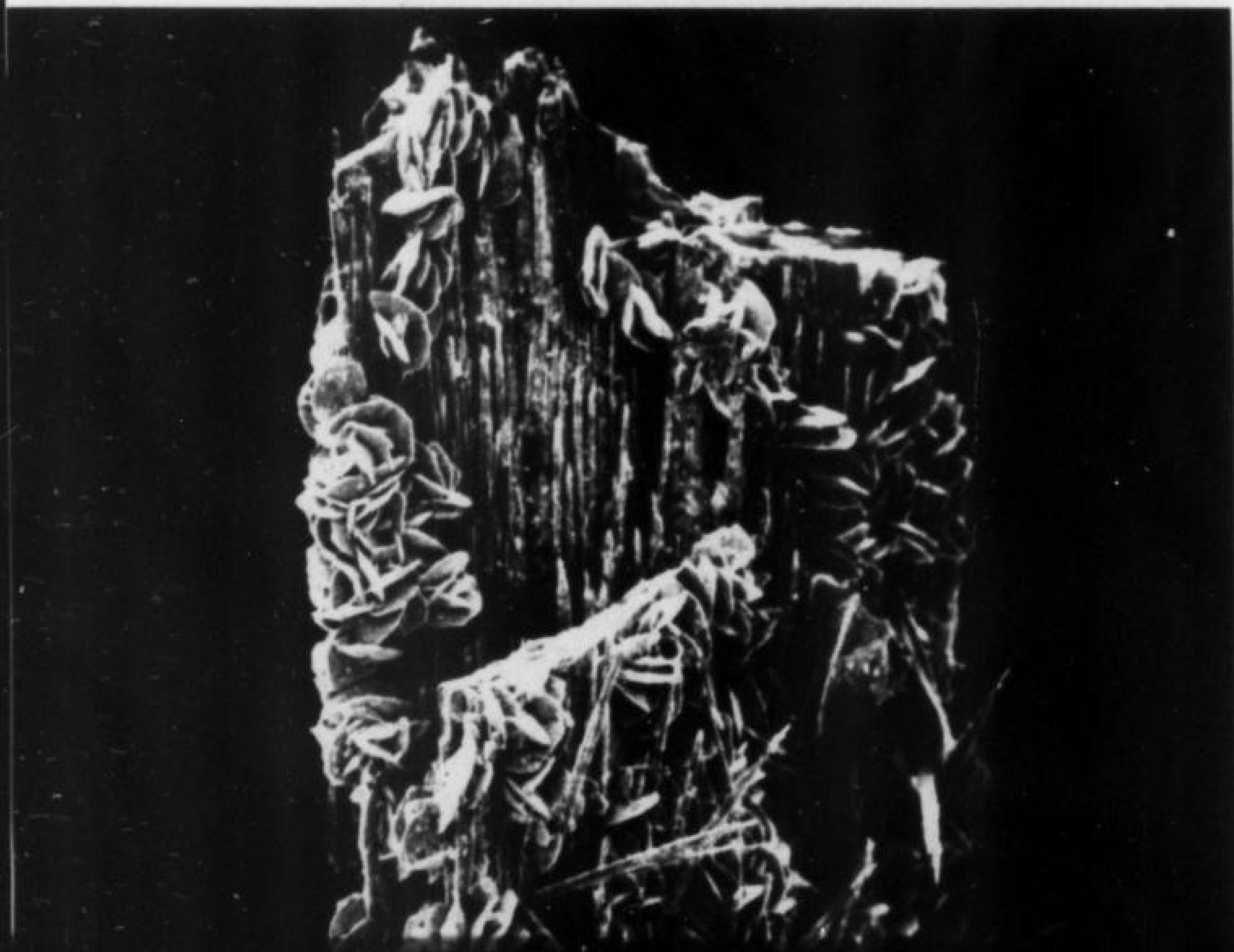

Fig. 9a. **Acicular goethite with platy goethite crystals at the end of the needles. X150. NMNH.**

of focus, and good resolution (∽ 200 Å) allows the observation of small particles in a way achieved by no other instrument or technique.

The results obtained with the SEM far exceeded our expectations. Not only were we able to observe more clearly the relationships between the minerals, but we were treated to an array of crystals that would rival most micromount collections.

The mineral sequence and intergrowths observed are probably due to changes in the chemistry of the mineralizing solutions or in the physical environments of the geodes. A discussion of the nature and causes of these changes is beyond the scope of this report. Our intention here is only to illustrate the variety of mineral intergrowths we have observed and to try to convey some idea of the vast quantity of information that can be gleaned from a study of microscopic crystals.

A good illustration of changes in the mineralizing solutions can be seen in Figure 3. This photograph shows euhedral quartz crystals growing in random orientations on a mat of fibrous todorokite which has completely covered a blade of goethite. The goethite blade grew on a large quartz crystal which in turn had grown on the chalcedony shell common to most of the geodes. Several areas of irregular particles on the todorokite suggest that at least one other mineral was deposited at about the same time as the last quartz cycle. Higher magnification reveals strands of todorokite growing over several of the quartz crystals.

Changes in the physical-chemical environment of the geodes is evidenced by the variety of crystal habits shown

Fig. 8c. **Lenticular hematite on platy goethite with a later generation of acicular goethite. X100. NMNH.**

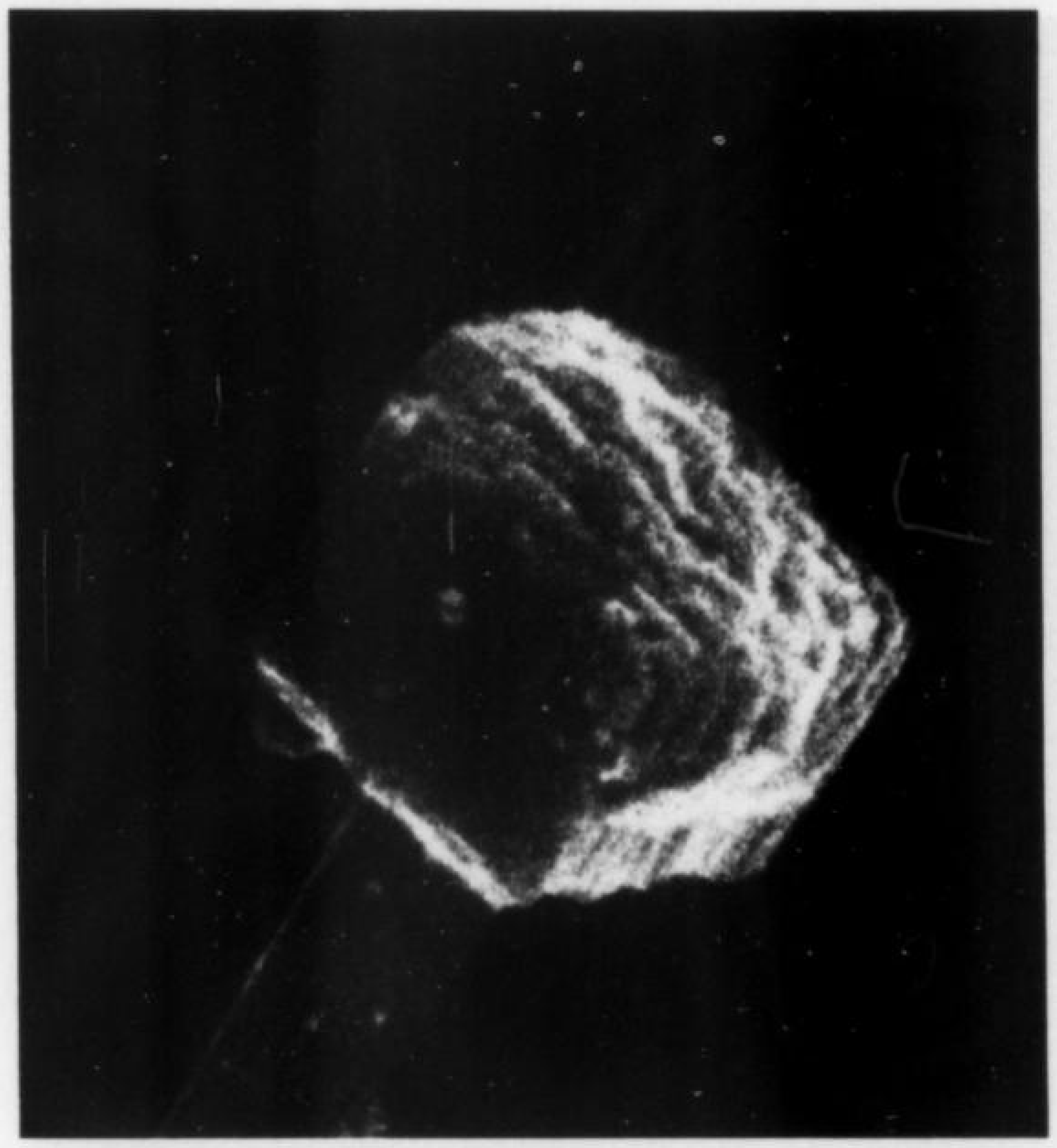

Fig. 9b. **Enlargement of the platy goethite on the tip of a needle in Fig. 9a. X15,000. NMNH.**

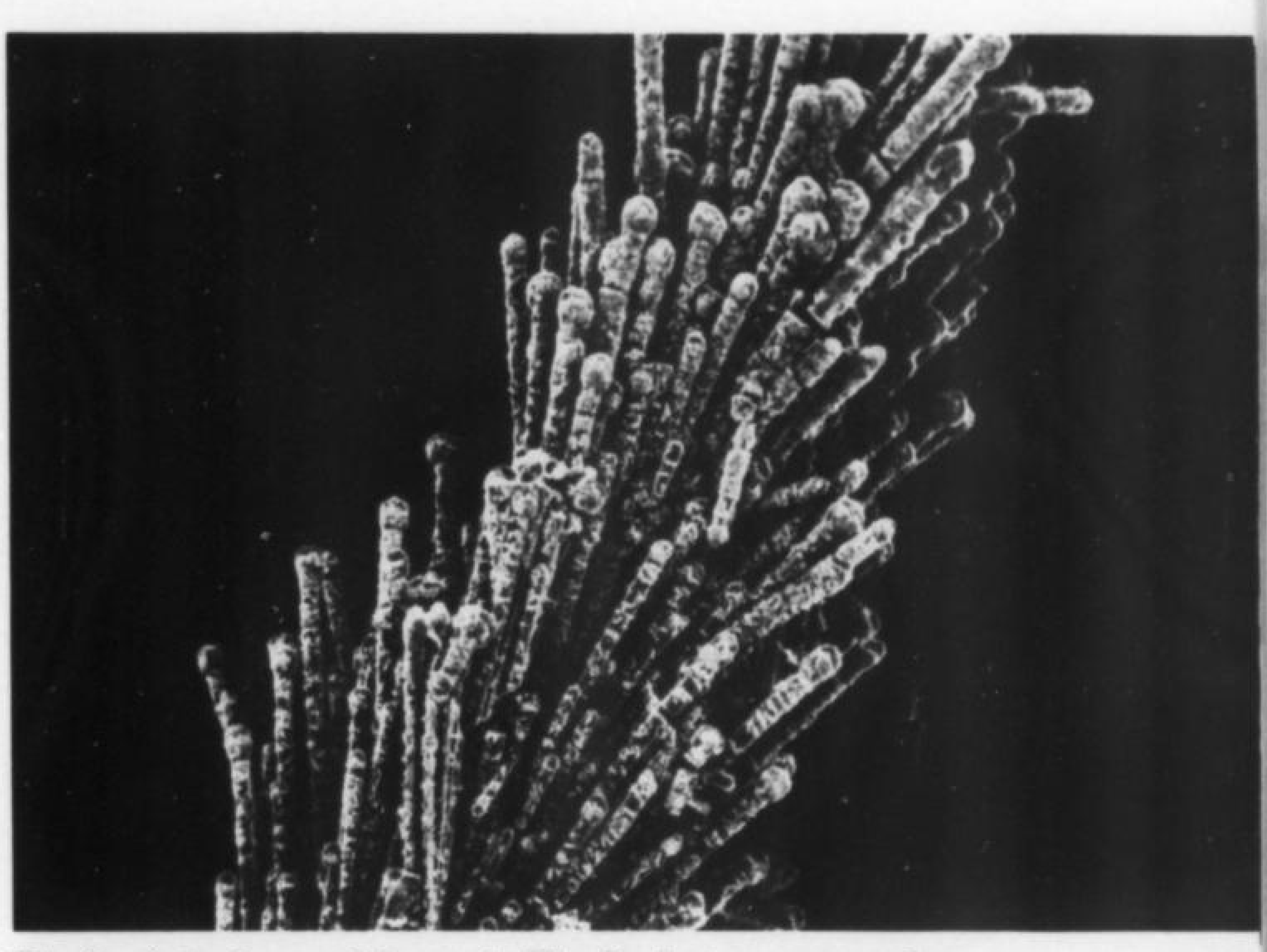

Fig. 9c. **Acicular goethite, as in Fig. 9a, but overgrown by an iron-oxide phase, possibly hematite. X150. NMNH.**

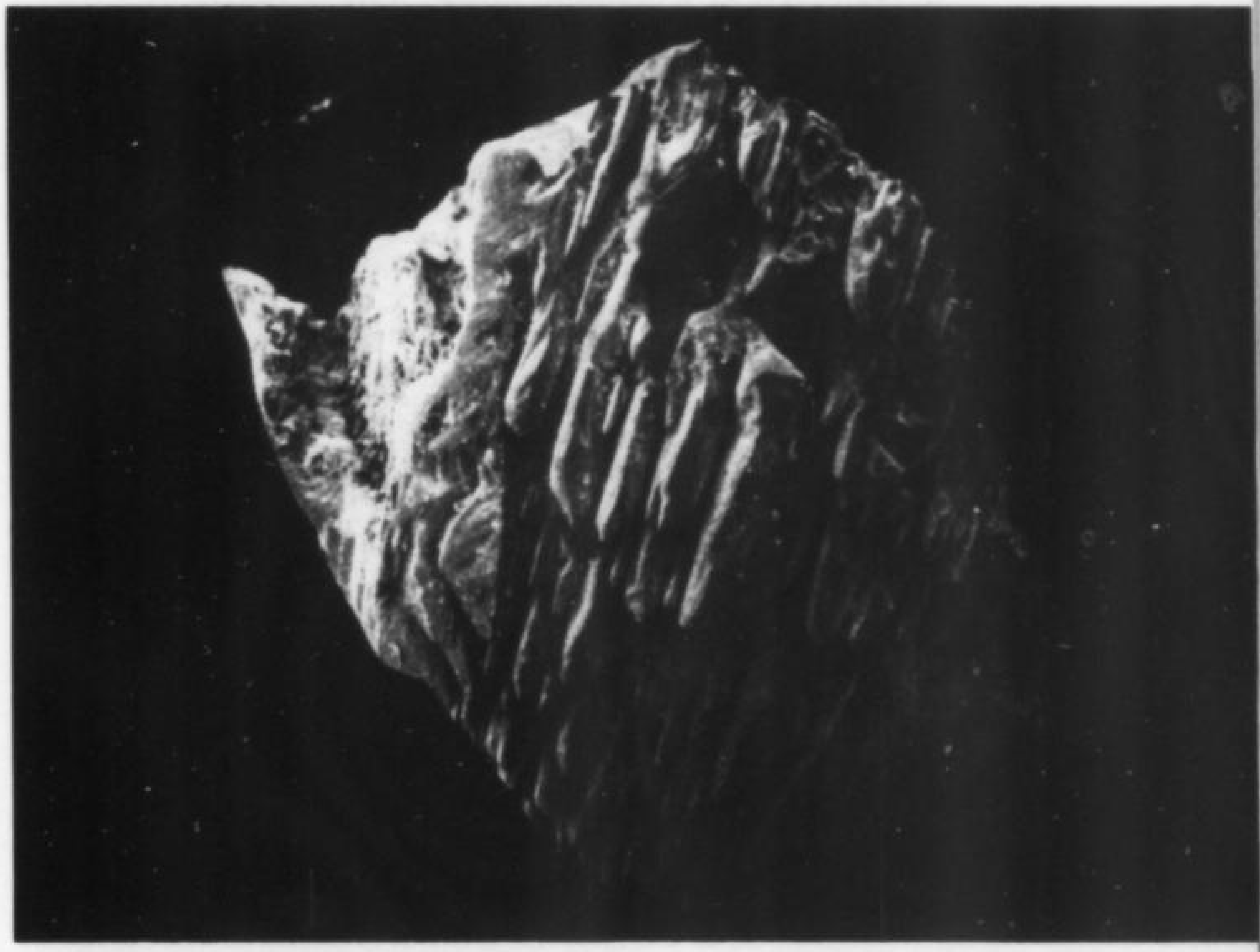

Fig. 9d. **Partly resorbed calcite growing over acicular goethite. The goethite may be seen in the broken area in the upper left. X22. NMNH.**

by several of the minerals, particularly hematite and goethite. Figure 4a shows a hemisphere of hematite that has a basket-weave texture. Hexagonal plates of apatite have grown on the upper surface. Figure 4b shows the underside of a grain similar to 4a. On this perfectly flat surface, three zones can be seen, suggesting that the growth of the hematite was interrupted twice. These hemispheres are most often found growing on the surface of quartz crystals. Because of subsequent growth of the quartz, black hemispheres can be seen suspended within transparent quartz crystals. Hemispheres are also found growing on goethite blades, as in Figures 5a and b. Hematite has also been observed as spheres (Figure 6), as rosettes (Figure 7), and as lenticular crystals (Figures 8a-c).

Goethite occurs in almost as many different forms as hematite. Figure 9a shows a bundle of fine acicular goethite. The needles appear to terminate in minute platy crystals (Figure 9b) which have been identified as goethite. It appears that the goethite growth pattern abruptly altered in response to some change in the geode environment. Geothite needles completely overgrown by another iron oxide phase, possibly hematite (Figure 9c), are growing a few millimeters distant from the grain in Figure 9a. Also found in the same geode are goethite needles overgrown by calcite, which was subsequently partly resorbed to give the etched appearance seen in Figure 9d. This geode was not unique in having different growth patterns which suggest the presence of several distinct microenvironments within an individual geode. Goethite was the only mineral identified by X-ray diffraction patterns in the unusual

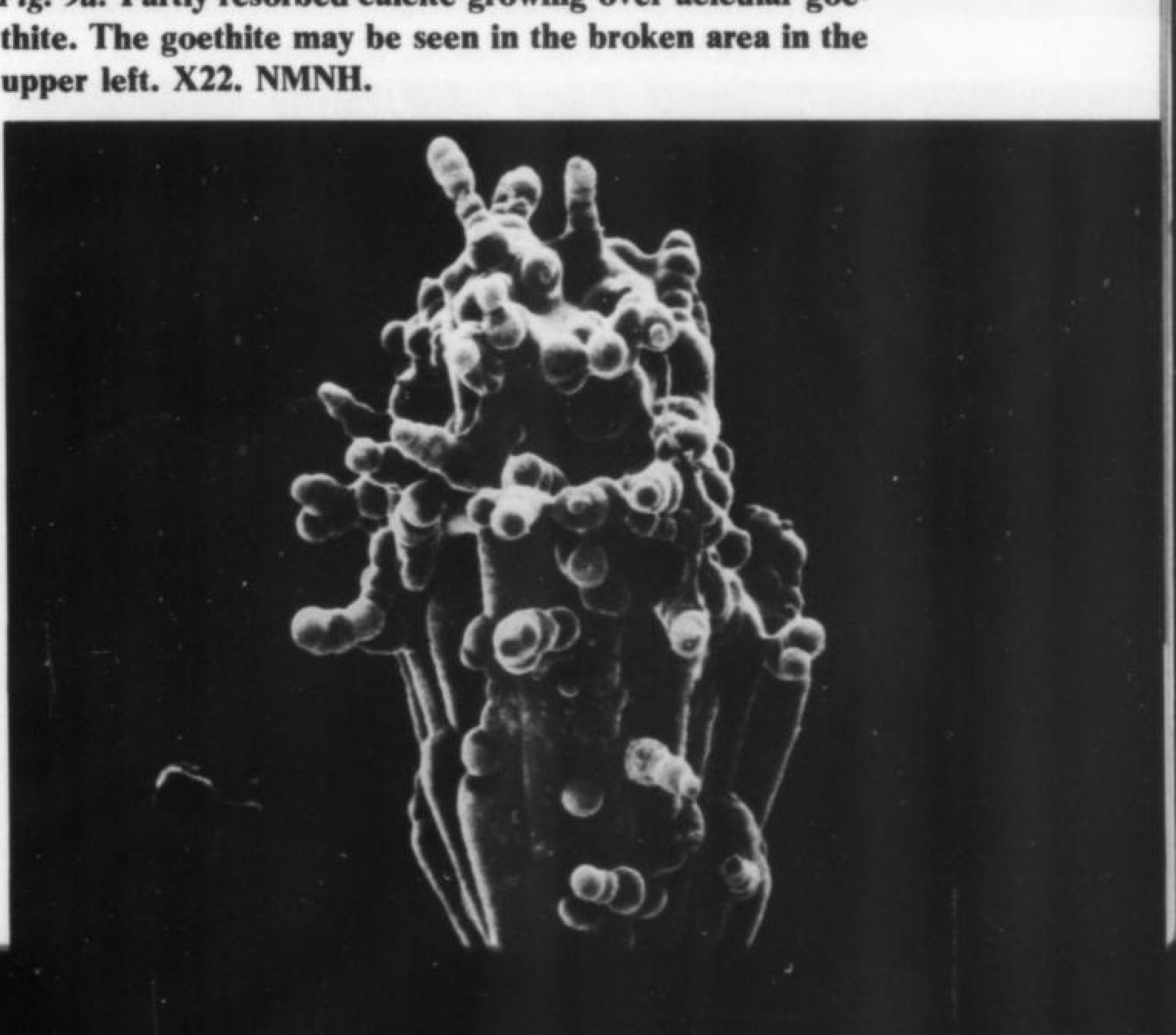

Fig. 10. **Goethite blades covered by a botryoidal amorphous silica phase. X50. NMNH.**

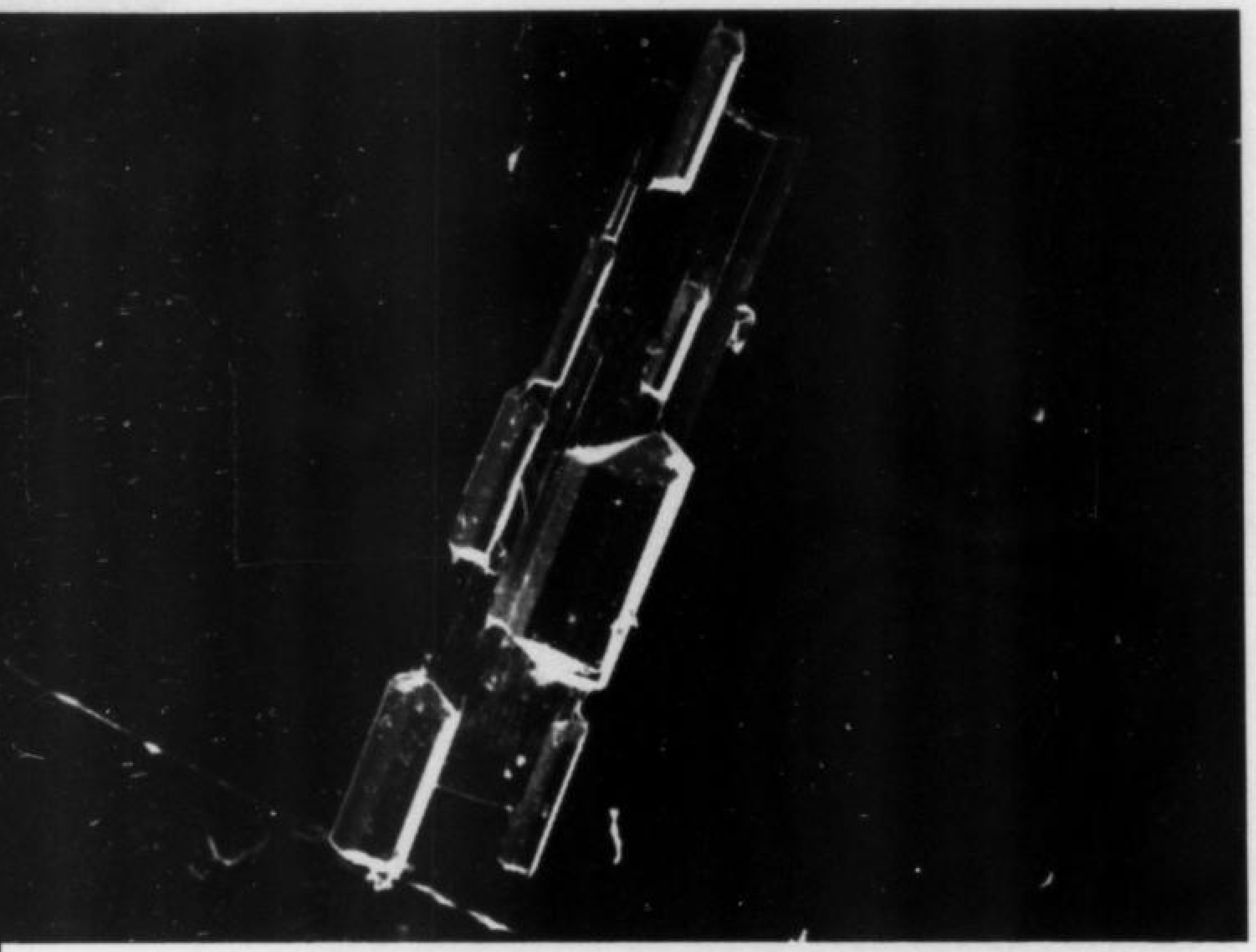

Fig. 11a. **Prismatic ramsdellite crystals elongated parallel to the c-axis of a goethite blade. X46. NMNH.**

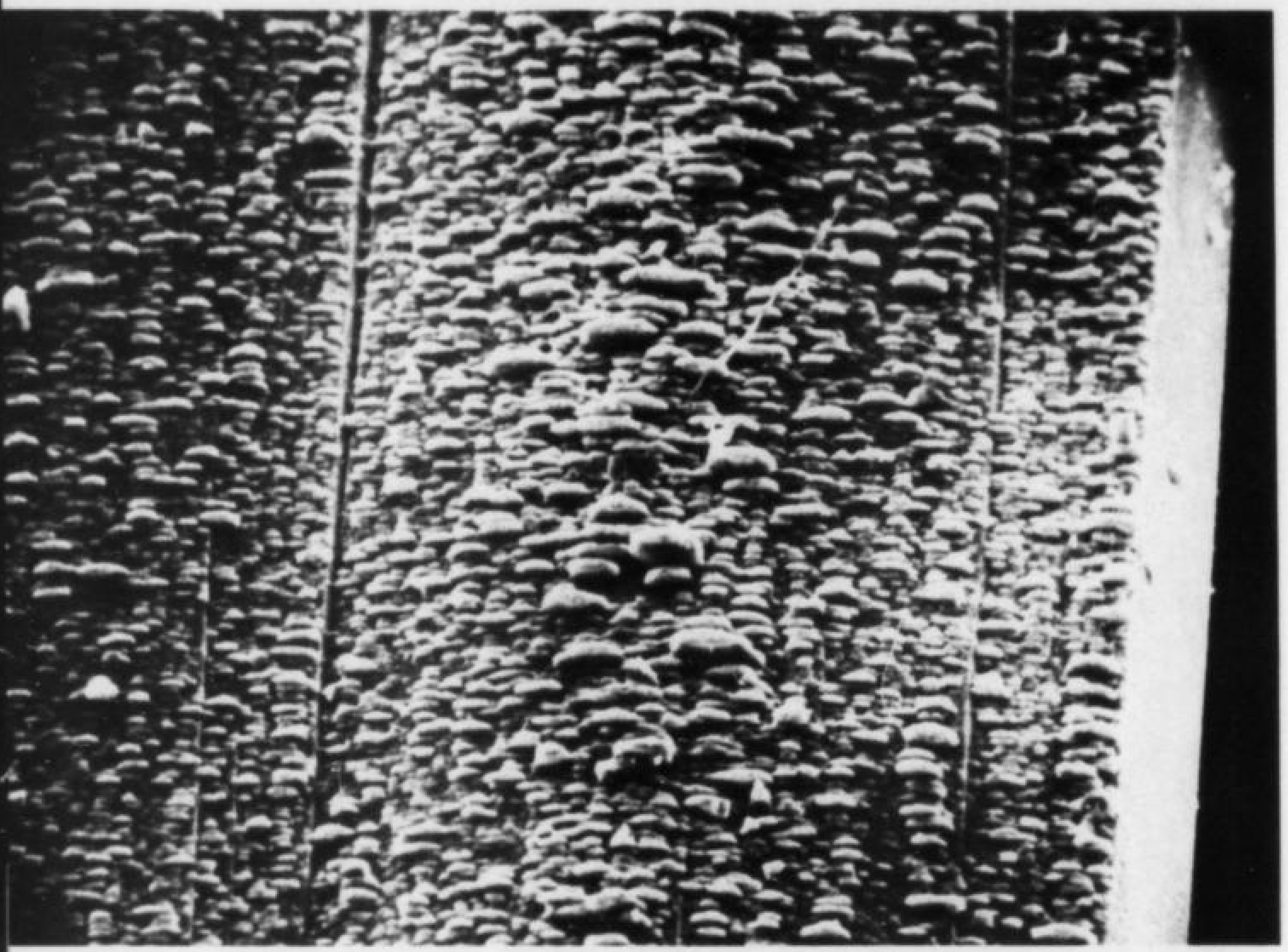

Fig. 11b. **Lenticular ramsdellite growing on a goethite blade. X400. NMNH.**

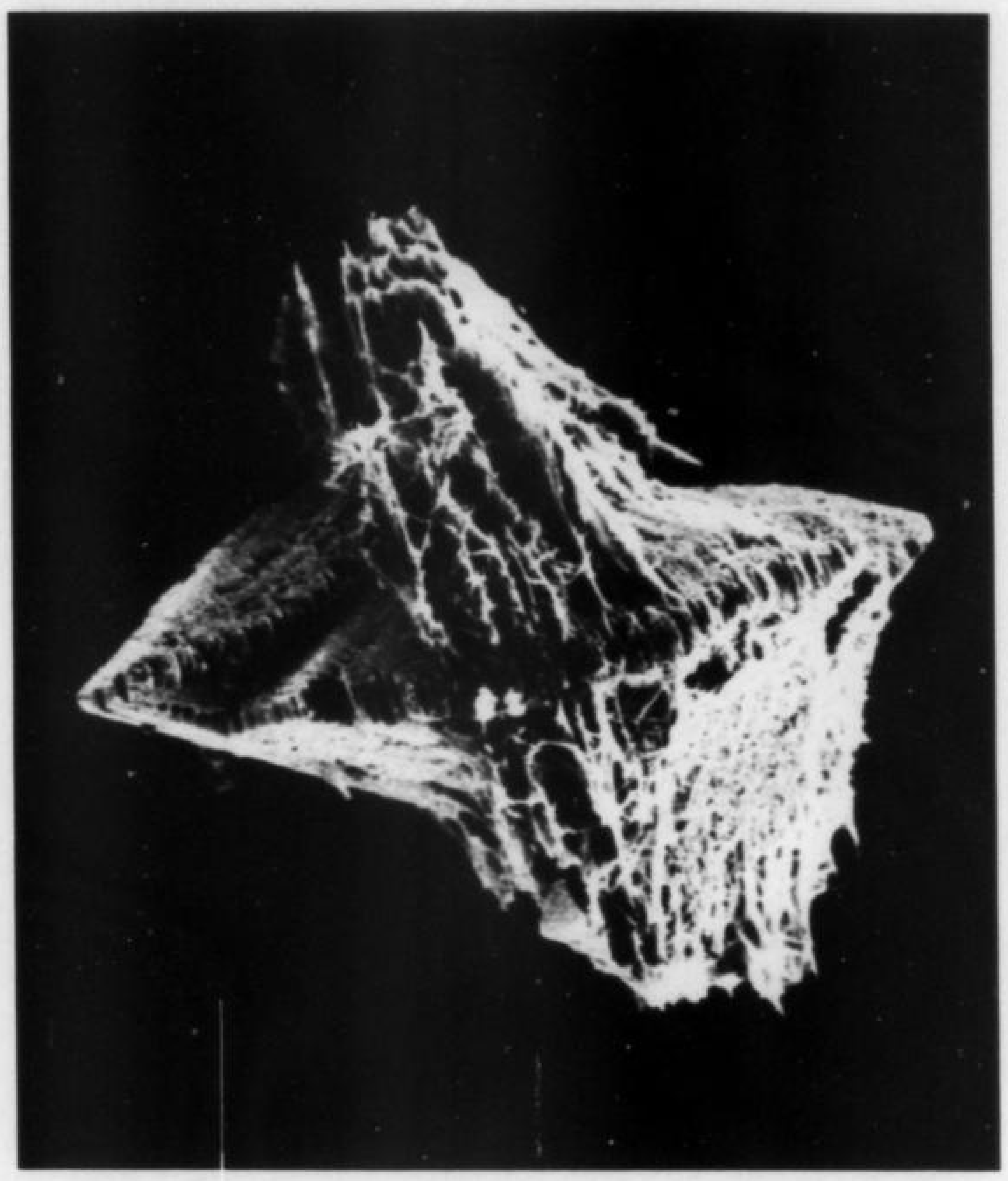

Fig. 12. **Fibrous todorokite on lenticular ramsdellite crystals (center). This specimen was removed from the surface of a goethite blade. X280. NMNH.**

grain in Figure 10. Microprobe analysis indicates the presence of major silicon, thus suggesting that an amorphous silica phase is responsible for the botyroidal appearance.

Ramsdellite, a relatively common mineral in the Chihuahua geodes, is found as fibrous dendritic masses on quartz but is more commonly found growing as well-developed crystals on goethite blades in two different habits (Figures 11a-c). The fibrous material growing on the ramsdellite crystals in Figures 11c and 12 is todorokite.

Todorokite is a ubiquitous late-stage mineral often found as a compact mat of fibers or needles (Figures 13a-c) or as fibrous overgrowths on most of the other geode minerals (Figures 3, 11c, 12).

Quartz is the most abundant mineral in these geodes; clear quartz predominates over the milky, smoky, and amethystine varieties. In most geodes the first mineralized zone on the chalcedony shell consists of medium to coarse-grained quartz crystals, generally with the apex of the pyramids pointing to the center of the geode. It is on or in this first cycle of quartz that most of the crystals depicted in this report were found. However, as is indicated in Figures 3, 14, and 15, quartz is also found as a finely crystalline late-stage euhedral mineral in random orientation. Figure 16 shows a euhedral quartz crystal which had grown on fibrous todorokite. The todorokite formed on a previous cycle of quartz crystals. In this and other Chihuahua

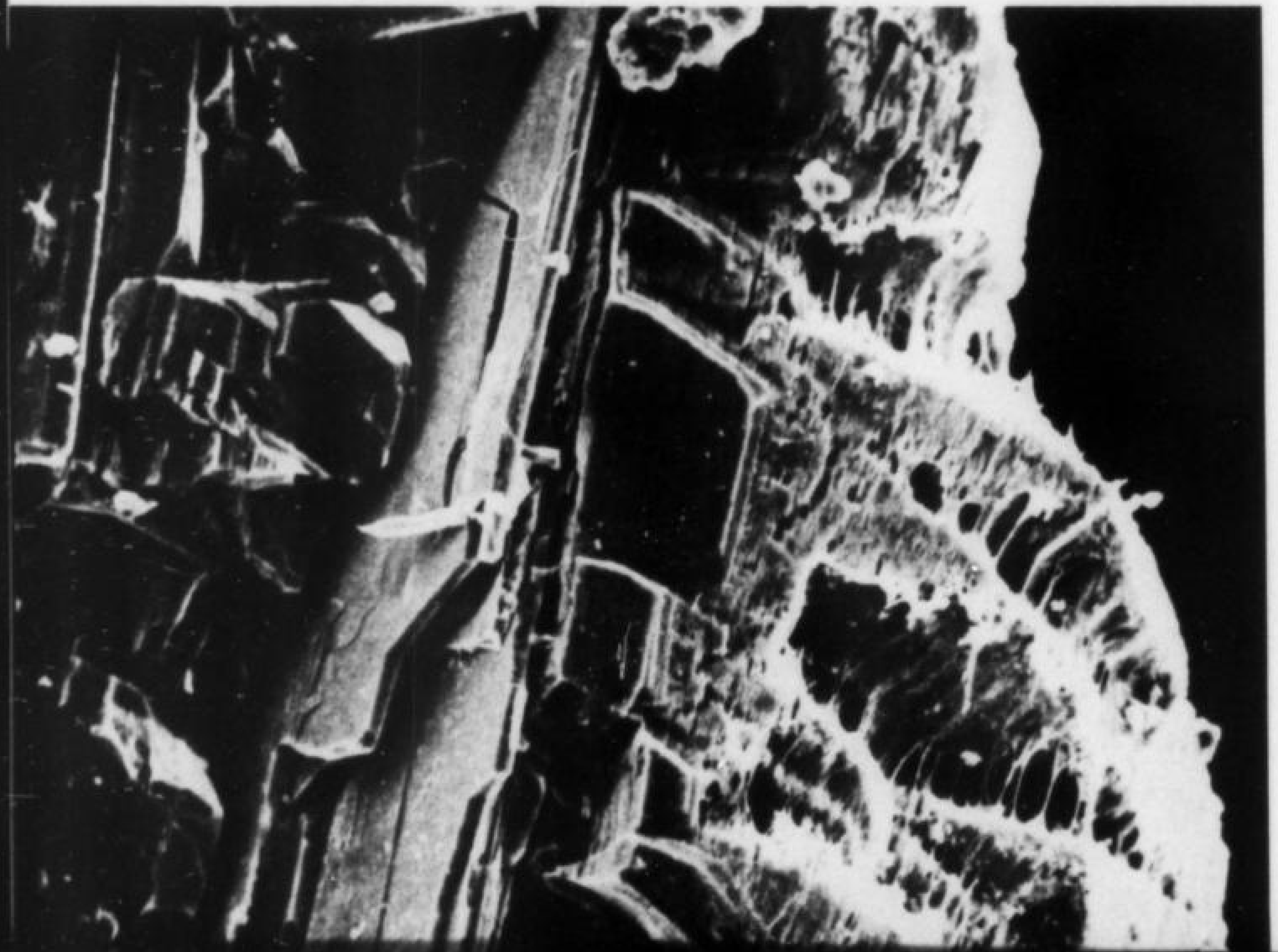

Fig. 11c. **Fibrous todorokite mat (right edge) covering ramsdellite crystals, which are elongated perpendicular to the c-axis of a stack of goethite blades. X500. NMNH.**

Fig. 13a. **A mat of fibrous todorokite. X75. NMNH.**

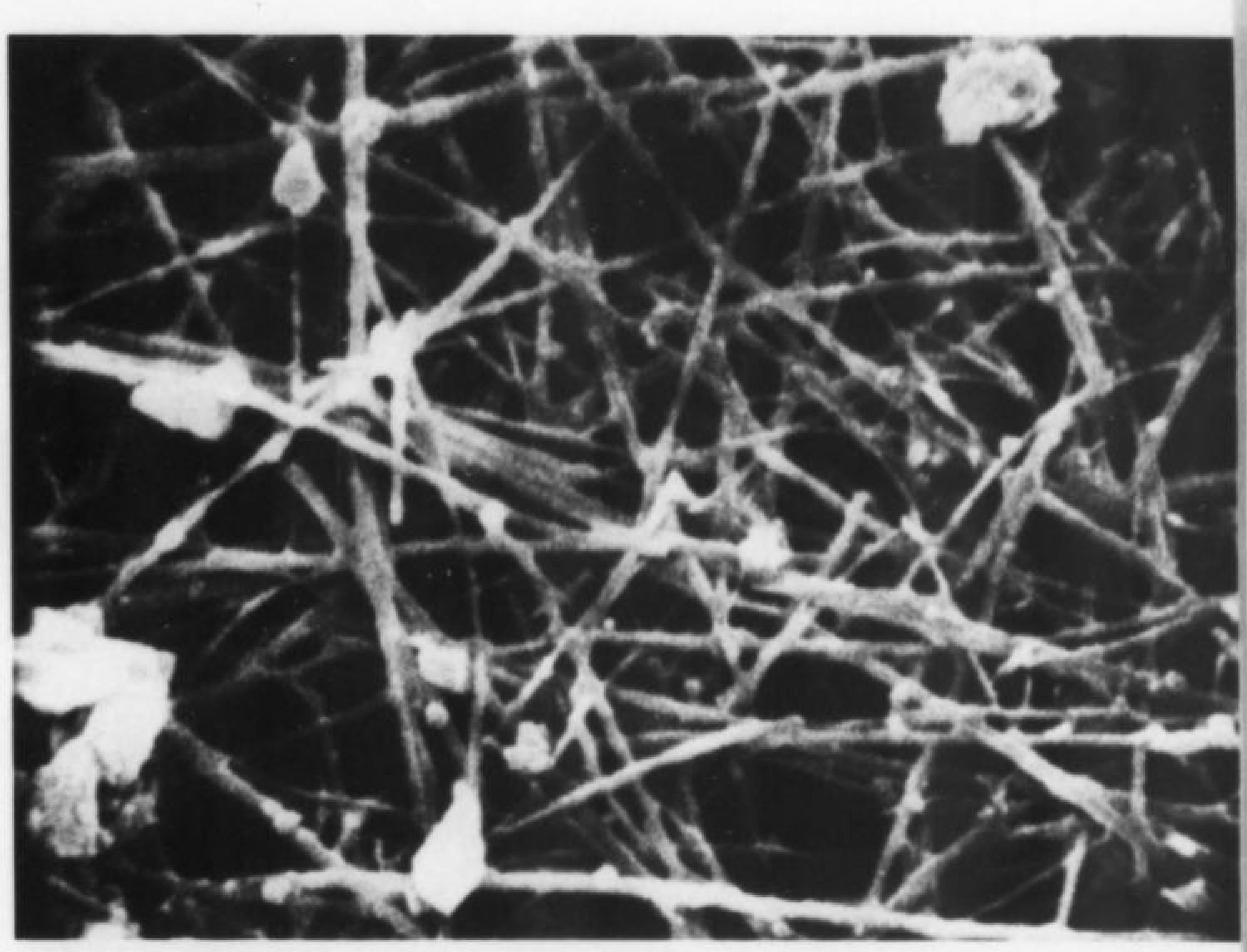

Fig. 13b. **Enlargement of the todorokite in Fig. 13a. Some of the irregular particles on the fibers have been identified as kaolinite. X10,000. NMNH.**

geodes, late-stage quartz and todorokite are precipitated simultaneously, leaving quartz crystals impregnated with dispersed strands of fine todorokite fibers. In other areas the todorokite has completely covered some quartz crystals. Subsequent growth of the quartz along the same crystallographic orientations has resulted in numerous brown phantom crystals within the quartz. Similar relationships are also found between todorokite and calcite.

The value of the SEM as an addition to the more conventional analytical instruments is obvious. But the SEM has its limitations. The images observed are reflections from surfaces coated with a conducting metallic film; therefore, all the minerals appear to be opaque. Thus, detection and observation of inclusions are precluded. Despite this, the great depth of focus, high magnification, and good resolution of the SEM are extremely useful in revealing crystal habits not perceptible under the light microscope. It thus appears that the SEM will prove to be an essential tool in helping to decipher the complex growth patterns in the Chihuahua geodes.

ACKNOWLEDGMENTS

We thank Dr. Anastasios J. Tousimus for his assistance and Biodynamics Research Corporation for the use of their SEM. We would also like to thank Mr. Ted Hodges for bringing the Chihuahua geodes to our attention. Dr. Adolph Pabst of the University of California supplied the geode from which the particle in Figure 11a was taken. We also wish to thank our colleagues at the U.S. Geological Survey, particularly George A Sellers and Mary E. Mrose, for their helpful suggestions.

Fig. 13c. **Enlargement of another todorokite mat in which the todorokite consists of stubby needles. X10,000. NMNH.**

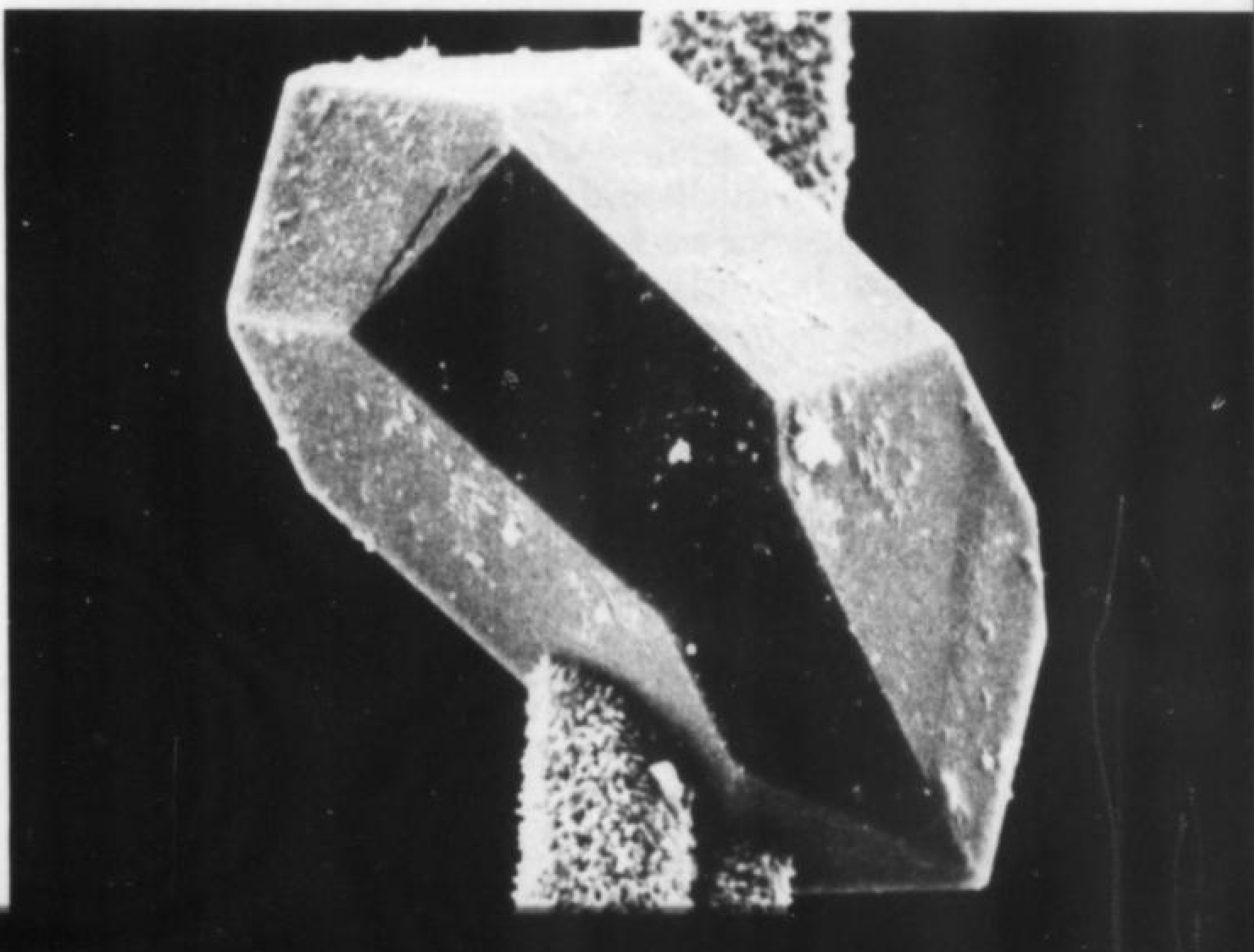

Fig. 14. **A quartz crystal growing around a hematite covered goethite (?) needle. X900. NMNH.**

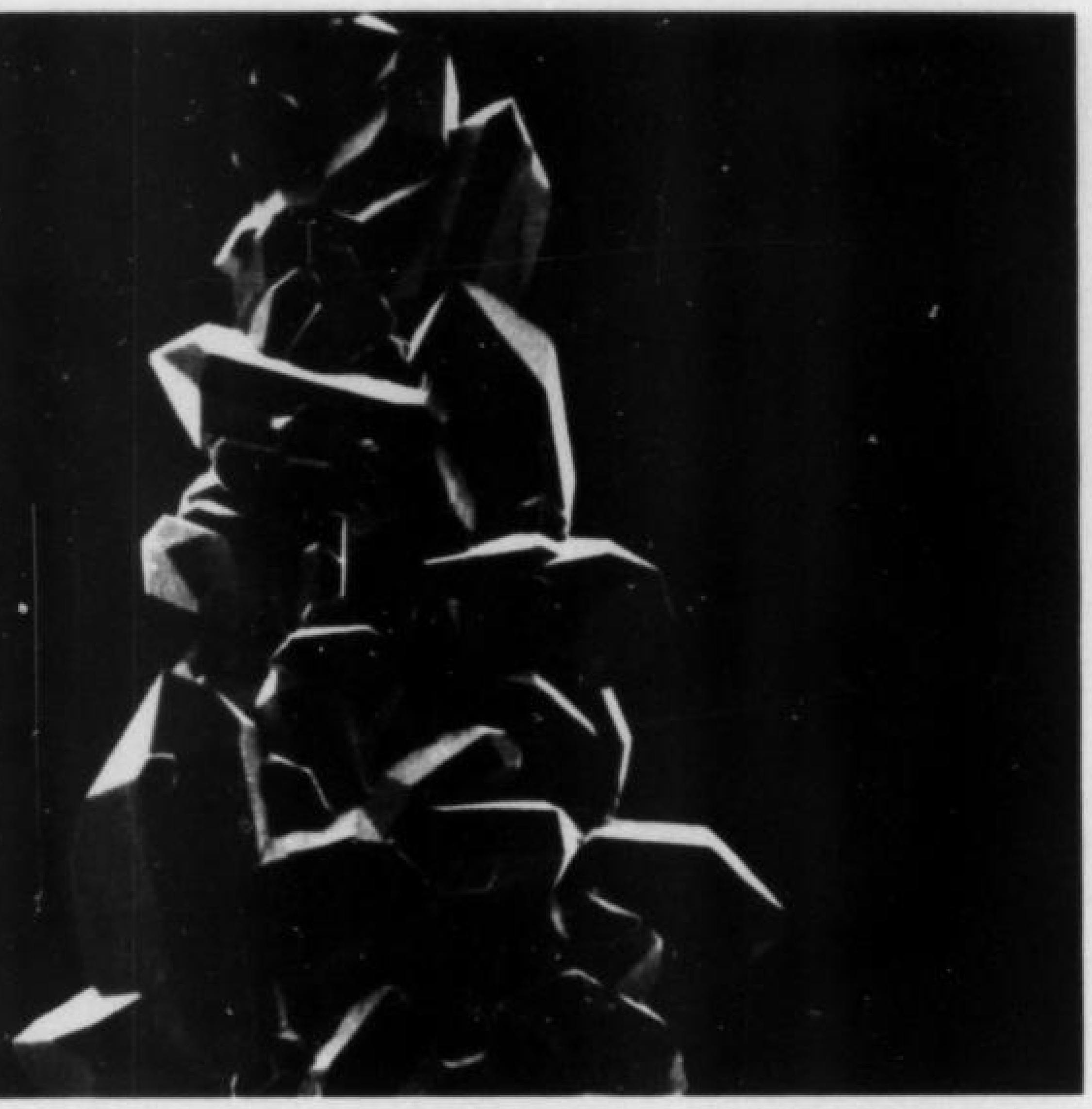

Fig. 15. **Randomly oriented quartz crystals. In a light microscope the nucleus was observed to be a ramsdellite covered goethite blade. X80. NMNH.**

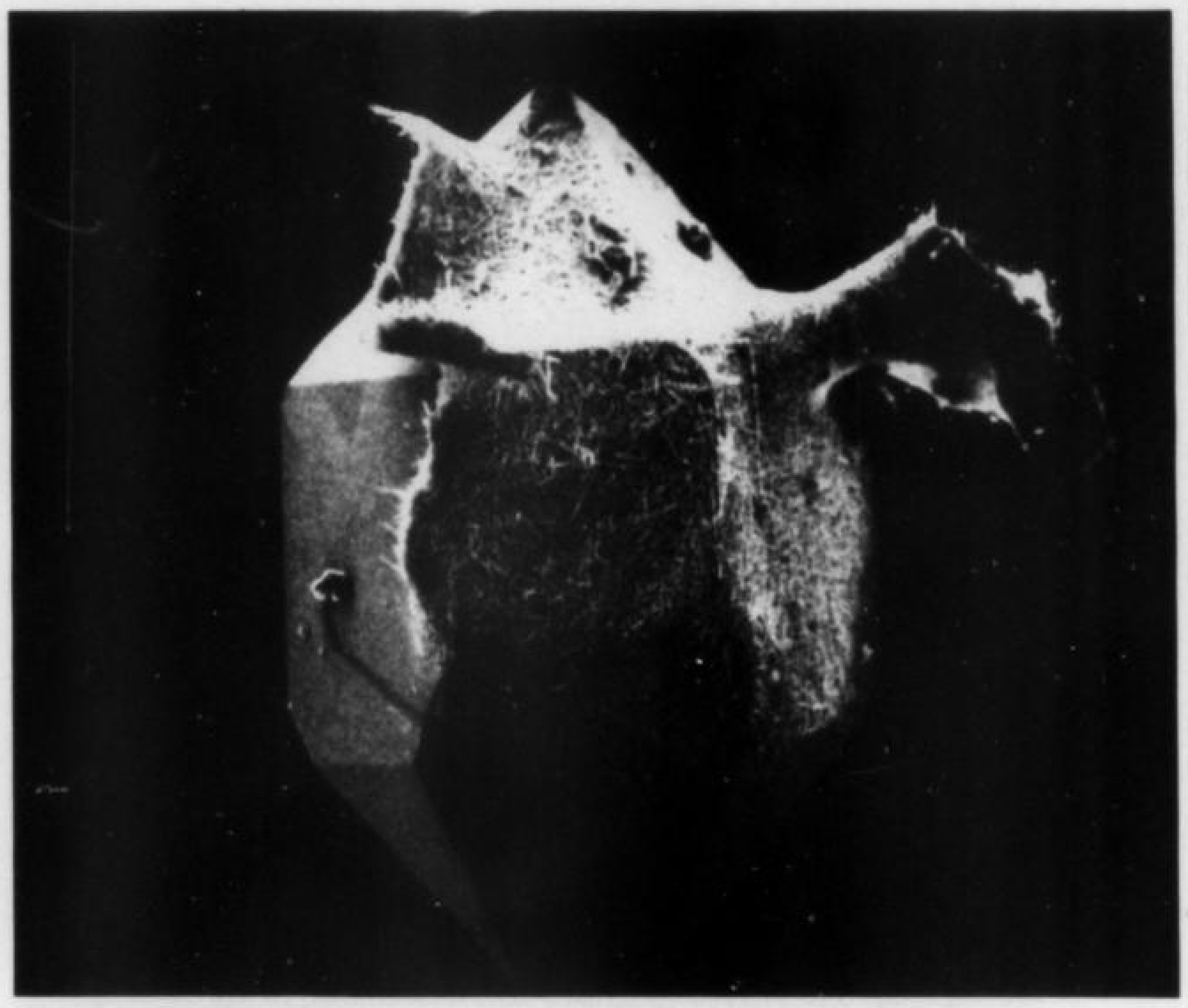

Fig. 16. **A euhedral quartz crystal torn from a mat of todorokite on which it had been precipitated. X75. NMNH.**

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Boron Minerals and Deposits

by L.F. Aristarain, **Comision Nacional de Estudios Geo. Heliofisios, Buenos Aires, Argentina and**

C.S. Hurlbut, Jr., **Department of Geological Sciences, Harvard University, Cambridge, Massachusetts**

Part II *GEOLOGICAL ENVIRONMENTS AND CLASSIFICATION OF BORON DEPOSITS*

In the brief discussion of the geochemistry of boron it was stated that of the common rocks, marine clays are richest in boron. However, it would be costly indeed to extract boron from them or from their metamorphic derivatives. Thus for economic exploitation, one must look to places where nature has made far greater concentrations.

There are three principal geological environments in which boron ore deposits have formed. They are related to: A. intrusive rocks; B. volcanic activity; C. marine sediments. The importance of the first type (A) is unknown but probably slight; the second group (B) is by far the most important; and, with the exception of the Inder region, U.S.S.R., the third type (C) provides boron only in small amounts as a by-product. In the genetic classification given in Table 4, a fourth class, D, is included for a type of deposit of uncertain origin.

Deposits related to intrusive rocks

As indicated earlier, during crystallization of magmas residual solutions are enriched in water and certain elements. Some of these elements originated within the magmas themselves, whereas others are derived from the country rock during the migration of the magma and its emplacement in the earth's crust. Most authors state that the boron associated with both intrusive and extrusive rocks is a primary element of the magmas. But a few suggest that the magmas have increased their content in this element by assimilation of boron bearing sediments.

After an intruded magma reaches its final resting place in the earth's crust, chemical and physical changes may take place at the contact, particularly when calcareous rocks have been invaded. The country rock may be extensively recrystallized and many new minerals may form by its reaction with magmatic solutions. During this process, called contact metamorphism or pyrometasomatism, frequently large amounts of Si, Al and Fe are introduced and the resulting rock is called *skarn.* When substantial quantities of metallic elements such as copper, iron, lead, zinc or tin are introduced, ore deposits of these metals result. There may also be formed concentrations of nonmetallic minerals including borates and borosilicates. Such metasomatic deposits are characteristically irregular and relatively small but there are exceptions in which they reach large dimensions.

Boron deposits of this type are in Table 4 as Class A Types 1 and 2. They have not been carefully studied in the western world and information regarding them is meager. This is because of the great tonnages of other borate minerals easily available and more economically treated. However, they are considered of economic importance in the Soviet Union. These deposits are commonly found at contacts of granitic rocks. When the skarn is in dolomitic rocks the common boron minerals are members of the ludwigite and sussexite series if magnetite is present; in the absence of magnetite, kotoite is also found. The borosilicates of the tourmaline and axinite groups are also common in these skarns, but thus far have no practical significance. When the skarn is in calcareous shales, marls or other lime-silica rocks, the borosilicate, datolite, may be present. Datolite rich rocks (B_2O_3 5-10%) are considered ore in the U.S.S.R.

Although pegmatites are an extremely remote source of boron they are included in Table 4 as Class A Type 3. Pegmatites are extremely coarse grained bodies, closely related genetically to large masses of igneous rocks. They are composed essentially of quartz, feldspar and mica but frequently, because of the presence of the rare elements, contain unusual minerals. Commercial quantities of beryl and lithium minerals may be present and tourmaline is a common associate. In countries where these bodies are exploited, ordinary tourmaline (there is a beautiful gemstone variety) is a waste product. If sufficient quantities of this borosilicate were produced as a by-product, it might possibly be an ore in areas lacking other sources of boron.

Deposits related to volcanic activity

Fig. 1. **Spring deposit of borates from which 10,000 tons of minerals, mostly ulexite, have been removed, Coyahuaima, Jujuy, Argentina.**

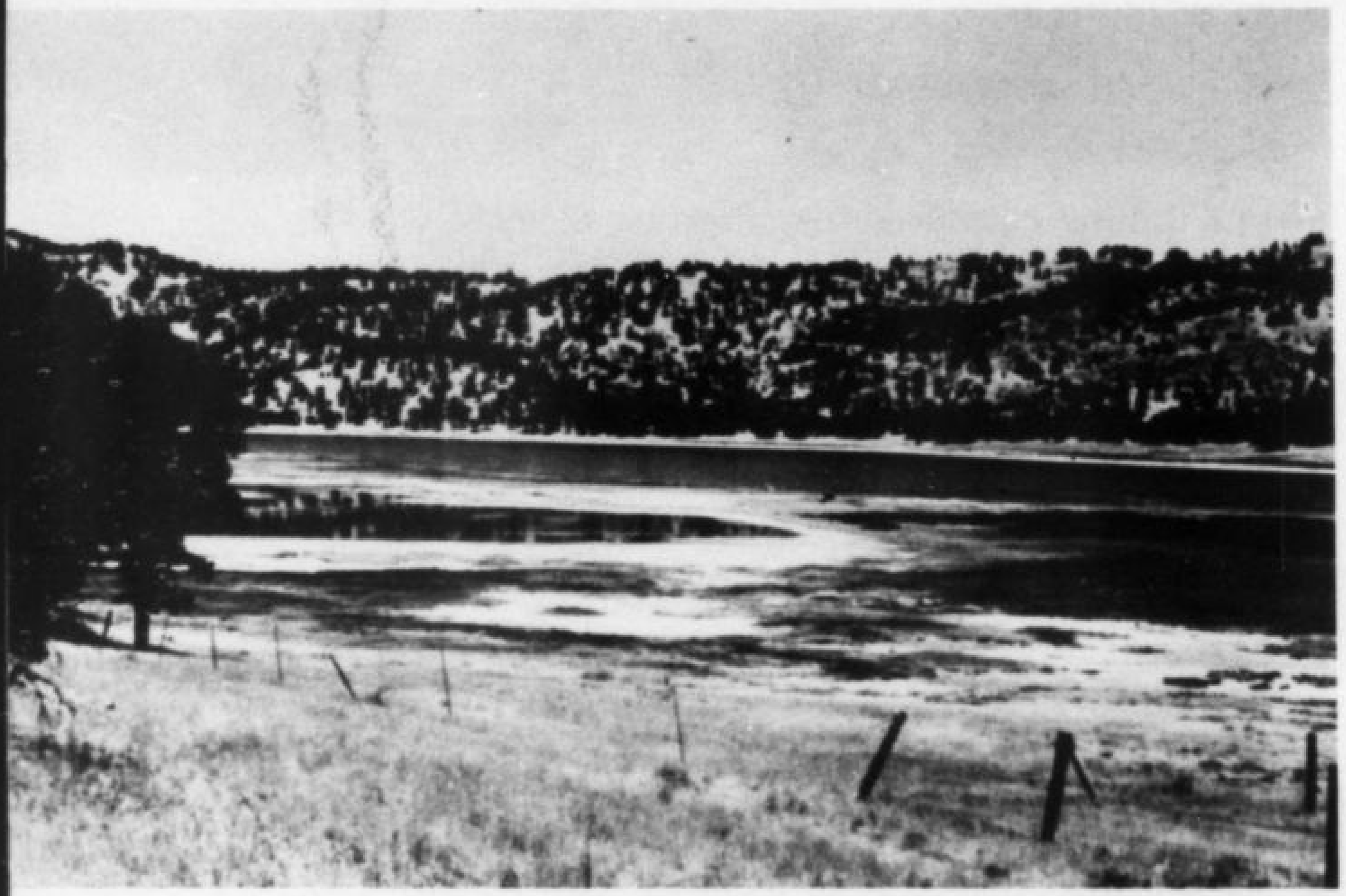

Fig. 2. **Borax Lake, Lake County, California, the scene of the first commercial production of borates in the United States. Beginning in 1864, borax crystals were recovered from the bottom muds of this lake.**

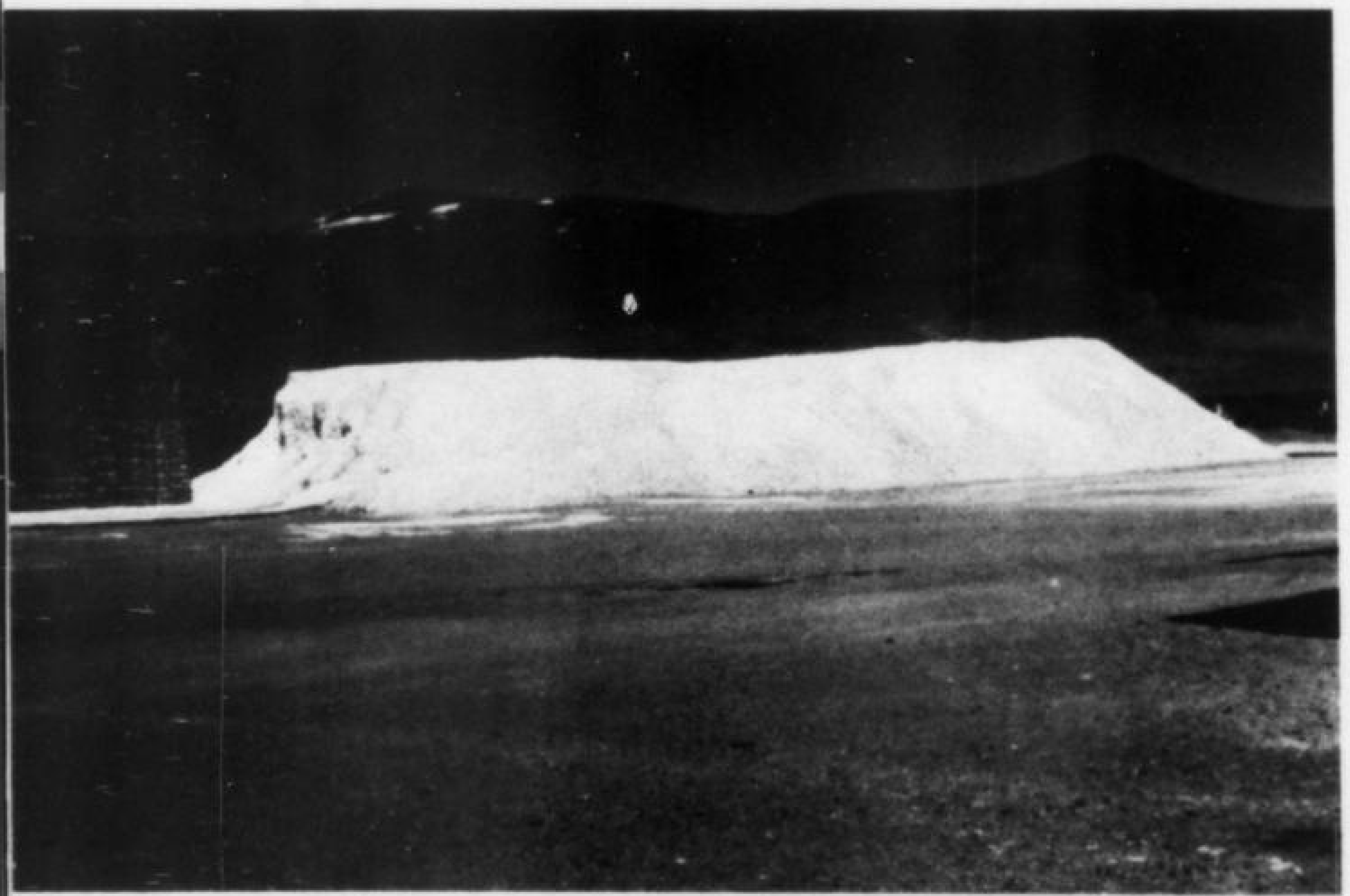

Fig. 3. **Ulexite, Olacapato, Salta, Argentina. The mineral partly sacked but mostly in an open stockpile of "cotton balls", has been mined from nearby playas.**

Although volcanic rocks have provided important amounts of boron to the oceans, no economic deposits have formed directly from the rocks themselves. However, the most important group of boron deposits is related to hot springs associated with "posthumous" volcanic activity.

Boraciferous springs alone cannot produce borates. The proper physiographic and climatic conditions must also exist. These are: enclosed basins to impound the waters and an arid or semiarid climate to evaporate them and thus precipitate boron minerals.

Boron has a strong affinity for oxygen and in a continental environment in contact with the atmosphere, it readily forms hydrated compounds with sodium and calcium and to a lesser degree with magnesium. These are the borates. The common minerals so formed are very soluble in the chemical and physical conditions of surface and near surface environments. Consequently, their preservation in the earth's crust for a long period is unlikely except when a deposit has been sealed within a perfectly impervious envelope. Thus no borate deposits related to volcanic activity are expected to be found in rocks older than Middle Tertiary.

Then the first rule to follow in searching for borate deposits of this class is to go to areas of the world where the three conditions—Cenozoic volcanism, arid or semiarid climate and enclosed basins—are satisfied simultaneously. The regions of California, Nevada and Oregon in western U.S.A., the Puna in South America, and Asia Minor and Tibet in Asia all have these characteristics. They also are the richest known borate bearing areas in the world. Other regions, for example northwest Mexico and Iran, have the same conditions and are of potential interest.

Hot springs themselves, boraciferous steam or solutions can be commercial sources of boron if the concentrations are adequate. Class B, Types 1 and 2 of Table 4 refer to such sources, and, of course, there need not be an arid climate. Such is the famous soffioni of Tuscany, Italy which in weight per cent contain 0.2-0.3 H_3BO_3 or 0.1-0.15 B_2O_3. Boric acid and ammonium sulfate are recovered by evaporating the condensed vapor using heat of the same steam whose temperature is above 100° C. Several thousand tons of boric acid are recovered each year in this manner.

When the boraciferous thermal spring waters evaporate very quickly under arid conditions, they can form borate deposits around the mouths of vents or along fractures. Such deposits are grouped as Class B Type 3. Their economic importance is limited and there are only a few examples in the world.

Usually spring waters with dissolved material move down valleys to eventually reach the sea. But if they flow into an enclosed basin in an arid region they join the lake waters to be later evaporated. The path may be long as in the case of Searles Lake or short as in many places in the Puna of Argentina where the springs are immediately adjacent to the basins.

In a rare case a mud flow borate deposit has formed along a valley floor which is designated as Class B Type 4.

If evaporation of the lake waters produces a brine relatively rich in boron it can be used directly, as at Searles Lake (Class B Type 5), to obtain borates and other dissolved salts. However, in most cases under arid conditions the lakes are shallow and evaporation, at least during the dry season, is complete or almost so. Strong diurnal variations of temperature will facilitate chemical precipitation and formation of the deposits. Borates and other salts—halides, sulfates, carbonates— will be deposited as a superficial crust in the flat central part of the basins. These deposits are named playa or marsh deposits and are included as Class B Type 6.

In Argentina borates have accumulated in basins (Catalano, 1926, 1927) rimmed by fault block mountains striking roughly north-south. At the contact of the blocks and obviously on the fault lines are numerous travertine deposits indicating the former presence of springs. These travertine deposits are numerous in the Puna and the waters from which they were deposited are considered the principal source of borates. Even today one can find active springs depositing travertine near their mouths, but the more soluble salts, including borates, find their way to the valley bottom. The presence of travertine is thus another guide to borates but in some basins the travertine has been buried or partly buried by younger sediments.

The accumulation of borates in these areas with centripetal drainage may be augmented by washing in borates from older deposits from higher topographic positions. At Pastos Grandes salar in Argentina there are recent playa borate deposits, but flanking the salar are folded Tertiary sediments which include borates. In this case these older borates have contributed to the boron of the deposit occupying the present playa. Elsewhere it may be difficult to establish the relationship of source and deposit, particularly where the boron has traveled tens of kilometers.

This type of deposit (B, 6) has a simple mineralogy and may be nearly monomineralic. The common borates are borax and ulexite, but there is one deposit of this type in which inyoite is the principal mineral (see Table 4).

Ulexite is found usually at the edge of the salar, whereas the more soluble halite occupies the center or lower parts. It characteristically occurs as beautiful silky nodules known as "cotton balls" or "potatoes" 2 to 10 centimeters in diameter, formed by acicular crystals practically free of sand or clay. Numerous voids between the crystals give the nodules a low apparent density. The ulexite is more or less regularly distributed near the surface included in the sediments of the playa, usually as balls but sometimes as platy bodies parallel to the surface. The boraciferous zone varies in thickness from a few centimeters to over a meter and in lateral extent from a few acres to several thousand.

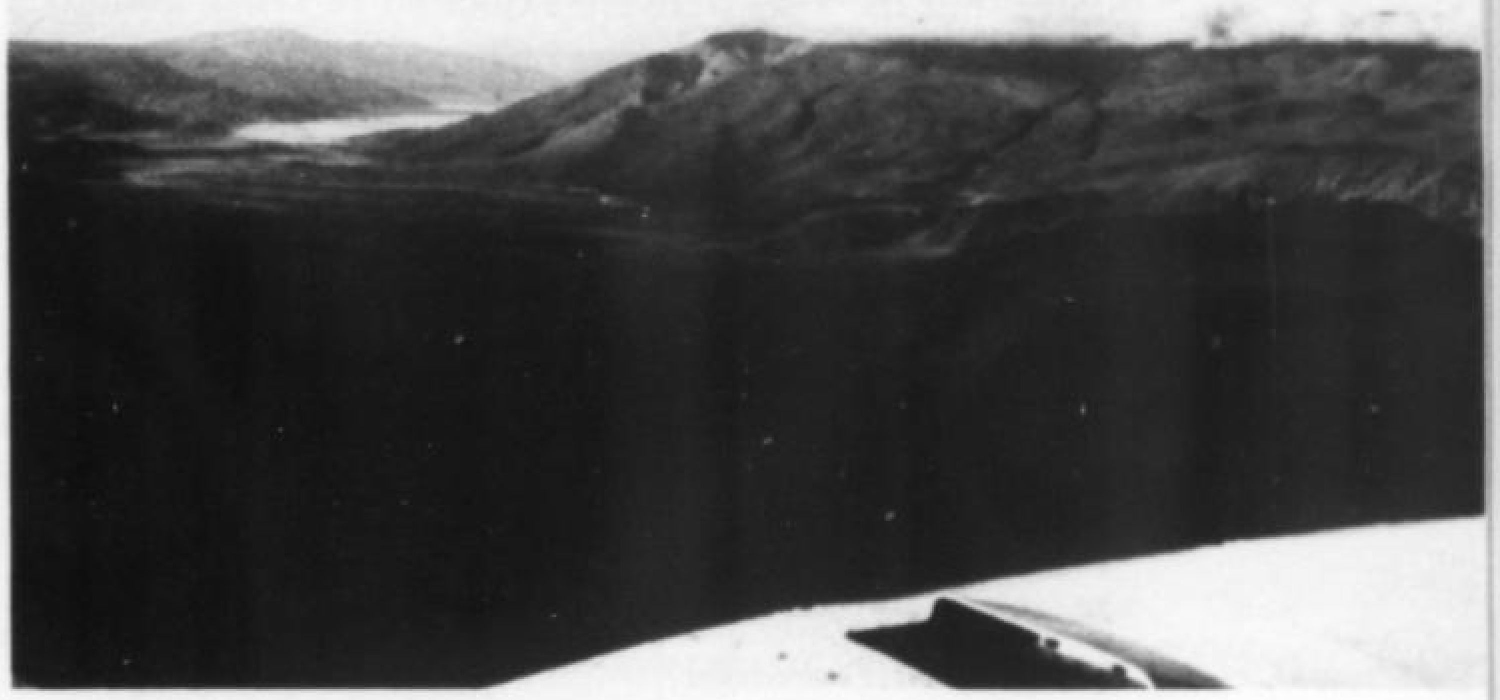

***Fig. 4.* Aerial view of a portion of the puna, Argentina. The puna, extending from Peru through Bolivia into Argentina, is a down-faulted zone in the Andes where borates and other evaporates may accumulate. In the above photograph the floor of the valley is about 13,000 feet above sea level.**

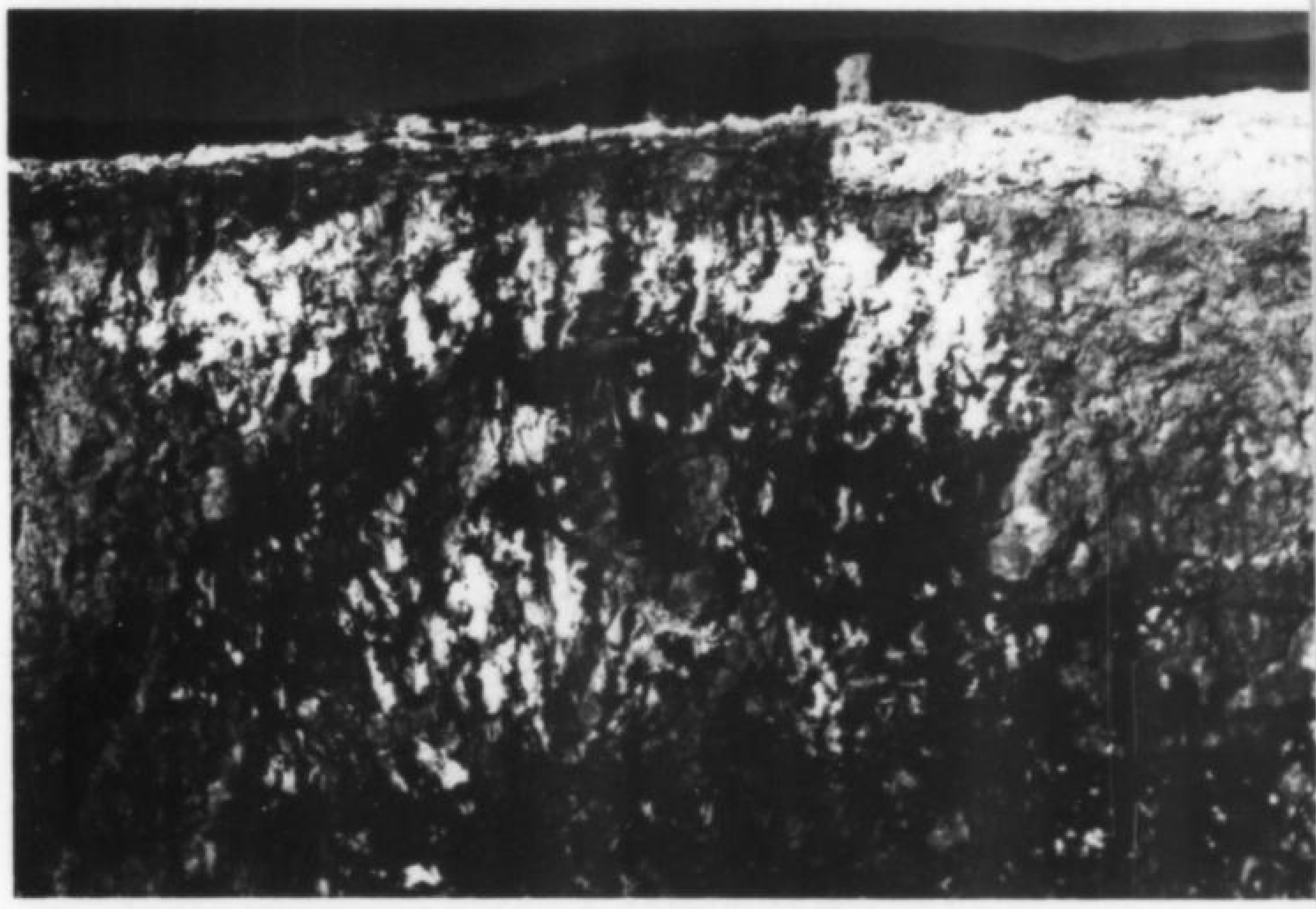

***Fig. 5.* White fibrous ulexite exposed in the mud of a playa lake.**

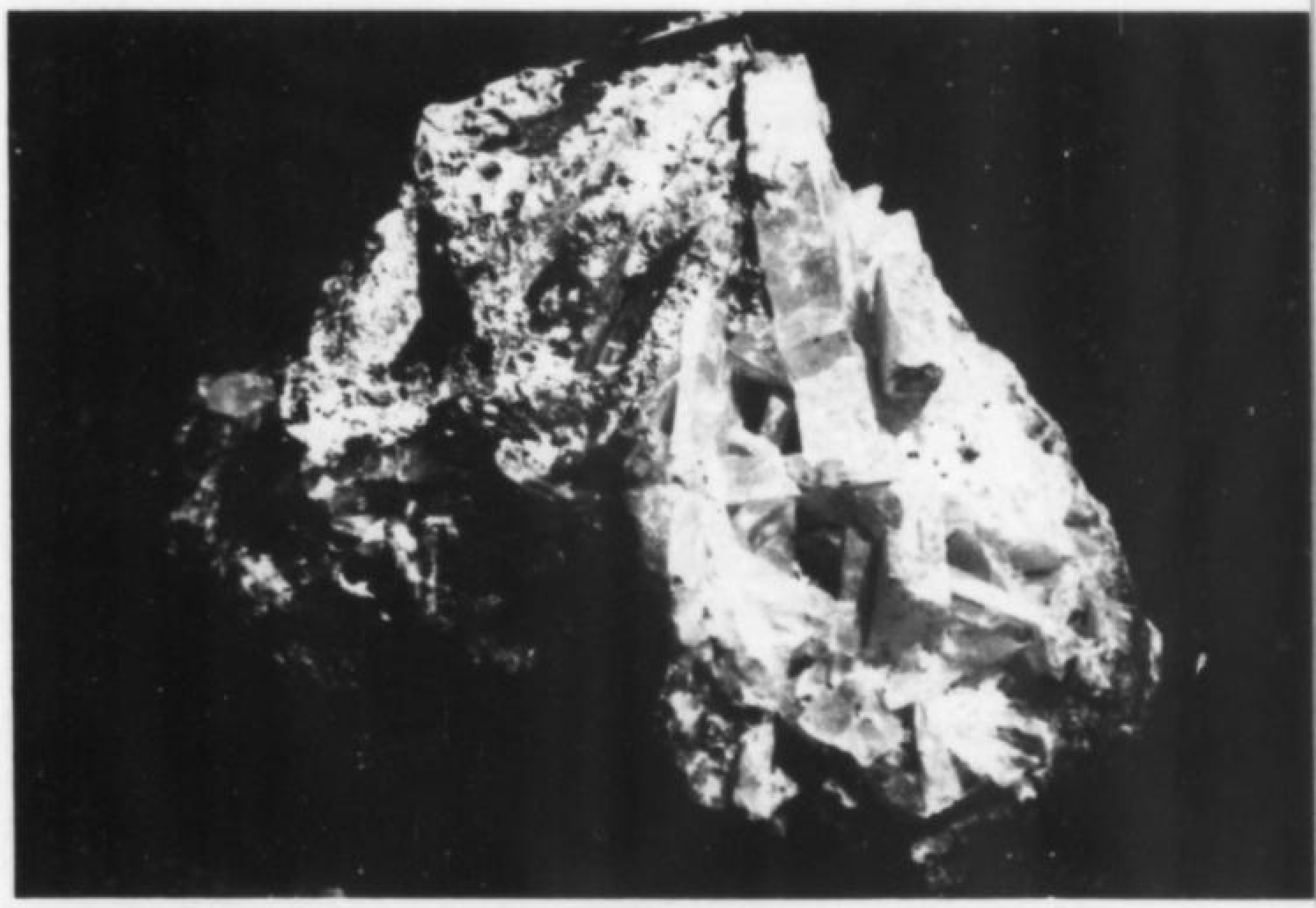

***Fig. 6.* Group of borax crystals weighing 70 kilograms. The largest crystal is 35 centimeters long.**

Deposits of this type are not worked today in the United States, but they are actively exploited in other countries lacking higher grade sources of boron.

Where borax is the principal mineral of this type of deposit, it occurs as a crust or as discrete euhedral crystals ranging in size from 0.5 to 25 centimeters in length. Borax may appear in the same salar with ulexite but separated from it vertically or laterally into monomineralic zones, and occupying an intermediate position between ulexite and halite.

The initial discovery of borax in the United States at the relatively small Borax Lake, California (200 acres) was of this type. So also was the legendary Tibetan deposit. There, in the Puga Valley, borax has a thickness of about 90 centimeters and covers a "large area" (Clarke, 1924, p. 251).

Many of the Tertiary playa deposits have been covered by younger sedimentary rocks. Later during Pliocene or even Quaternary times, the sediments in these basins were compressed, folded, faulted and subjected to chemical changes. A few of them crop out at the surface but most remain buried and can be located only by drilling or geophysical prospecting. All known accumulations of this type are Middle Tertiary to Pliocene although some authors suggest they extend into the Quaternary (?). The huge Kramer deposit in California has been dated by mammalian fossils overlying it as Middle Miocene.

During the life of a deposit the original mineral composition may undergo important changes; but the tendency to be monomineralic remains and one mineral or possibly two predominate. When chemical transformation has been incomplete there are two or even three major minerals. Also many new and unusual borates may develop in small amounts. These old playa deposits are classified in Table 4 as Class B Types 7 and 8.

Most authors agree that the high hydrates are the stable phases under the surface condition of playas (Muessig, 1959). Burial, with rising temperature and increase in both confining and tectonic pressure, favors the development of lower hydrates. For example colemanite ($2CaO \cdot 3B_2O_3 \cdot 5H_2O$) and meyerhofferite ($2CaO \cdot 3B_2O_3 \cdot 7H_2O$) are considered to be derived from inyoite ($2CaO \cdot 3B_2O_3 \cdot 13H_2O$) by dehydration and recrystallization (Meixner, 1953); kernite ($Na_2O \cdot 2B_2O_3 \cdot 4H_2O$) from borax ($Na_2O \cdot 2B_2O_3 \cdot 10H_2O$) (Christ and Garrels, 1959) and probertite ($Na_2O \cdot 2CaO \cdot 5B_2O_3 \cdot 10H_2O$) from ulexite ($Na_2O \cdot 2CaO \cdot 5B_2O_3 \cdot 16H_2O$) (Foshag, 1931). In addition reactions may have taken place between the mineral phases and residual brines trapped at the time of the deposit's formation.

Because of these chemical changes, Type 7 is distinguished from Type 8 of Class B. In Type 7 are included those deposits in which the boron minerals remain with their supposed original composition. In type 8 are grouped deposits with low to moderate chemical modification. Borax deposits are included with the latter group because they are partially transformed to kernite. The subdivisions of both groups are based on the principal mineral components.

However this division into two types is partly arbitrary because of the different "resistance" of the primary minerals to change. In the Sijes zone, Argentina, folded Tertiary sediments include colemanite bodies derived presumably from inyoite, and ulexite deposits with the original apparent low density cotton balls transformed to compact ulexite disks because of moderate mechanical deformation. The ulexite bodies do not present chemical changes and are grouped in Type 7 although most of the folded deposits of the area are of the other type.

Type 8 is the most important group of deposits from the economic point of view, and some of them are extraordinarily large. To give an idea of size, the Kramer deposit has estimated reserves of more than 80 million tons containing 25 Wt% B_2O_3 (Eng. Min. Journal, 1958; Smith, 1960), and the newly discovered borax deposit at Kirka, Turkey, has 5 to 8 times the reserves of Kramer (Industrial Minerals, 1970).

A comparison of the size of Types 7 and 8 deposits with those of the younger playa accumulation, Type 6, (Upper Quaternary to Present), shows that those of Types 7 and 8 are far greater. This suggests that the older cycle (or cycles) of boron mineralization was more intense and important than the ones following.

Marine environment

Sea water contains 3.5 weight per cent of dissolved salts of which boron makes up slightly more than one part in ten thousand, an amount far too small to be recovered economically. However, in certain geologic periods huge quantities of sea water have evaporated in relatively isolated marine basins giving rise to rocks formed principally from the dissolved salts. Before precipitates are obtained a high percentage of the water must be evaporated. When the original volume of water is reduced by 80 per cent, gypsum is precipitated and when reduced by 90 per cent, halite is deposited.

These large reductions in volume of the original sea water also cause boron to be precipitated. It forms principally magnesium borates, but calcium, strontium, sodium and potassium ions may be present in some boron minerals. The borates occur as discrete grains chiefly in beds of sodium and potassium salts but may also be in gypsum (or anhydrite) layers.

Some deposits of this type of marine evaporites formed during the Permian are actively mined, such as the well known Zechstein potash deposit of Germany. Here borates are obtained in small amounts as a by-product, principally as the mineral boracite.

Another area where boron is found in marine evaporites is in the Permian gypsum beds of Oklahoma. In these deposits, because of dehydration and later rehydration, boron has been concentrated in nodules, principally as calcium borates. They are not recovered economically.

Table 4

Classification of Borate Ore Desposits and Other Potential Sources of Boron

Class	Type of deposits	Principal minerals	Examples	References
A) Related to intrusive rocks	1) Contact metasomatic deposits in skarns at contacts of dolomites and granitic rocks	a) ludwigite and szaibelyite, with magnetite	Yakutia, Siberia, USSR Norberg, Sweden	Palache, Berman, Frondel (1951) Geijer (1939)
		b) kotoite, ludwigite and szaibelyite, without magnetite	Hol-kol, Suan district, Korea	Watanabe (1939)
		c) tourmaline and axinite		Barsukov and Egorov (1960)
	2) Contact metasomatic deposits in skarns at contacts of lime-silica rocks such as calcareous shale and marls with granite, diorite and other intrusive rocks	datolite	Northern Caucasus	Kurman and Usacheva (1937)
	3) Pegmatites	tourmaline	Cordoba and San Luis Provinces, Argentina	
B) Related to volcanic rocks (largely dacite, andesite and basalt	1) Steam vents (= soffioni), natural and drilled	recovered as sassolite	Tuscany, Italy	Cavinato (1952)
	2) Thermal spring solutions	solutions	Japan Sulphur Bank Spring, California, U.S.A.	Tagaya (1942), Uzumasa 91965) Smith (1960), White (1957)
	3) Thermal spring deposits	a) ulexite	Supisaino, Jujuy, Argentina	Barnabe (1915), Aristarain and Hurlbut (1968)
		b) borax and ulexite	Coyaguaima, Jujuy, Argentina	Ahlfeld (1948), Aristarain and Hurlbut (1968)
		c) inyoite and ulexite	Loma Blanca, Jujuy, Argentina	Aristarain and Hurlbut (1968)
		d) priceite	Chetco, Oregon, USA	Staples (1948), Palache, Berman & Frondel (1951)
	4) Mud flow	ulexite	Coyaguaima, Jujuy, Argentina	Ahlfeld (1948)
	5) Desert lake (Brine)	recovered as borax	Searles Lake, California, USA	Garret (1960)
	6) Playa (= marsh) on or near surface	a) borax	Teels marsh, Nevada Puga Valley, Tibet	Smith (1960) Clarke (1924)
		b) ulexite	Salares de Uyuni, Coipaza and Empexa, Bolivia	Ahlfeld (1954)
		c) inyoite	Laguna Salinas, Peru	Muessig (1958)
	7) Old playa, buried, highly deformed, low to no chemical changes	a) ulexite	Sijes, Salta, Argentina	
		b) inyoite	Sijes, Salta, Argentina	Aristarain and Erd (197)
		c) kurnakovite	Tincalayu, Salta, Argentina	Aristarain and Erd (197)

	8) Old playa or lake deposit, buried, highly deformed, low to moderate chemical changes	a) borax kernite	Kramer, Calif., USA	Barnard & Kistler (1965)
		b) colemanite	Begindikler, Balikesir Prov., Turkey	Helke (1955)
		c) colemanite ulexite	Günevi, Balikesir Prov., Turkey	Min. Res. & Expl. Inst. Turkey, Pub. 125, (1965)
		d) probertite, ulexite-colemanite	Ryan, California, USA	Foshag (1921, 1931)
		e) colemanite-terschite	Kürtpinari, Balikesir Prov., Turkey	Min Res & Expl Inst, Turkey, Pub 125 (1965)
		f) hydroboracite	Sijes, Salta, Argentina	Catalano (1927)
		g) hydroboracite-colemanite	Sijes, Salta, Argentina	Aristarain and Erd (197)
		h) priceite	Sultancayiri-Aziziye, Balik. Prov., Turkey	Schlüter (1922)
C) Related to marine sediments	1) Evaporite marine sediments, crystals disseminated in K and Na salt beds and associated layers. By-product of potash industry	boracite and other Mg and Ca borates	Stassfürt, Germany, Permian saline series of Zechstein	Braitsch (1960a & b), Palache, Berman, Frondel (1951)
	2) Nodules in gypsum beds	probertite, ulexite	West Central Oklahoma, USA, Blaine Formation	Ham, Mankin and Schleicher (1961)
	3) At margins of salt dome with karst development, concordant or cross-bedding deposits formed by subsidence of the boraciferous cap rock; tabular lenticular or irregular bodies	a) hydroboracite in clays or in gypsum b) szaibelyite c) ulexite d) inyoite e) colemanite f) priceite	Inder District, USSR	Godlevsky (1937)
	4) Nodules in alluvial argillaceous sands	ulexite	NW of Inder Uplift, USSR	Godlevsky (1937)
	5) Desert lake fed with waters draining marine evaporite sediments	brime	Inder Lake, USSR	Godlevsky
D) Related to marine, volcanic, others?	Nitrate deposits. Borates disseminated in nitrates which cement gravels and sands. By-product of nitrate industry	unknown	Eastern slope of the Coastal Range, Septemtrional, Chile	Ericksen (1963)

These two types of borate deposits are designated as Class C, Types 1 and 2 of Table 4.

In the examples mentioned the boron accumulations may be considered preconcentrates, not developed sufficiently to be economic *per se.* But there is one important region where nature has further concentrated boron from a deposit of this type to produce commercial deposits. This is the Inder district of Russia located 150 km north of the Caspian Sean and only a short distance east of the Ural River. In this area parts of a Lower (or Early?) Permian marine evaporite series have been elevated as a salt dome (Godlevsky, 1937). The structure known as the Inder Uplift rises 20 to 30 meters above the surrounding plain and covers an area of 250 square kilometers.

The dome reached the surface during Quaternary times following solution and development of karst phenomena. Subsidence of the caprock of gypsum, derived from anhydrite, and interbedded clays has resulted in the formation of abundant gypsum hills and basins. Probably during the late history of the dome the scattered borates were dissolved and either recrystallized nearby or were transported to be concentrated by redeposition. This process involved replacing of sediments or filling cavities to form concordant or cross-bedded deposits. The resulting bodies are tabular, lenticular or irregular with massive or nodular structure.

The Inder district includes many important economic deposits and from available data appears to be one of the most important borate producing regions in Russia. The most common minerals are hydroboracite, szaibelyite, ulexite, inyoite, colemanite and priceite. The deposits originating within the dome itself are designated as Class C, Type 3.

Waters have dissolved borates from the dome and transported them to the surrounding areas. At the northwest part of the uplift are deposits of nodular ulexite in young sandy argillaceous sediments, elongated in the direction of the ground water filtration. Also boraciferous waters feed Lake Inder whose brine contains 0.23 Wt% of B_2O_3. These two types of deposits are designated Class C Type 4 and Class C Type 5, respectively.

Finally, there are deposits in which boron is obtained as a by-product of the mining of nitrates. The only accumulations of this type are in the northern part of Chile in a belt 700 km long by 15 to 80 km wide, along the eastern slope of the Coastal Range in the region of Atacama, Taparaca and Antofagasta deserts. The nitrates occur near the surface on gentle slopes cementing sands and pebbles of igneous rocks. Ericksen (1963) stated that the mineralogy of the associated borate minerals has been little studied, and mentioned only the presence of ulexite. He further indicated that the boron content expressed as $Na_2B_4O_7$ ranges from 0.47 to 0.82 Wt%, that is, approximately 0.32 to 0.56 Wt% $B_{.2}$ O_3.

The genesis of these deposits has been the subject of considerable discussion and many hypotheses have been proposed to account for it, such as volcanic, marine, organic; etc. Because of the uncertainty of origin, they are set apart as Class D.

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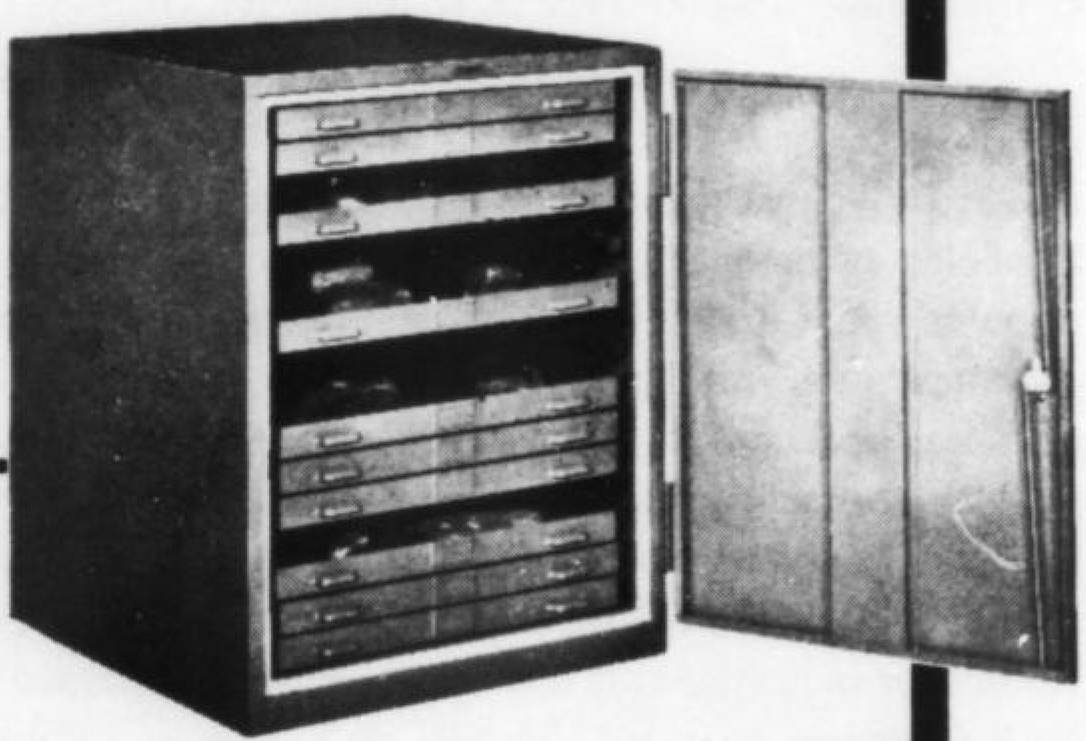

AMETHYST

*by Farkhonda Hassan**

The American University in Cairo • Cairo, Egypt

Amethyst, a well known violet variety of quartz, was one of the twelve gem stones mentioned in the Bible as used to adorn the linen bag worn by the High-Priest. It has been known since the ancient Greeks. In the 4th century B.C., Theophrastus, a pupil of Aristotle, mentioned in his work *On Stones* that *amethystus* was found when certain rocks were cut through. The name amethyst is derived from the Greek: *αμεθνστ*-ος *not drunken,* and it is thought to express the mistaken belief that the wearer is protected against the intoxicating effect of wine. Others believe that the name means that the color of amethyst approaches, but does not quite reach, that of red wine. The possibility that amethyst is a variety of ordinary (alpha) quartz was first indicated in 1546 by Agricola in his *De Natura Fossilium.* Agricola said that amethyst is found in large crystals having a hexagonal base and terminated in a point similar to quartz (Fig. 1). Later, the identification of amethyst as a coarse-grained variety of alpha-quartz was explicitly stated in the beginning of the 19th century. Some mineralogists would call amethyst only those parts of the quartz crystal that are colored. Uncolored portions of the same crystals are ordinary alpha-quartz.

Occurrence

Natural amethyst quartz crystals are widespread in hydrothermal veins formed at relatively low temperatures and pressures. When associated with other varieties of alpha-quartz, amethyst is the latest to crystallize. It is known to be the most epithermal generation of alpha-quartz. The temperature at which amethyst crystallizes is believed by the author not to exceed 450°, otherwise no amethyst color is to be observed even if the mineral is exposed to radiation (see below). Amethyst is most common in basic igneous flow rocks where it is found lining large open geodes and other cavities.

Commercial amethyst is obtained mainly from Uruguay and Brazil. At Serro do Mar, Rio Grande do Sul, Brazil, a single cavity 33 ft. in length, 5 1/2 ft. in width, and 3 ft. in height was entirely lined with brilliant, deep violet amethyst crystals averaging about 4 cm. across. The export of amethyst from Brazil is said to have begun in 1727. Fine qualities of amethyst are found in the Urals where it occurs in quartz veins in granite, and from the gem gravels of Ceylon. Also, fine specimens of amethyst are found in hydrothermal sulfide veins at Porkura and in iron deposits at Macskamezo, Transylvania, Rumania.

Crystal Structure of alpha-quartz

Alpha or low ordinary quartz crystallizes in the trigonal-trapezohedral class of hexagonal lattice type. The crystal class has the quality of enantiomorphism, a word derived from the Greek *enantios:* opposite, and *morphis:* form, and indicates the existence of two identical but opposite objects; simply mirror-images. Alpha-quartz crystallizes in one or the other of the two forms for which the terms right-handed and left-handed are conventionally used. The crystal habit in general is a result of the environmental conditions during crystallization. Quartz forms twins in accordance with a number of known twinning laws, the most common are the Dauphine and the Brazil laws. Brazil (optical) twinning in which both enantiomorphs are present in the same crystal sharing the (1120) plane is particularly common in amethyst quartz.

Amethyst crystals have a very simple habit with dominant, well-developed rhombohedral faces. The crystals always show polysynthetic twinning on the Brazil law. Untwinned crystals are rarely found in nature. Brazil twins commonly develop as thin extended lamellae. In amethyst, these twin lamellae, a fraction of a millimeter thick, are remarkably uniform and are arranged parallel to the terminal r or z faces. The lamellae are alternately right- and left-handed. They may give rise to sets of delicate striations and cause a rippled or finger-print appearance on fractured rhombohedral surfaces. In polarized light under crossed nicols, in basal sections of amethyst (2-4 mm thick) the twinning appears as alternating light and dark stripes. These stripes radiate in sets 120° apart from the center of the crystal (Fig. 2). The way the lamellae are distributed in a basal section of amethyst usually depends on the habit of the crystal under investigation and on whether both r and z faces are equally developed, or the r dominates over the z, or whether the crystal is of distorted habit.

Pure alpha-quartz is an optically positve uniaxial substance. Colored portions of amethyst quartz show anomalous biaxial character; also a weak dichroism can be seen in basal sections. Both the anomalous pleochroism and

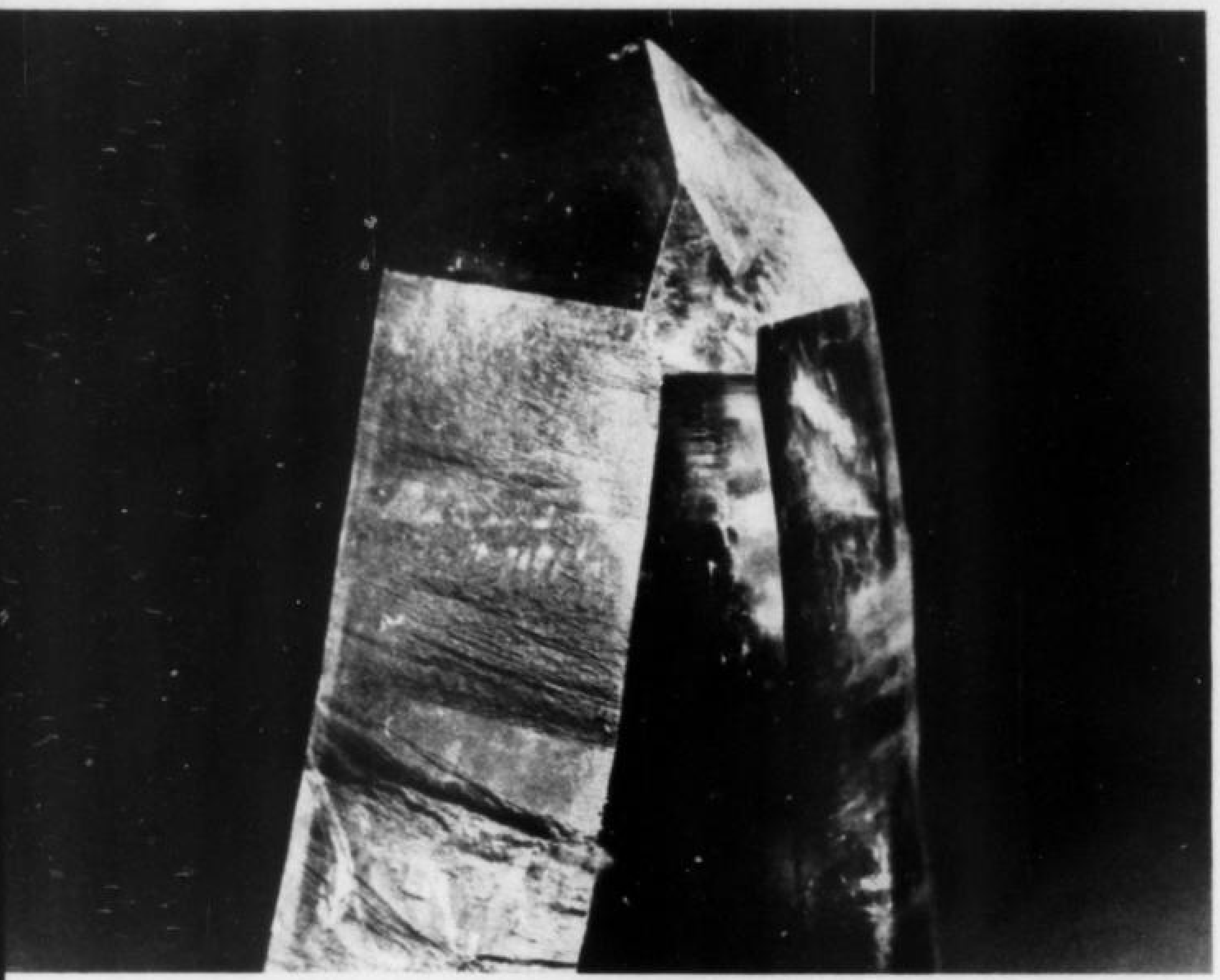

Fig. 1. **Natural amethyst crystal. Photo by Joel E. Arem.**

the biaxiality of amethyst are in direct conflict with the holotrigonal symmetry of the alpha-quartz structure. This conflict led to numerous suggestions that the symmetry is lower than holotrigonal. There were several attempts to explain this observed anomalous biaxiality. Melankolin and Tsinober (1963) linked it to the Brazil twinning. Shlössin and Lang (1965) related the biaxiality to the abundance of dislocations in the positive rhombohedral faces. Barry and co-workers (1965-1966) suggested the biaxiality of amethyst is due to nonrandom distribution of ferric ions known to exist in amethyst. However, these views were weakened and even abandoned after a thorough study of the biaxiality of amethyst (Hassan, 1970). Optically bleaching an amethyst section by exposing it to intense ultraviolet light resulted in the complete disappearance of the anomalous biaxiality and pleochroism. The disappearance of the biaxiality was accompanied by the disappearance of the absorption bands in the visible region—responsible for the amethyst color, which indicated that the observed anomalous biaxiality is a property of the color center itself not the alpha-quartz structure (Fig. 3).

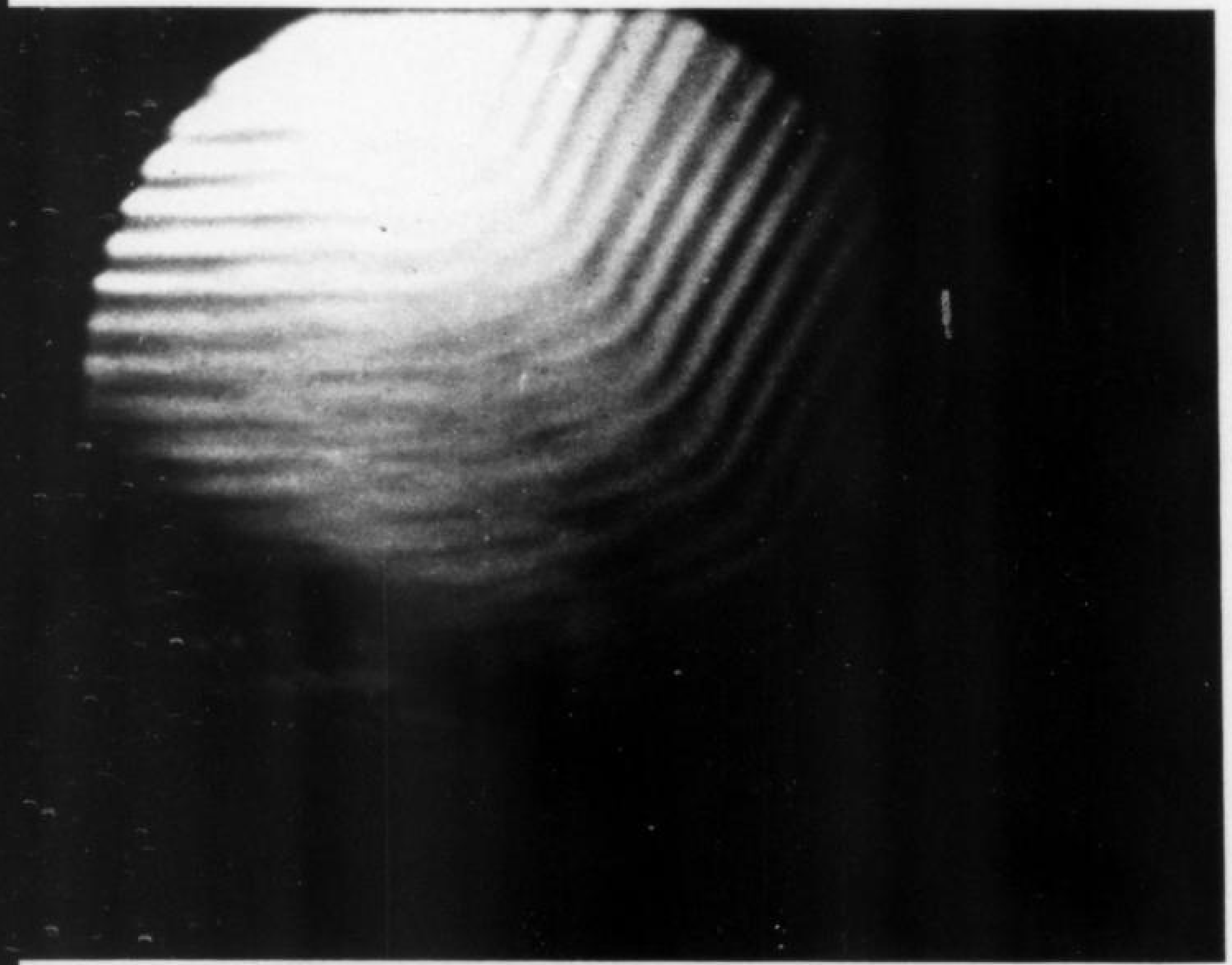

Fig. 2. **Basal section of an amethyst crystal, as seen in polarized light under crossed nicols.**

Nature of the Amethyst Color

The amethyst color is rarely distributed uniformly; it usually develops only in sectors under the positive rhombohedral faces. In the crystal shown in Figure 4, the positive rhombohedral faces (*r*) were deep amethyst in color, while the negative rhombohedral faces (*z*) contained a faint smoky tinge. The color may also be disposed in layers or bands parallel to the external crystal faces or in irregular patches in the direction of the *c*-crystallographic axis, but never beneath the prism faces.

The amethyst color disappears upon heating the crystal. Heating a deeply colored Brazilian amethyst crystal at 380° C for 2 hours was enough to turn it colorless with milky flaws. The color remained almost unchanged until 300° C when it started getting more and more pale upon increasing the temperature. Some dark-colored amethyst developed upon heating a beautiful citrine or reddish brown color. Citrine is a yellowish brown transparent variety of alpha-quartz containing colloidally dispersed particles of hydrous ferric oxide. Most of the commercial gem ctirine is made in this way. The response of different specimens of amethyst to heat treatment varies considerably. Some specimens phosphoresce, others develop a grass green color in place of the citrine color. This tendency to become green when heated seems to be observed only in amethyst from Montezumus, Minas Gerais, Brazil. The amethyst color was recognized by Berthelot (1906) as radiation color. It is bleached by heating the crystals at about 400° C and restored upon re-irradiation with x

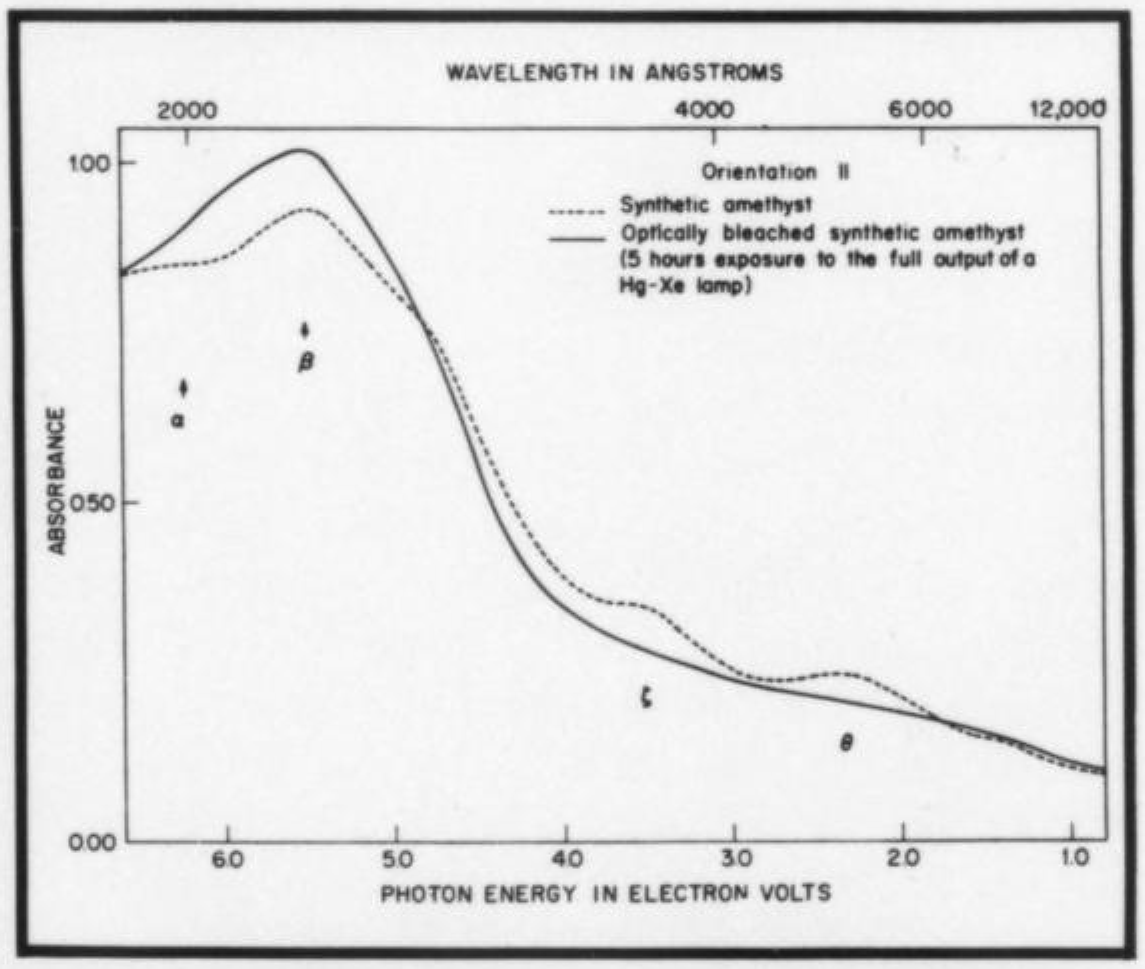

Fig. 3. **Absorption spectra of synthetic amethyst before and after optical bleaching.**

or γ-rays or other ionizing radiation (Fig. 5). A few minutes of x-irradiation were found sufficient to restore the amethyst color in alpha-quartz, which indicates that natural ionizing radiation from any nearby radioactive nuclide could produce the color. Some unsaturated natural amethyst can be darkened in color in this way. Different varieties of amethyst, from different localities, show different shades of violet. It seems that the difference in the color shade and the response to both heat treatment and irradiation is due to different coloring mechanisms, or the coexistence of different impurities together with the main ion responsible for the color.

The secret of the color of amethyst attracted the attention of many investigators since Henkel (1725) who attributed the amethyst color to colloidal gold. Experiments done by H. Rose in 1800 indicated that the color of amethyst is due to manganese. This theory was later supported by Berthelot (1906) when glasses containing traces of Mn acquired an amethystine color upon irradiation. However, chemical analyses show that the Mn content of quartz in general varies regardless of color, it is very low or even lacking in some amethyst crystals. Bruce (1813) suggested that the color of amethyst from Delaware County, Pennsylvania is caused by titanium impurity. Others believed that the presence of hydrocarbon might be the reason for the color.

The idea that iron is the cause of the amethyst color is supported by several observations and evidenced by many experimental investigations since Woodward (1729). Amethyst is characterized by a relatively high content of Fe_2O_3 in comparison to other varieties of α-quartz except citrine. Frondel (1962) observed that in some instances the colored faces of amethyst are selectively filmed by finely divided iron oxide. Although the amethyst color appears to be deeper when the Fe_2O_3 content is higher, an accurate quantitative correlation between the depth of color and the iron content could not be reached. Hutton (1964) found that the presence of iron alone is not sufficient for development of the color as indicated from his studies of both natural amethyst and citrine. Hutton concluded that high energy radiation is necessary if the violet color of amethyst is to be produced. This conclusion supports the early view of Berthelot (1906) and also provides one possible reason for the lack of quantitative correlation with iron content. The similarity of several of the absorption bands of amethyst to iron (ferrous and ferric) optical transitions strengthens the belief that iron is the key impurity (Schlazinger and Cohen, 1965). The absorption spectra of both a naturally occurring Brazilian amethyst and an x-irradiated Fe^{3+} doped synthetic alpha-quartz were studied by the author and found identical (Fig. 6). A synthetic Fe^{3+} quartz grown hydrothermally by Sawyer was a yellowish brown single crystal. Upon exposure to x-irradiation a deep beautiful amethystine color (accompanied by two major bands in the visible) developed only in rhombohedral growth regions. This is the way synthetic amethyst is made (Fig. 7). This experiment shows that if the amethyst color is to develop, the iron should be in a special restricted environment available in the rhombohedral growth regions only (Fig. 8). Other growth regions of the same sythetic crystal containing Fe^{3+} did not develop the amethyst color upon x-irradiation.

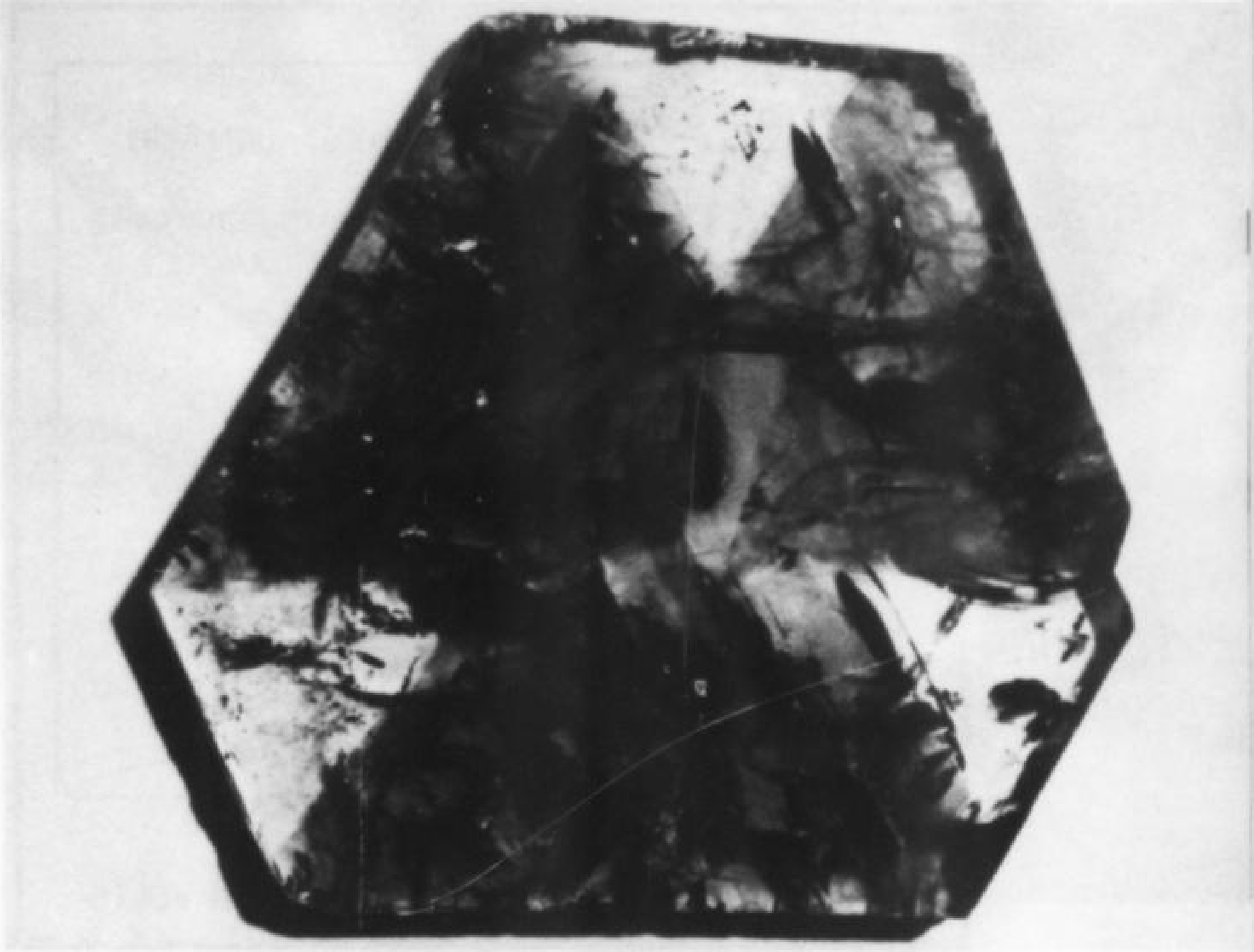

***Fig. 4.* Natural amethyst crystal from Brazil. Smithsonian Institution specimen. Photo by Joel E. Arem.**

The state in which the ferric ion (Fe^{3+}, ionic radius = 0.63 Å) is present in amethyst is still a matter of controversy. While it is believed by some investigators to exist

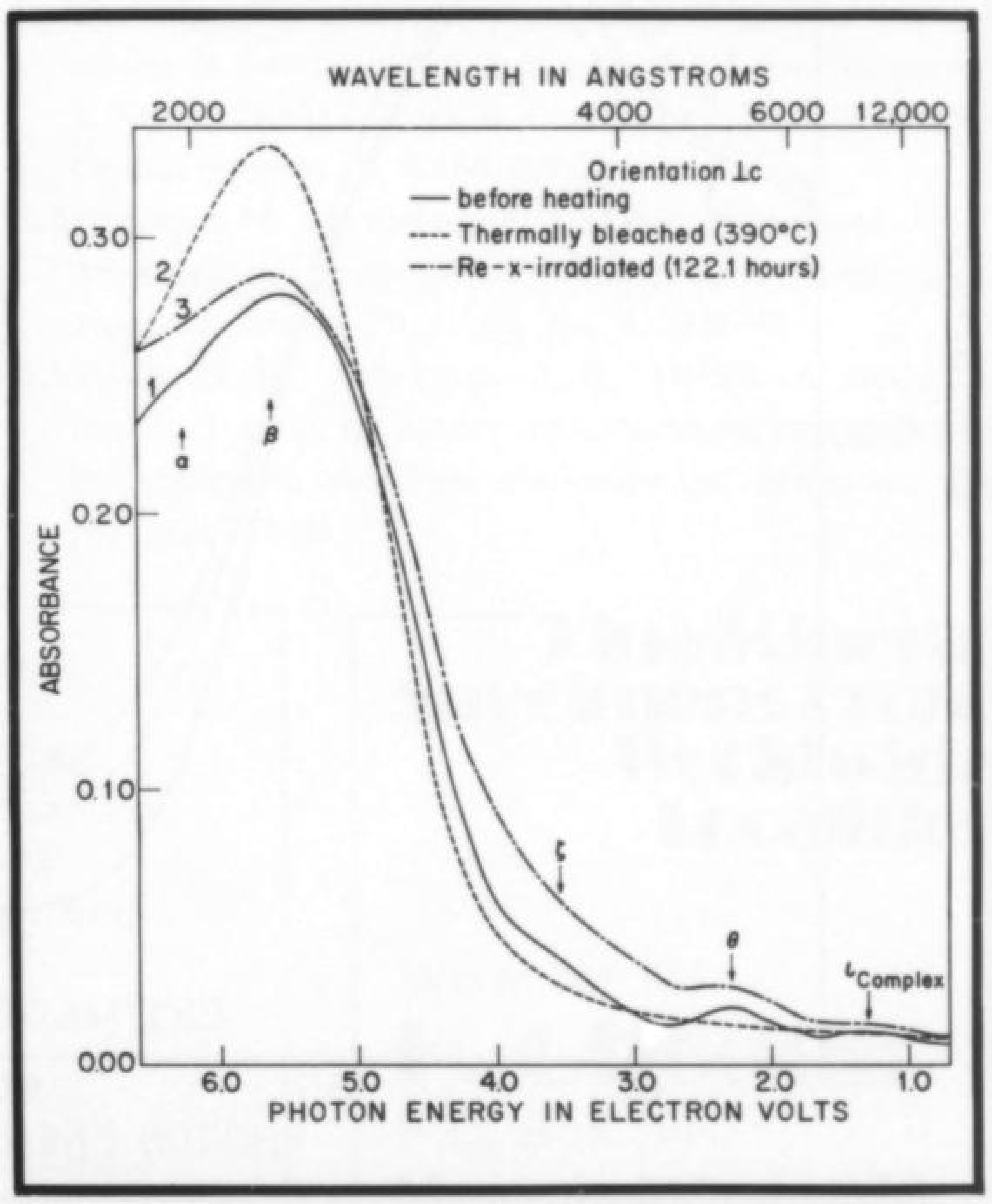

***Fig. 5.* Absorption spectra of Brazilian amethyst before and after heating and re-irradiation with x-rays.**

substitutionally for silicon (Si^{4+}, ionic radius = 0.46 Å) in the SiO_4 tetrahedron, others think it might be interstitial. Experiments done by the writer indicated that an interstitial Fe^{3+} near a substitutional Fe^{3+} is the actual precursor center responsible for the amethyst color-production.

X-irradiation, like any other ionizing radiation, results in the removal of a negatively charged electron from an ion leaving behind a hole of positive potential. The free electrons may wander in the lattice till they either recombine with their holes or be trapped elsewhere. Electron traps could be any existing entities having a positive potential sufficient to attract these negatively charged electrons. In the case of amethyst, upon x-irradiation, an electron is removed from the substitutional Fe^{3+}, changing it to Fe^{4+}, thus satisfying charge neutrality in the FeO_4 tetrahedron, at the same time the freed electron is trapped by a nearby Fe^{3+} changing it to Fe^{2+}. Optical bands corresponding to Fe^{4+} and Fe^{2+} centers were observed to grow upon irradiation. Meantime, the absorption bands known to be due to Fe^{3+} were found to decrease in inten-

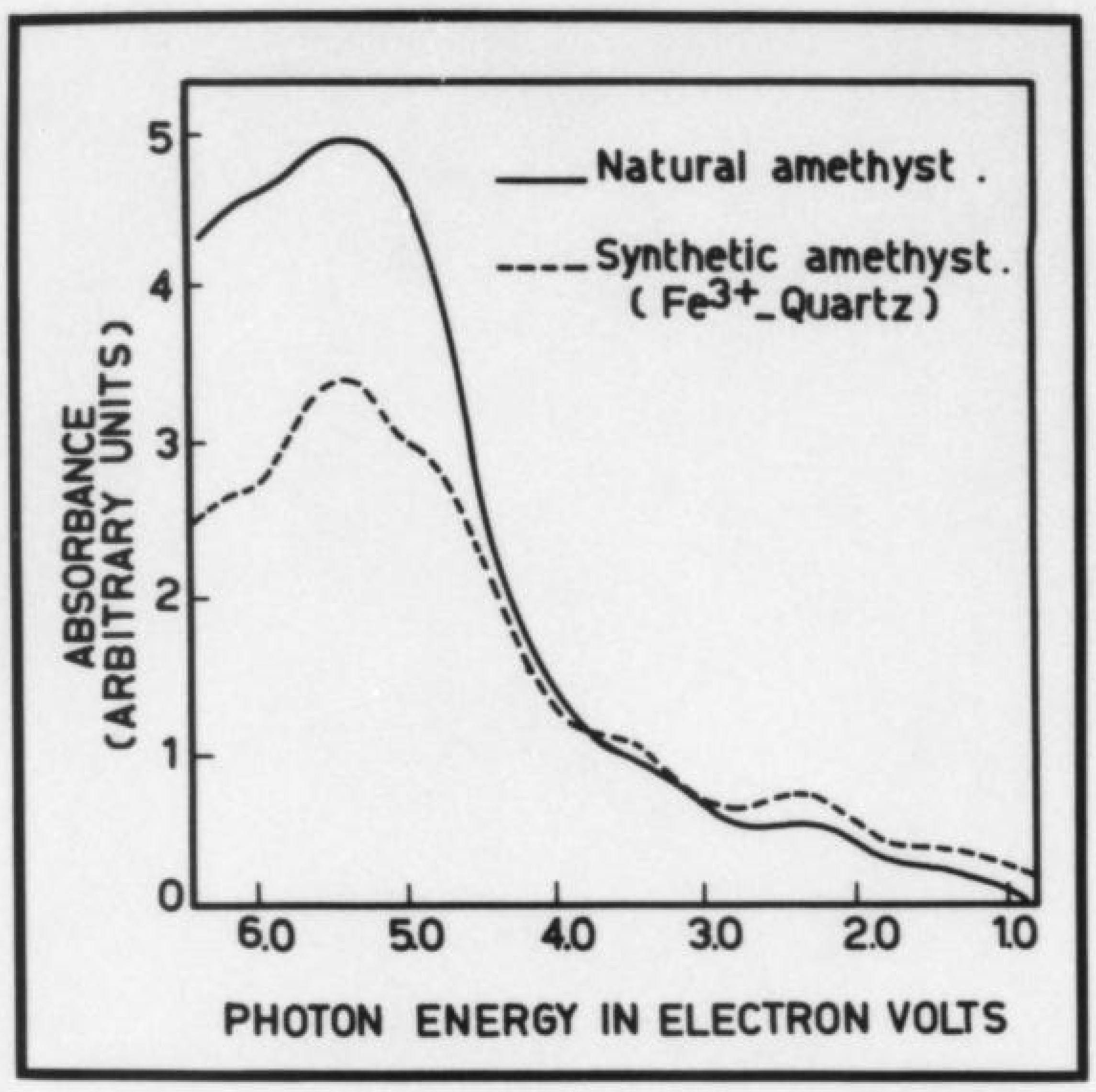

Fig. 6. **Absorption spectra of natural and synthetic amethyst crystals.**

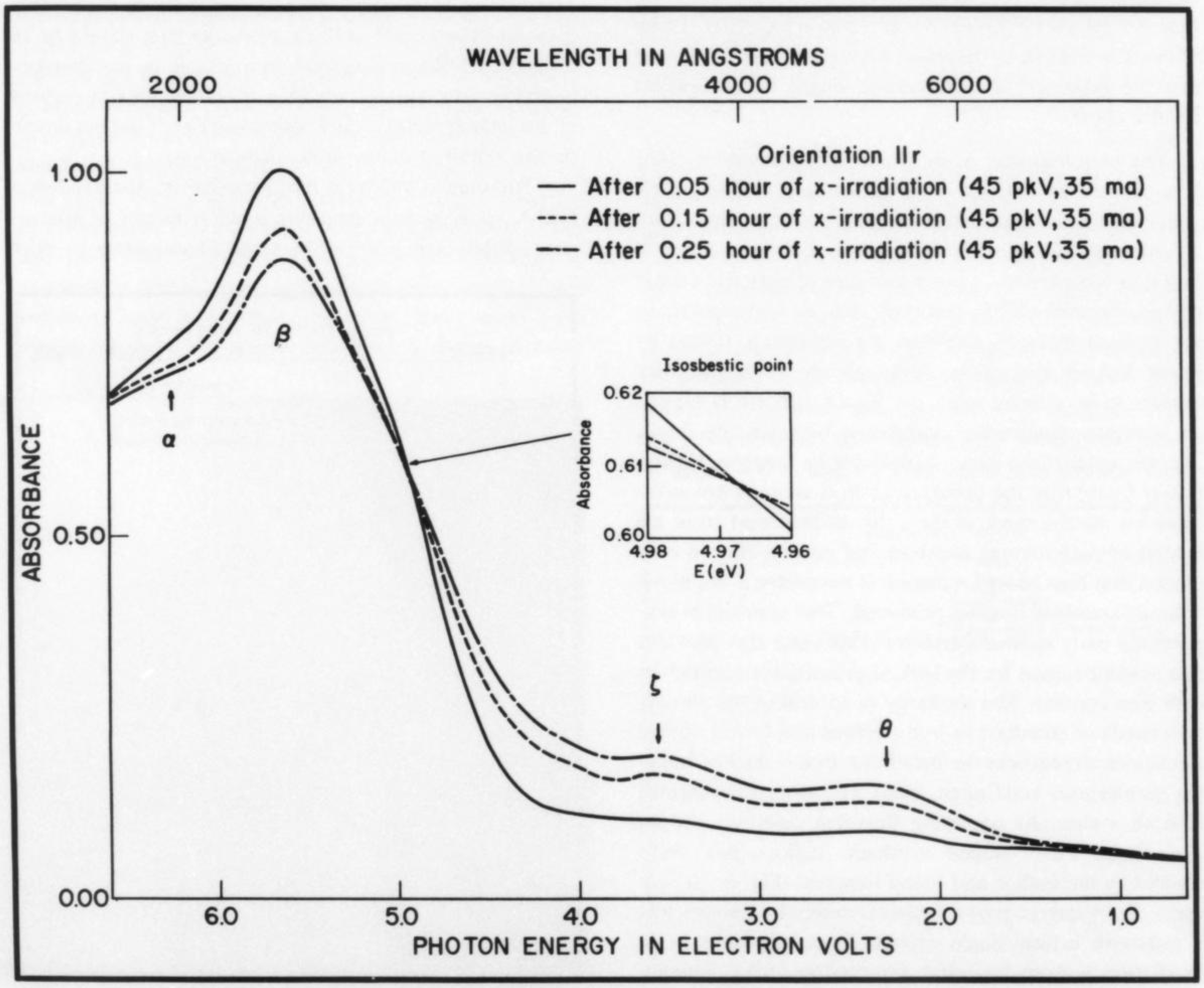

Fig. 7. **Details of X-irradiation of synthetic quartz doped with ferric ions. While the α and β bands in the ultraviolet decreased in intensity, the ζ and θ bands located in the visible grew as the color developed.**

sity. The situation can be described by the following equation

$$Fe^{3+}\text{(substitutional)} + Fe^{3+}\text{(interstitial)} \underset{380^\circ C}{\overset{\text{x-rays}}{\rightleftharpoons}} Fe^{4+}\text{(subs)} + Fe^{2+}\text{(int.)}$$

Raising the temperature of a section of amethyst from 300° to 380°C is sufficient to provide these trapped electrons with enough kinetic energy to escape from their traps and move in the lattice towards their original sites, i.e. anihilating the positive holes. The crystal will return back to its original state and no amethyst color is exhibited. Upon re-irradiation the color redevelops. It happened that when the amethyst sections were heated to temperatures above 400° or 450°, the amethyst color disappeared permanently and did not redevelop even upon increasing the x-ray dose.

An interesting geologic implication is that hydrothermal veins containing amethyst crystals are more likely formed below 400° C, otherwise no amethyst color would be generated if trace radioactivity is present. This view, however, needs further detailed study. An interesting point of research would be collecting as many as one can of amethyst crystals from various localities and trying to find out the temperature range at which the color permanently disappears. Once this range is established amethyst could be used as a geothermometer.

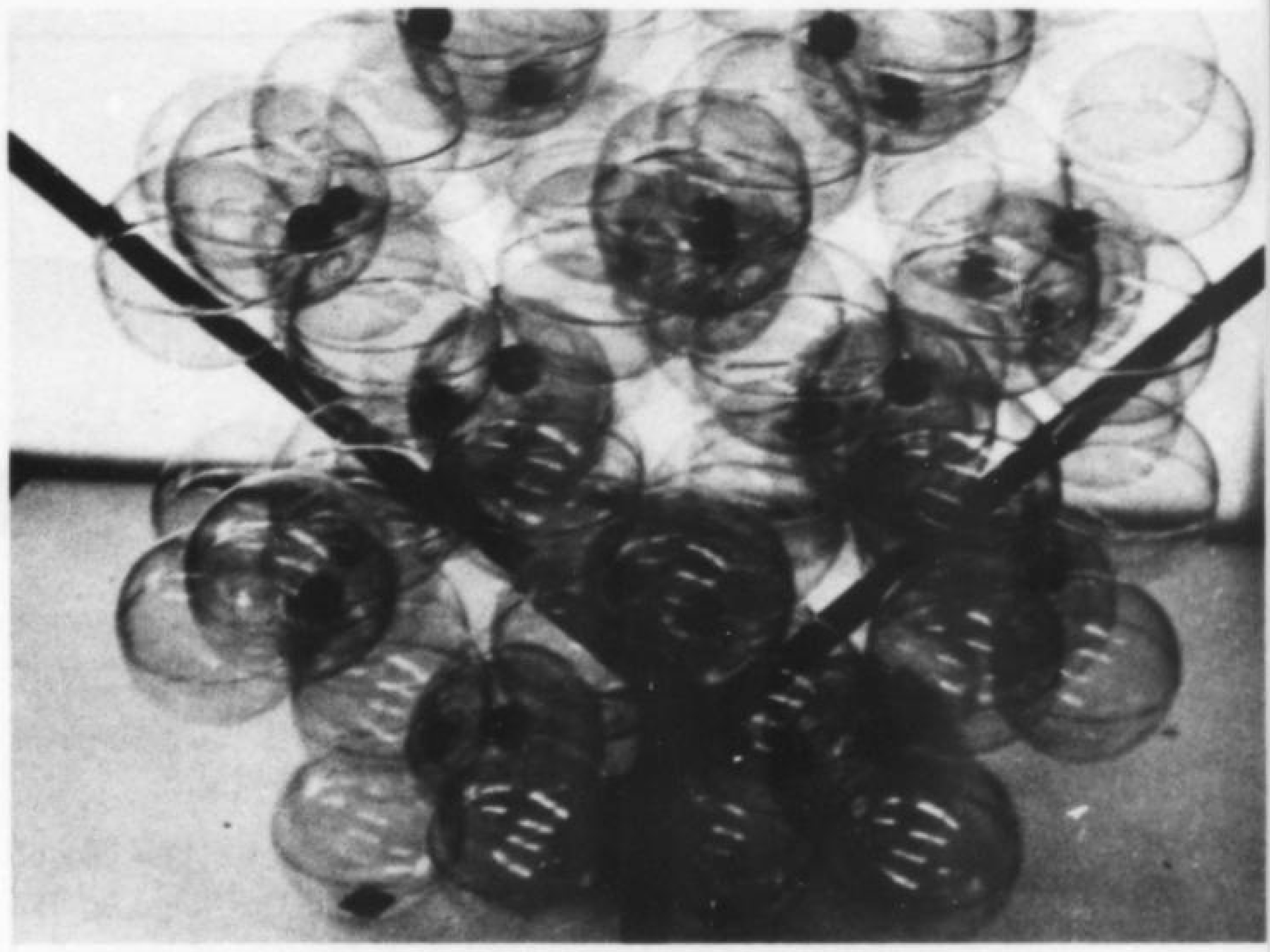

***Fig. 8.* View looking down the rhombohedral face direction of a plastic model of alpha quartz. The voids in this direction are clearly seen. Rods are inserted in some of them.**

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Specimen Requests

Here is a fine opportunity for mineral clubs in the United States to come to the aid of a University in Belgium. We hope that many of you (and individual collectors too) will respond to this request by sending materials that are readily available to you.

Dear Sir:

We are interested in the study of mineralogy and geology. For this reason, we are looking for some samples of crystallized minerals that are found in your country. For the moment, we are making a study about the minerals of the U.S.A. but obtaining the different samples of this continent is very difficult for us, especially as we don't have a budget for this kind of study.

We would, of course, be very obliged to you if you could supply our Museum with a good sample of the principal minerals that are found in your country, to add to our didactical collection. We would also be so glad to receive the list of the mines, quarries and places of extraction of the different minerals and gemstones in the different states. This would interest us to contact personally some societies who would help us in our studies.

We sincerely hope that you will be so kind as to help us in our difficult mineralogical studies, and that we may have the pleasure of adding some interesting samples from your country to our study material, and to receive the literature. Thanking you in advance for your kindness,

DR. C. VANDEN DRIESSCHE
Avenue Mingers 6
B-8370 Blankenberge
Belgium

Dear Sir:

I submit the following request with mixed feelings. As a caver and speleologist, I am worried about the irresponsible removal of cave formations which we, as members of the National Speleological Society, are violently opposed to. The largest perpetrator of cave vandalism is the amateur "mineral collector." However, I am in need of such material for legitimate scientific purposes (which) is permitted under our cave conservation stance), but am afraid that such a call as this will result in not only collecting for me, but also for the readers own collections. This is wrong. Thus, I face this dilemma.

We here at the carbonate sedimentology research section are involved in a crystallography project on lattice distortions in stalactites and stalagmites. We are interested in securing examples of such formations to confirm our preliminary observations on the three examples that we have. Unfortunately we are not in a karst area, and thus must seek the aid of fellow cavers and speleologists. Consequently, we are in need of several hundred (at least 100) such speleothems for this project. Specifically, we would like to have mailed to us a wide range of sizes, geographical locations, but also several examples from a single cave. Name of the cave and location should be noted, as well as whether the specimen is a stalactite or a stalagmite unless obvious. They need not be whole specimens: broken stubs or tips of fragments are satisfactory, from a 1/4 to 12 inches in length.

WE REALIZE THAT THIS IS A BENDING OF THE CAVE CONSERVATION POLICY, BUT MUST EMPHASIZE THAT THIS IS INVOLVEMENT IN A LEGITIMATE SCIENTIFIC RESEARCH PROJECT.

Any help in securing such specimens from your local area or in fact an area, would be deeply appreciated. We will cover any expenses involved. Thank you for your interest in this matter, and we shall look forward to hearing from you.

PAUL L. BROUGHTON NSS 8496
Subsurface Geological Laboratory
201 Dewdney Avenue East
REGINA, Saskatchewan
CANADA

For an investigation of the crystallographic and magnetic structure of maghemite (γ - Fe_2O_3) I am interested in acquiring as many specimens of this mineral as possible (even doubtful ones). Maghemite almost always occurs in intergrowth with lepidocrocite, hematite and goethite or as a weathering product of magnetite. The natural material is usually identified by its isotropic, white to greyish blue reflectivity; in finely powdered form its color is brownish red. All assistance will, of course, be gratefully acknowledged.

HANS-PETER WEBER
Dept. of the Geophysical Sciences
The University of Chicago
5734 S. Ellis Avenue
Chicago, IL 60637

The Mineral Resources Division of the Pennsylvania Geological Survey is presently conducting a mineralogic and geochemical trace element investigation of all sphalerite and galena occurrences in Pennsylvania. Information and/or samples from the following locations are needed to complete the study:

1) Galena, sphalerite, chalcocite, chalcopyrite, millerite, etc. in a "roll" along Roaring Branch of Lycoming Creek, near the line of Lycoming and Tioga Counties (Meyer, 1893).

2) Surface ore (apparently galena and sphalerite) from S. Snyder's farm (1879), 3 miles west from Woodberry, Bedford County (McCreath, 1879).

3) Galena from a "lost" lead mine approximately 5 miles north or northeast of Shirleysburg, Huntingdon County.

4) Sphalerite and galena in Pocono sandstone of "Victor" Hollow, a tributary to Georges Creek, in Georges township, Fayette County. Could this be "Hector" Hollow?

Replies on these or any Pennsylvania galena or sphalerite occurrences not mentioned in the literature should be sent to:

ROBERT C. SMITH
Pennsylvania Geological Survey
Dept. of Environmental Resources
Harrisburg, PA 17120

Yedlin on Micromounting, continued from page 204

separating stuck-together corks by stirring when they're half done.

Most of our pedestals are made from balsa sticks, obtainable at hobby shops wherever model airplanes are sold. They're available in many sizes, and cost but a few cents each. They're soft, light, and easily shaped. Specimens with uneven bases are easily seated on the balsa with but a bit of pressure. We darken them with India ink or "Flowmaster Felt Tipped Pen" ink, or its equivalent. With the India, we use a small brush, put two or three sticks together, paint them with a few strokes, and let dry. Q.E.D

Specimens should be as close to the top of the box as possible. The method that works well for us is as follows: Cement the specimen, after cleaning and orientation, to the end of a large section of balsa stick, say 6 or 8 inches. Let it dry. (Minutes only, if you use Duco cement or equal.) Now slide the mounted mineral into the plastic box until it almost touches the bottom. Score the pedestal, at the upper edges of the box, with a single edged razor blade. Remove, cut the balsa at the scored mark at right angles to the "c" axis of the stick. That's it. Cement in place, label top and bottom of the box, catalogue and file.

Buy and use a good mineral book, affix a label directly to the specimen where possible, and be certain that your microscope is clean and operative.

Neal Yedlin
129 Englewood Drive
New Haven, Connecticut 06515

What's New in Minerals?

When is a mineral not a mineral? If copper sulfate pentahydrate forms in nature it is the mineral chalcanthite. Specimens of chalcanthite can be very beautiful, mostly because of its intense blue color. Groups of well-formed crystals are practically unknown in nature. This compound is one of the easiest minerals to synthesize; that is, to grow in the laboratory or at home. Thus it is not surprising to find lovely crystals being sold as chalcanthite by some mineral dealers. There is little doubt that these have been "manufactured" and are not natural. Figure 1 shows a synthetic crystal group measuring about 10 inches from bottom to top. One can accept the selling of this material by mineral dealers, but it is not really fair to the customer to pass them off as mineral specimens. It is not enough for the dealer to admit to their synthetic nature when questioned, the labels should clearly indicate that they are manmade. While one may not care to object to a dealer selling synthetic chalcanthite as long as it is identified as such, one should feel compelled to object to a dealer selling synthetics that will soon deteriorate and fall apart, as will these "chalcanthite" crystal groups. The selling of these unstable specimens to the unsuspecting, for this reason, should therefore be actively discouraged.

Somewhat more difficult to label are the "chalcanthite" crystals that form in flooded mines where the mine waters are rich in copper sulfate. The conditions which led to their growth were created, in part at least, by the mining and it is probably safe to say that the crystals never would have formed if there had been no mining. The same may be said, of course, of a suite of "minerals" formed in a mine fire at Jerome, Arizona and another suite in the smelter slags at Laurium, Greece. There are numerous examples of compounds formed in other than completely natural conditions that have been accepted as mineral species. Perhaps two of the most questionable are the tin "minerals" found on the surface of oxidized tin pannikins dredged from the St. James River in Canada. The pannikins even carried the imprint of their maker on the bottom surface.

Other objectionable practices rumored to occur are the dipping of rocks into copper sulfate solutions (in mines and at home) to produce matrix "chalcanthite" specimens, and the putting of dye into natural brine pools to generate pink halite crystals. On a more sophisticated level I am told that natural-appearing inclusions are now being introduced into synthetic emerald crystals so that they cannot be distinguished from natural crystals. Where will it end?

FLUORITE FROM NAICA

For several years the famous gypsum locality of Naica, Chihuahua, Mexico, has been providing exciting fluorite which should rank with that from Cumberland and Weardale, England; Rosiclare, Illinois; Clay Center, Ohio; and Madoc, Ontario, Canada. These are not to be confused with fine specimens of a dark purple color from Mapimi, Durango and from Santa Eulalia, Chihuahua.

The most characteristic feature of Naica fluorite is the way the specimens are composed of stacked cubes, the edges of which are beveled by the dodecahedron and the points by the octahedron. Particularly nice are the stack-

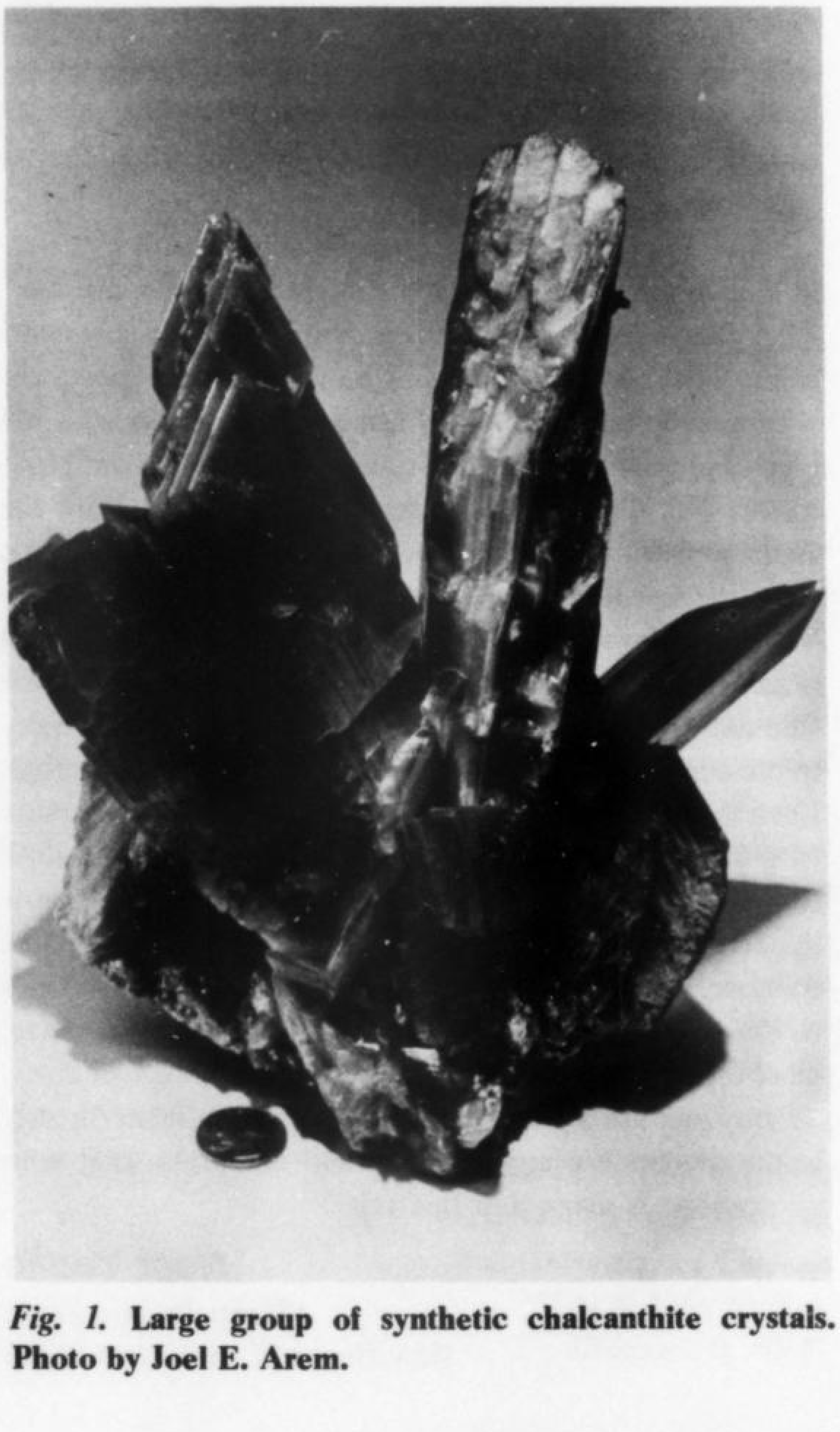


***Fig. 1.* Large group of synthetic chalcanthite crystals. Photo by Joel E. Arem.**

ings of cubes that produce an overall octahedron shape (Fig. 2), resembling closely the pyraminds of Egypt. Others are simple stackings in the direction of one or more cube face normals (Fig. 3). It is easy to see that these habits are related, the octahedra are merely more symmetrical and complex stackings of nearly equal length in each direction.

The commonest colors are very pale lavender and dark purple but all shades between these extremes are known. The pyramid-shaped crystals tend to be colorless and the cubes are usually nearly colorless or dark purple. Some specimens are pale green.

Associated minerals include galena (often with a brilliant metallic luster making it appear highly polished), pyrite, calcite, and black sphalerite. On the basis of habit, color and associated minerals Naica fluorite is relatively easy to recognize.

TENNANTITE–TETRAHEDRITE

In my article about tennantite-tetrahedrite (Volume III, no. 3) I was mistaken about the source of the specimens - I reported that it came from Naica, Chihuahua, which is the locality I have always seen on its labels. Since the article was published I have been informed that the proper locality is El Cobre, Concepcion del Ore, Zacatecas, Mexico. Those of you fortunate enough to have specimens should change your labels as I am sure the newer information is accurate.

From Davis M. Lapham, Pennsylvania Geological Survey, comes the following note:

. . . I am somewhat confused between parts of the text and your electron photographs. From the latter (as published) it seems a distinct possibility that some of the shell material might be described as arsenic-rich tetrahedrite and perhaps even some antimony-rich tennantite. In fact, your preliminary data cast doubt on any stoichiometric tennantite or tetrahedrite. Most of the zones appear to be 'constant-composition zones' as if there were discrete compositional steps rather than a continuous solid-solution series, but of course as you state, there is more work needed. Obviously you have illustrated very well a nomenclatural problem that is bothering the IMA Committee on mineral nomenclature (with respect to other series) and for which there seems to be no easy answer.

I am in complete agreement with these statements. The terms antimony-rich tennantite and arsenic-rich tetrahedrite could have been used in the article and the reader should not have been led to believe that anything approaching pure end-members in the series were encountered. That the composition changes occur in discrete jumps is rather obvious from the photographs but this might have been stated in the text. One further source of confusion was introduced by the printer. Figure 7a was supposed to have been reversed so that it corresponded with figures 7b-e.

"BLANCHARDITE"

A note from Abraham Rosenzweig, University of New Mexico. . .

Having been involved for a number of years in the "blanchardite" controversy, I found your comments in the QA column of the May-June issue very interesting. I heartily agree with most of what you have said, and I wish to commend you for your strong position against the indiscriminate use of unverified mineral names. My one point of disagreement is your statement that "it appears to be a new species". A number of highly competent mineralogists have studied this supposed new mineral, but until now have remained silent. My first encounter with the name was in 1959 when a specimen from the Blanchard claims, near Bingham, New Mexico, was brought to me. The individual stated that it gave a negative test for sulfate, that he thought it was a copper phosphate or arsenate, and that he was suggesting the name "blanchardite". I obtained a positive test for sulfate, and found the optical properties and X-ray diffraction pattern to be identical to those of brochantite. The material consisted of very brilliant, fibrous, green crystals up to half an inch in length. Numerous other specimens of similar material have reached my hands or been available on the market during the past twelve years, and all proved to be brochantite. There are numerous botryoidal and fibrous, blue to white minerals which occur in the same deposit. Most of these have not been identified, but to my knowledge the term "blanchardite" has not been applied to them.

If any of your readers have more specific information about this material, I hope they will come forth. For the time being, however, I must adhere to the viewpoint that "blanchardite" is identical to brochantite.

The following note was received from Peter Embrey, Department of Mineralogy, British Museum (natural History), London: *Some years ago I examined every bit of "blanchardite" that I could lay my hands on. The fibrous green mineral, when it wasn't malachite, always turned*

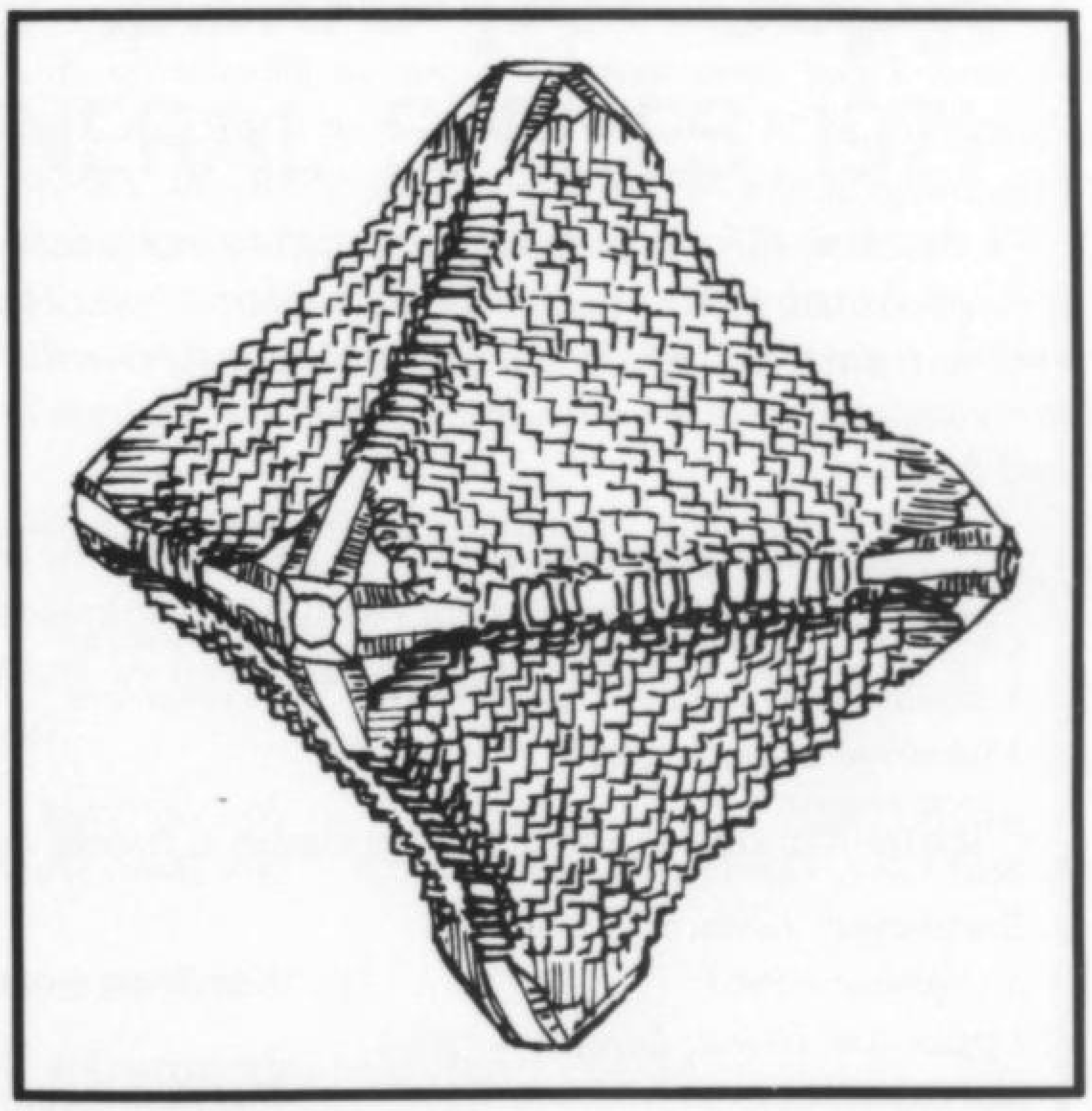


Fig. 2. **Fluorite — Naica, Chihuahua, Mexico. Drawn by Wendell E. Wilson.**

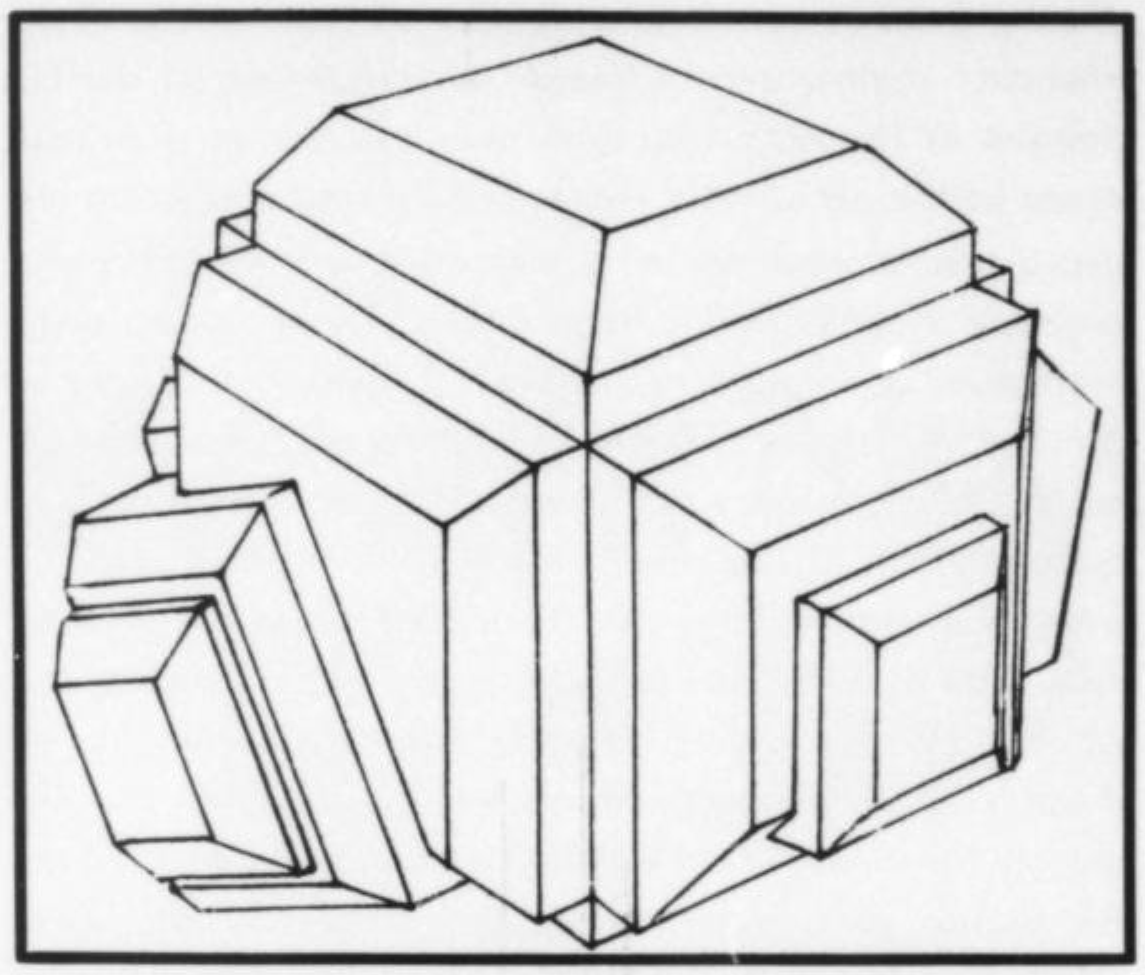


Fig. 3. **Fluorite — Naica, Chihuahua, Mexico. Drawn by Wendell E. Wilson.**

out to be brochantite. As far as I'm concerned, "Blanchardite" is an unnecessary synonym for brochantite.

STILL MORE ON BARYLITE

A note from Roy Kristiansen, P. O. Box 19, N-1652 Torp, Norway . . .

*I'd like to give some information on new findings (*of barylite*) in addition to the localities mentioned in the May/June issue. The crystals are not as large as the Colorado occurrence. First, we have two localities of barylite in Norway:*

1. *In Bratthagen, Lågendal, about 10 km NW of Larvik (town) on the western side of Oslo fjord.*
2. *At Upper Arő Island in Langesundfjord. Further details are given in the rather comprehensive paper by Per Chr. Saebő: "The first occurrences of the rare mineral barylite,* $Be_2BaSi_2O_7$*, in Norway," in* Norsk Geol. Tidsskr. **46,** *335-348, 1966.*

Second, I just came across a paper in Russian by A. F. Efimov, et al: "A new find of barylite in USSR," in Trudy Mineralogicheskii Muzej Akad. Nauk SSSR, **20,** *198-201, 1971. As usual with Russian descriptions, the exact locality is not indicated, but at least it is in the western Urals. The barylite is analysed and the physical and optical properties are compared with barylite from Vishnevye Mountains, and Seal Lake.*

So, altogether the chronological finding of barylite are as follows:

1. Långban, Sweden (1876, etc.)	*Fluorescent*
2. Franklin, New Jersey, USA (1930)	*Fluorescent*
3. Vishnevye Mtn., S. Urals, USSR (1960)	*Not reported*
4. Seal Lake, Labrador, Canada (1962)	*Not fluorescent*
5. Bratthagen, Lågendal, S. Norway (1966)	*Not fluorescent*
6. Upper Arő Island, Langesundfjord, Norway (1966)	*Not fluorescent*
7. Western Urals, USSR (1971)	*Not reported*
8. Park County, Colorado, USA (1972)	*Not fluorescent*

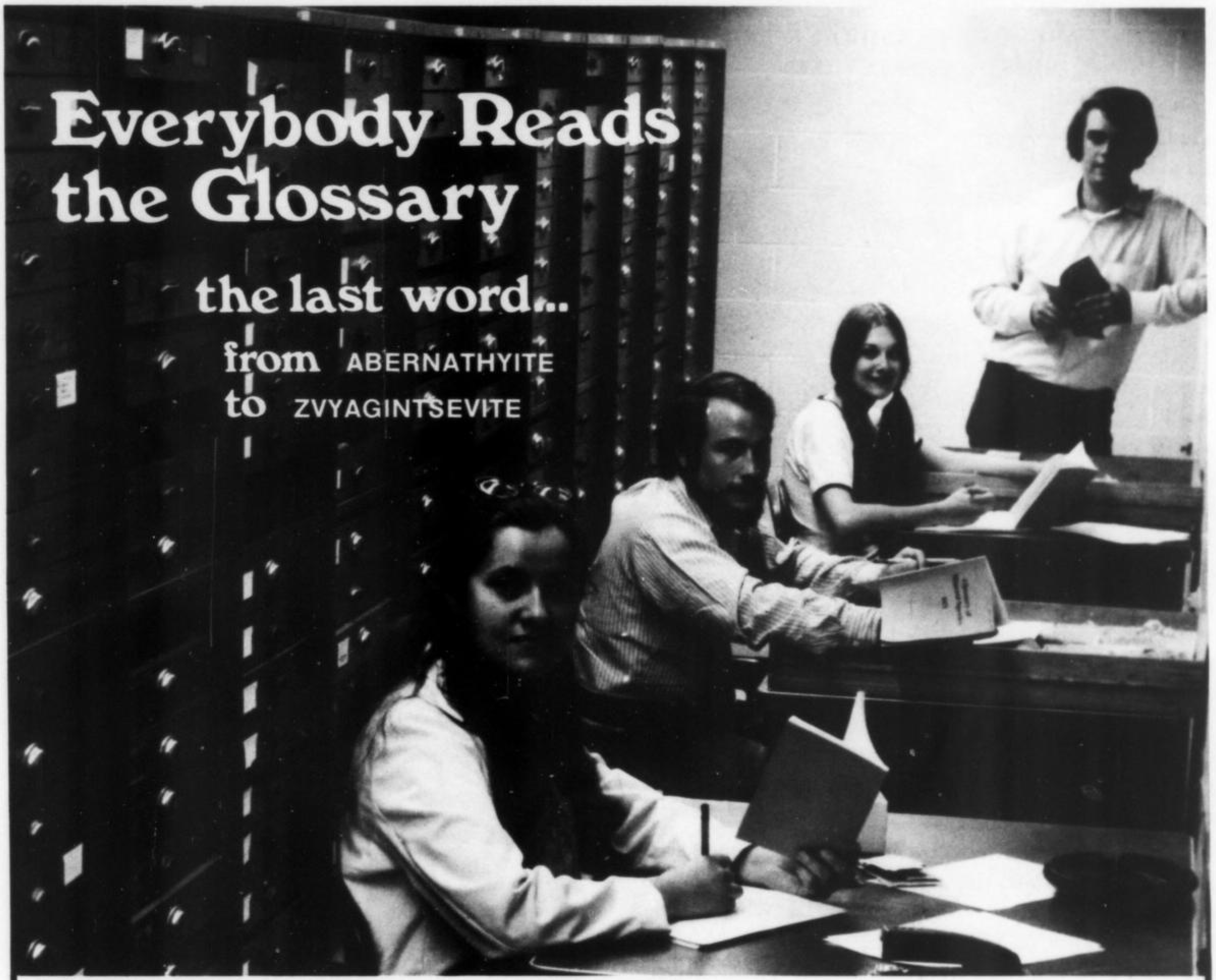
The Långban and Franklin parageneses are closely related, and are different from Seal Lake, Vishnevye Mtn., Norwegian localities and perhaps from the western Ural locality, and these deposits show also some general relationship in their mineralogic and genetic features. The Colorado occurrence seems to be unique compared with the other known deposits of barylite.

MINERALS IN OHIO

A note from Henry H. Fisher, 4636 Dundee Avenue, Columbus, Ohio 43227 . . .

Ohio has long been known for producing fine specimens of fluorite and celestite. Unfortunately, this has become a thing of the past. At present there is only one quarry, the Pugh quarry, in the entire state that is open for mineral collecting. The great names of the past: Woodville, Gibsonburg, Clay Center, Lime City, etc., are "dead" as far as entry for collecting is concerned. If anyone knows of a good quarry still open in Ohio, please let the writer know.

JSW,JR.


Everybody Reads the Glossary
the last word...
from ABERNATHYITE
to ZVYAGINTSEVITE

WALTER F. FERRIER AND THE FERRIER MINERAL COLLECTIONS

Walter F. Ferrier, a geologist and mining engineer who graduated from McGill University in 1887, collected thousands of excellent mineral specimens which enrich several of the important mineral collections in North America today (Fig. 1). It was largely due to Dr. Ferrier's efforts that priceless specimens from the early days of mining and field work in Canada were preserved and kept available for current and future reference and research.

Minerals interested Ferrier keenly even when he was a very young boy, and he was admitted to the Mineral Section of the Natural History Society of Montreal at the age of nine. While still a student, he carried on correspondence and exchange of specimens with some of the most eminent mineralogists of the time, and built the foundation for an outstanding private collection.

After graduation from McGill, he took postgraduate studies at Heidelberg, Germany, and returned to become Geologist for the State of New Jersey. The zinc mines of the Franklin area were very productive mineral localities at the time, and among the most avid collectors was the inventor, Thomas A. Edison, who wrote the young geologist in 1890: "I am very pleased with the thorough work you have done in connection with the arrangement of my Mineral cabinet."

At this time Ferrier also became well acquainted with Dr. George F. Kunz, the distinguished mineralogist and consultant to Tiffany, the New York jeweler. When Ferrier became engaged to Miss Josephine Holt, he asked Dr. Kunz to pick out "the whitest diamond Tiffany's has" that would be within the limits of a young man's budget.

From 1891 to 1898 he served as Lithologist with the Geological Survey of Canada. In the course of his Survey work, Ferrier made the first discovery of commercial deposits of corundum in Canada in the Hastings district of Ontario, and rightly predicted that these deposits were of great economic value and would become the basis of an important Canadian mining industry.

After his government service he embarked on a career as mining engineer and consultant (Fig. 2) which enabled him to add much to his mineral collection. His daughter, Miss Dorothy Ferrier, recalls that her father's enthusiasm for mineral collecting caused their home in Ottawa to be crowded with mineral cabinets: "There were two of them in the nursery on which I frequently barked my shins and even one on the landing of the stairs." Although Ferrier was reluctant to part with his specimens, the great size of the collection made it impractical to retain it in a private home, and in 1912 he agreed to set up the systematic collection for the University of Toronto which consisted of some 3,600 Ferrier specimens. This was registered into the Royal Ontario Museum in 1913, and formed the nucleus from which their present collection grew. Shortly thereafter a somewhat similar collection was acquired by McGill University and installed during 1913 and 1914 by Dr. Ferrier and Professor R. P. D. Graham. The McGill collection numbered over 7,000 specimens (Fig. 3).

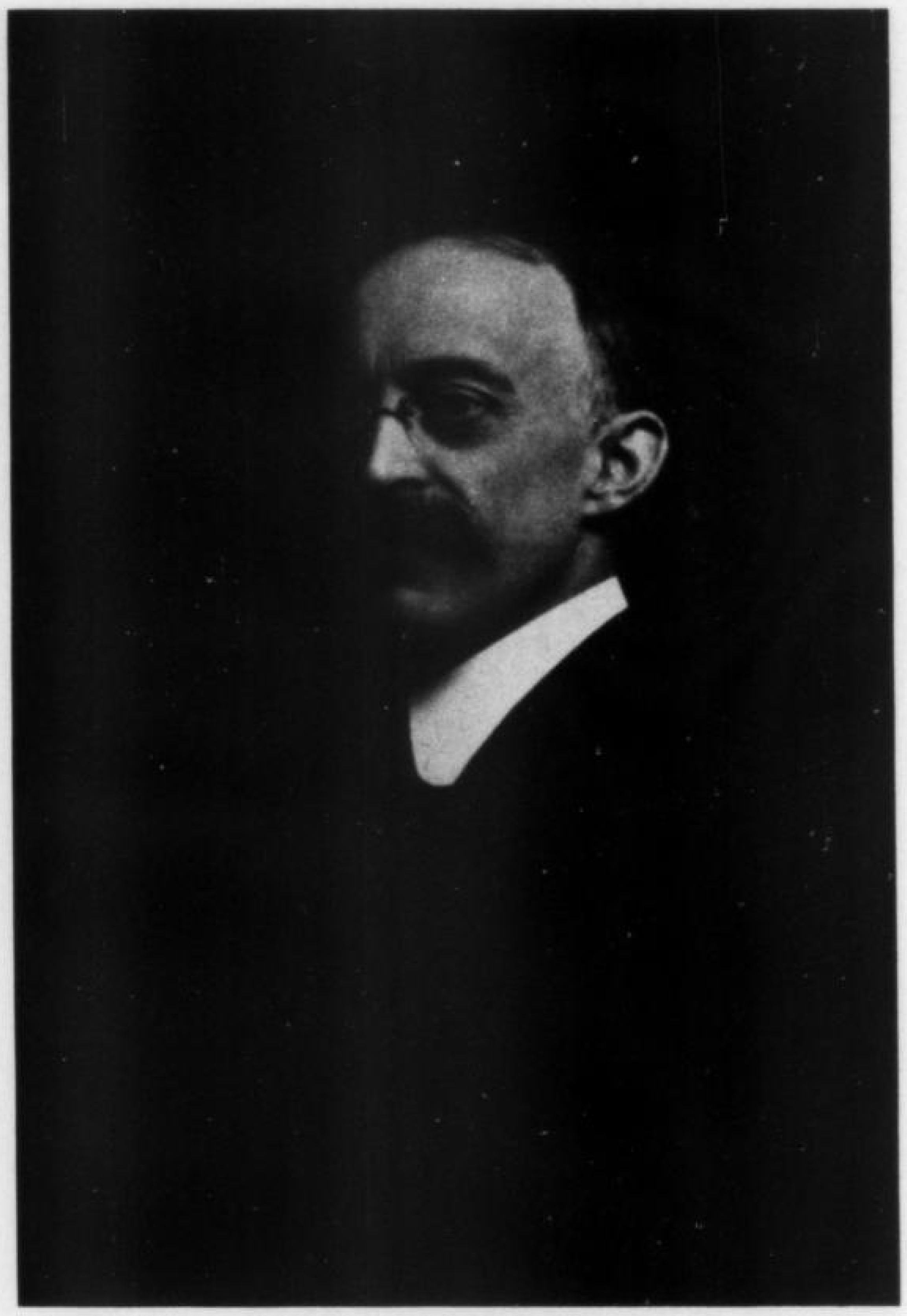


Fig. 1. **Walter F. Ferrier (1865-1950).**

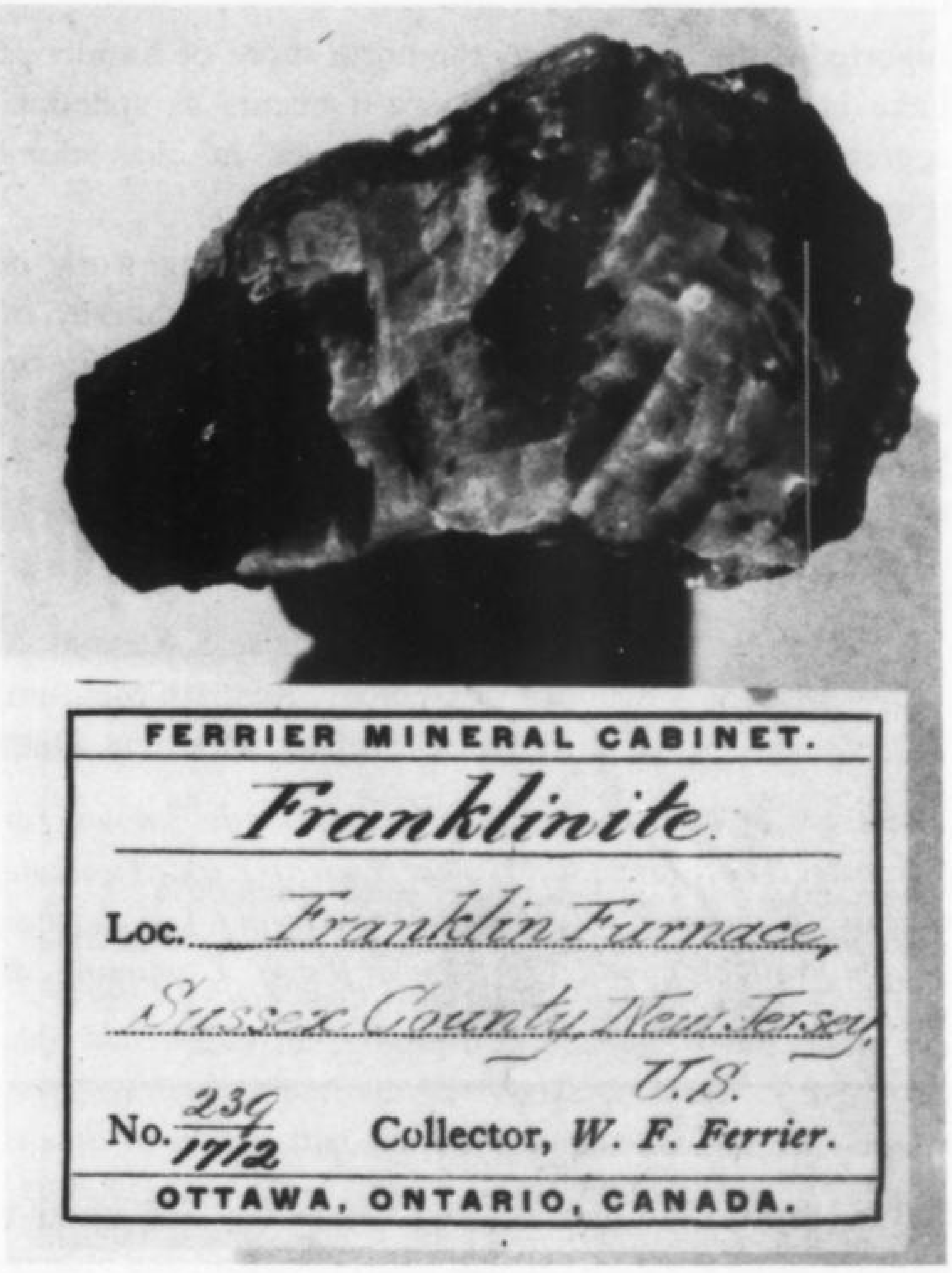
Also during this period Dr. Ferrier corresponded with other important collectors of the time, and a number of specimens collected by him were acquired by Colonel Washington A. Roebling through exchange and purchase. These were sent to Washington, D.C. to the National Museum of Natural History (Smithsonian Institution) in 1926, shortly after Roebling's death. The histories of the specimens in the Roebling collection were not detailed, so that it is not possible to know how many Ferrier specimens are now incorporated in that collection. However, Dr. George Switzer, of the Department of Mineral Sciences, has recently reported working with a Roebling specimen of calaverite which still had its original Ferrier label, an example of the acquisition that must have taken place.

Several hundred Ferrier specimens, chiefly from Canadian localities, are now incorporated in the Harvard University Mineralogical Museum collection. These were either donated or purchased by Professor Charles Palache. Both Professor Palache and Dr. Ferrier were particularly interested in fine crystal specimens showing excellent or rare crystal faces.

Dr. Ferrier was commissioned to acquire and arrange two large collections, that of the University of Alberta

Fig. 2. **Dr. Ferrier on a field trip, Peace River, Canada.**

in Edmonton, 1914-1915, and that of the Museum of Mineralogy and Economic Geology of the University of Manitoba in Winnipeg, 1921-1922. Several years later Professor J. A. Allen of the University of Alberta wrote to a friend recalling his work with Dr. Ferrier: "We traveled through the eastern U.S.A. as far as Washington, and I had to admire the way this man could talk a mining president or manager or university into donating one mineral specimen or a collection to a new struggling university museum in Edmonton." For the Winnipeg museum, personal contacts were also useful. Donations included specimens from the Brush collection of Yale University "through the kindness of Professor W. E. Ford", a large collection of "fine and rare specimens" from Frank L. Nason of West Haven, Connecticut, and contributions from "the Guggenheim brothers, who have forwarded fine ore samples and crystallized minerals from their properties in north and south America."



FERRIER MINERAL CABINET.

Franklinite.

Loc. Franklin Furnace, Sussex County New Jersey, U.S.

No. $\frac{239}{1712}$ Collector, *W. F. Ferrier.*

OTTAWA, ONTARIO, CANADA.

Fig. 3. **Franklinite, Franklin Furnace, New Jersey, with original lable. Redpath Museum No. F1712. (X 1)**

During World War I Ferrier was engaged by the Munitions Resources Commission of the Canadian government to explore the possibilities of finding strategic minerals to overcome wartime shortages. In the course of this field work he discovered the rare zeolite mineral which was named in his honour by Professor Graham of McGill University. The presence of almost 3 per cent magnesia in ferrierite makes it unusual among the zeolites. Even today, the only locality from which ferrierite has been

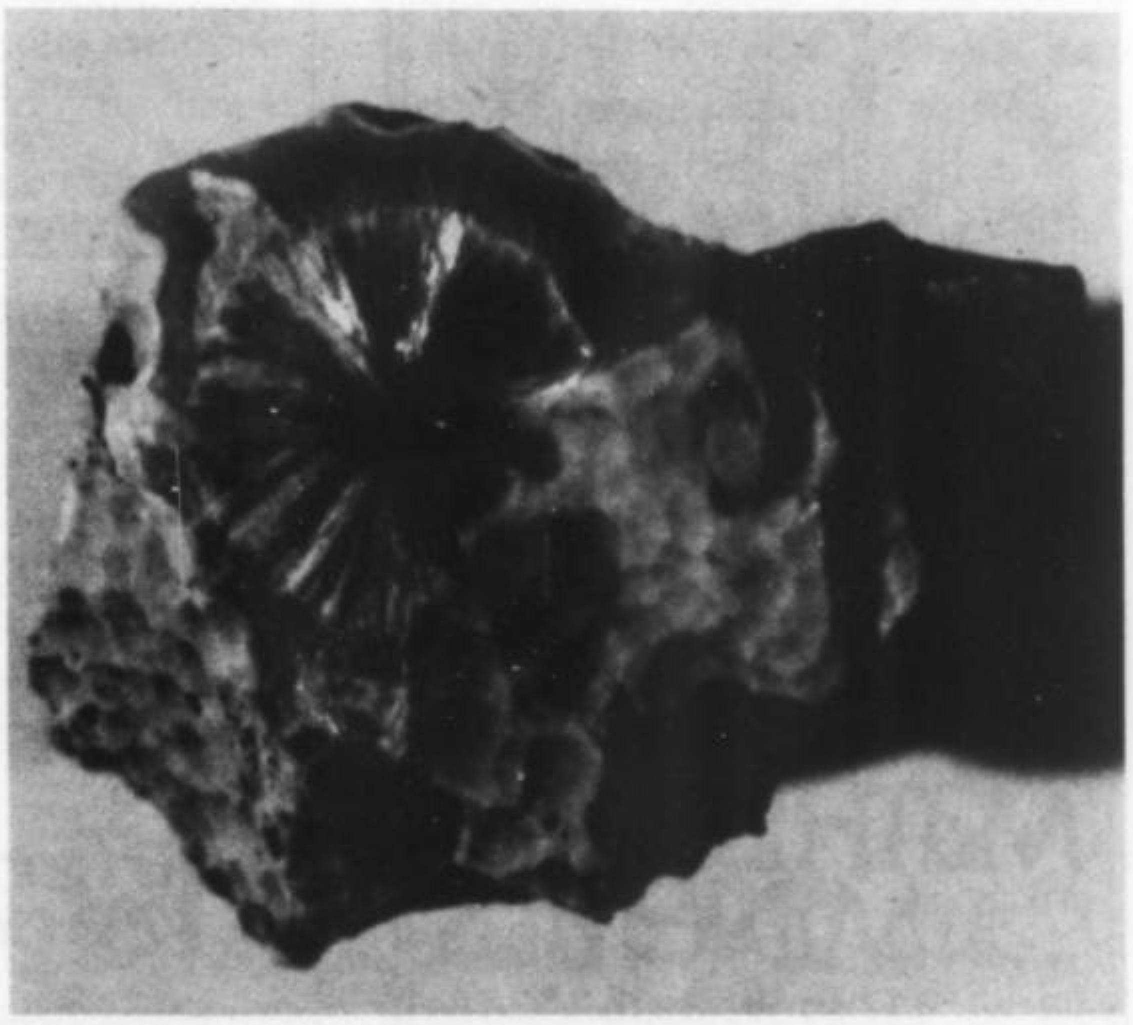


Fig. 4. **Ferrierite, Kamloops Lake, British Columbia. Redpath Museum No. F3909. (X 2)**

reported is the original site, the north shore of Kamloops Lake in British Columbia, where it occurs as spherical aggregates of radiating blades enclosed in chalcedony (Fig. 4).

Although he retired from active consulting work in 1925, Dr. Ferrier returned to the Geological Survey of Canada between 1925 and 1928 to assist Dr. Eugene Poitevin as special adviser in revising and rearranging the National Mineral Collection. He carried out this final task with keen interest and according to the very high standards that characterize Ferrier collections.

Louise S. Stevenson
Curator of Geology, Redpath Museum
McGill University, Montreal, Que.

There are at least three other localities now known for ferrierite. These include (1) near Leavitt Park, Tuolume County, California, (2) Agoura, California (no further details available), and (3) Albero Basso, Commune di Santorso, Vicenza, Italy. Ed.

Museum Record, continued from page 196

and his profit. The time lag and the money tied up and transportation costs, etc. all add to his overhead and reduce the profit he may eventually realize. Why should he bother! If the exchange can be made monetarily lopsided so that he can cover the increased overhead he will at least be back where he started. In some cases a feeling of obligation or good will toward the museum may be sufficient additional reward to get things going. If not, then the trade must be made even more lopsided monetarily. Sharp judgement is necessary for the curator to know how far he can afford to unbalance the scales without detriment to the collection. Some curators shy away from this "wholesale for retail" sort of exchange with dealers because they feel it is like giving away money. Usually they forget that the greater portion of the specimens in their collections they got for nothing and they are thus disposing of nothing — acquiring something the collection needs.

Ideally, as I see it, a well managed exchange program will convert as rapidly as possible any accumulation of specimens of little forseeable use into an incoming flow of specimens of various species, localities, etc. nor represented in the collection. This means that the curator must know his collection and have a good idea what must be saved and what is needed. How many specimens of the same thing from the same place — all excellent — must he hold to have a fine representative sample? All others must be converted to new specimens quickly. Why quickly? It is a matter of economics. Exchanging is just another name for bartering and the specimens themselves are bartering capital. In any kind of business there is something unhealthy about capital sitting idle. The profits of a business are those dividends, in whatever form, which result from the employment of capital. The more this capital can be turned over in a given period of time the higher the profits. In the mineral museum business the profit from motion of specimen capital is the flow of new and desirable specimens into the collection. Once there, these specimens are fixed only until the time they are joined by something better when they once more become part of the working capital.

Unfortunately, most mineral collection curators are heavily burdened with a multitude of other duties so that there is little time to approach this kind of capital investment seriously even when they have the authority. Perhaps this explains quite clearly why most museum mineral collections, not having cash to work with, don't change or improve very much through the years.

WHAT'S IN A NAME; MAC VS. MC IN MINERAL NAMES

*by Michael Fleischer**

*** Publication authorized by the Director, U.S. Geological Survey**

Since it was formed in 1959, the Commission on New Minerals and Mineral Names of the International Mineralogical Association has tried to obtain international agreement on a single name for mineral species for which two or more names have been in general use. It has had some success (a list is given in *Mineralog. Mag.* **38,** 104 (1971), but quite a few problems remain undecided, for example allanite-orthite, kyanite-disthene, stibnite-antimonite, and merrillite-whitlockite (the last has been discussed by Brian Mason, *Mineralog. Record,* **2,** 277-279 (1971).

The Commission has also, on numerous occasions, been successful in persuading persons proposing new names to abandon, before publication, names so similar in spelling or pronunciation to existing names that confusion would surely have resulted.

The Commission has also tried, with less success, to obtain international agreement on the spelling of mineral names. Such attempts must fail when the structure of a language forbids them, for example sphalerite-esfalerita (Spanish) or halite-galite (Russian). The present note discusses the Commission's ten-year attempt just abandoned, to have names for persons named Mc— or Mac— uniformly spelled Mac—.

This began in 1950 when M. H. Hey in his *Chemical Index of Minerals* used the spelling Macgovernite in place of McGovernite, named in 1927 by Palache and Bauer. In 1963 the Commission was asked by the authors of a proposed new mineral, to be named for J. F. McAllister, whether the name should be spelled mcallisterite or macallisterite.

Dr. Hey, representative of Great Britain, and Dr. Duncan McConnell, representative of the United States, urged that the Commission require all such names to be spelled "mac—". Reasons given included the difficulty of pronunciation and of spelling, difficulty of transliteration into non-Latin alphabets, and difficulty of indexing (some indexes place "mc" as spelled, others place it as though it is spelled "mac—". It was also pointed out that biologists had long ago adopted the rule that names spelled "mc" were to be changed to "mac".

The arguments were persuasive and the Commission voted 12 for macallisterite, 1 for mcallisterite. At the time, I wrote to McAllister, regretting that the mineral named for him would not conform in spelling to his name and suggesting that perhaps he would consider changing his name to match that of the mineral. He replied that the authors of the paper describing macallisterite were Schaller, Vlisidis, and Mrose; if the latter two would change their names to Valisidis and Marose, he would consider the proposal. Regrettably neither Mrs. Vlisidis nor Miss Mrose was willing to cooperate in this worthy project.

The question was raised again on three occasions; in each case the Commission was informed that the namer of the mineral desired to use the unaltered "mc" form. Nevertheless, the Commission voted in 1964, 9 for mackelveyite, 4 for mckelveyite (named for V. E. McKelvey); in 1966, 7 for mackinstryite, 4 for mckinstryite (named for H. E. McKinstry); in 1967, 14 for macconnellite, 4 for mcconnellite (named for R. B. McConnell).

Thus the problem seemed to have been settled. Actually however, it had not been. It should be remembered that the Commission cannot enforce its rulings, but must rely on their acceptance by the mineralogical community. Although the "mac"spelling was accepted by most, there were notable dissenters, including Professor Hugo Strunz in his *Mineralogische Tabellen,* Professor Brian Skinner (editor of *Economic Geology,* who had named mckinstryite), and Dr. Charles Milton of George Washington University (who named mckelveyite and mcconnellite).

In late 1971, Dr. Milton asked the Commission for a new vote. He considered the difficulties of pronunciation, transliteration, and indexing to be minor, and wrote:

> "A man's name is his peculiar possession, in which he should take pride, and which should demand respect. It is morally wrong to tamper with it. When society seeks to humiliate a man, as in a prison, it unnames him and designates him as a number. A poet once wrote: '.....he who filches from me my good name, Robs me of that which not enriches him, But leaves me poor indeed.'

Each of the four minerals mentioned above was named to honor an individual, and changing the name, for whatever alleged reason, negates and denies this act of honor. I therefore request that the Commission reconsider and rescind its previous rulings."

Whether moved by this eloquence or influenced by the fact that Dr. Hey had changed his mind, the Commission voted on Jan. 10, 1972, by a vote of 13-6 that for these four minerals and presumably for mcgovernite and for the future that mineral names shall be named "mc—" or "mac—", as spelled by the person for whom the minerals was named.

Professor Duncan McConnell of Ohio State University then requested the Commission to reconsider. He pointed out that changing "mc" to "mac" (Scottish for 'son of') is not an alteration or change of anybody's "good name", but is merely an abbreviation or contraction in an effort to obtain something that can be pronounced, transliterated, and indexed. In Cyrillic, *mc* becomes Mk and both *mcc* and *mck* become MKK, which cannot be pronounced, so that in all Slavic languages, both become MAK.

The Commission voted in July, 1972, by the narrow margin of 8-7 with 1 abstention, to confirm its vote of January, 1972.

The Commission has been very reluctant to change established mineral names and presumably will not do so, but one may speculate as to whether the principle underlying this latest vote will be applied rigorously to names proposed in the future. Must we spell the mineral name exactly like the name of the person honored? For example, consider the following queries, none of which as yet has been considered by the Commission:

Must we retain capitalization in the middle of a name, as mcKelveyite rather than mckelveyite?

Accents and diacritical marks have generally not been used in mineral names. Must we write roméite, not romeite?

Will it be permissible in the future to alter a person's name (a) by dropping a final e (curite, goethite), a final a (tavorite), a final o (domeykite), a final y (jouravskite), final ing (witherite), final an (fersmite); (b) by adding l for euphony (bandylite, derbylite, cesarolite); (c) drastically as in berzeliite and berzelianite (for Berzelius), descloizite (for Des Cloizeaux), fornacite (for Fourneau)?

Should the Commission continue to approve the growing tendency to combine first and last names (henritermierite, joesmithite, julgoldite, djerfisherite, tombarthite, etc.)?

Should the Commission continue to approve names for two or more persons (reedmergnerite, ludlockite, armalcolite)?

Should the Commission continue to approve names whose connection with the person being honored is far from apparent (pavonite for M. A. Peacock, stenhuggarite for Brian Mason, twinnite for R. M. Thompson, ludlockite for Frederick Ludlow Smith III and Charles Locke Key?

CERUSSITE — Tsumeb, Southwest Africa. A pair of unusually large clear, colorless to slightly "smoky" crystals in the mineral collection of the Royal Ontario Museum in Toronto, Canada. The left crystal measures 4" x 4" x 1/2" and the right 4"x 3" x 1". It carries the ROM number M28761.

To the Editor

REQUIRED READING

Dear Sir:

Please send (my subscription) as soon as possible, it (the *Mineralogical Record*) is required for courses here.

James F. Young
Concord, New Hampshire

OOPS!

Dear Sir:

The comments about species collectors (Vol. III, no. 3) by Mr. Minette and the editorial reply brought out several points concerning the availability of mineral specimens for research. Mr. Minette has suggested that museums too often become places for hoarding specimens which, "tends to retard research rather than advance it." In reply, the editorial suggests that the role of a mineral museum is specimen preservation and support of research, both functions which are better accomplished by a museum. The editorial question, "Would... these collectors...be willing to give up their specimens for research without compensation", implies that it is really the private collector who is guilty of hoarding rather than the museum.

My personal experience with the two sides of this argument would seem to contradict this conclusion. I recently made a request, published in the *Mineralogical Record* (Vol. III, no. 1), for mineral specimens, needed to complete thesis work for an M.S. degree in geology. The response to this request is as follows.

Total specimens received	40
Total from private collectors	28
Total from museums	12
Number respondents, collectors	6
Number respondents, museums	1

In this one example, the generosity of private mineral collectors is apparent. The one museum respondent was the British Museum of Natural History, with a very generous gift of twelve specimens. My experience with our own National Museum was very disappointing. I have made three separate requests for the loan of research material from the Smithsonian. Each request has gone unanswered. Since one of these requests was in the form of a personal contact with the museum collection curator, I doubt that the quality of mail service is to be blamed.

The thesis of your "Species Collector" editorial is a good one, "specimen preservation and support of research", however, it would be welcomed if our museums practiced a little more support of research and a little less preservation.

Thomas D. Palmer
Livermore, California

As the editor of the MR I am absolutely delighted at the response to your appeal for research specimens generated by our "Specimen Requests" column. It is most reassuring. As a Smithsonian employee I am embar-

rassed at the difficulty you have had in obtaining specimens from the Institution. It was an oversight, plain and simple, and will have been corrected by the time your letter appears in print. One need only glance at the acknowledgements in the literature to see that we don't miss many requests, but now and then a request gets neglected in the rush. Two other points in your letter should be commented upon. I did not intend to imply, in my response to Mr. Minette's letter, that "the private collector... is guilty of hoarding." Rather I can readily understand why a collector with limited resources and little depth, if any, in most species would be reluctant to part with his specimens for research. I feel that hoarding is a poor word for this attitude. Your letter also suggests that my remarks were in reference to all museums. Actually I was referring only to major museums, particularly national museums, as most smaller museums do not systematically accumulate reference material with support of research as an objective. Ed.

Dear Sir:

The give-and-take between James Minette and the editor in the May/June issue is very well worthwhile. If the *Mineralogical Record* does nothing more than illuminate the discussion of concentration versus dispersal of mineral collections — and, in a broader sense, of exhibits in general — it may justify its entire existence.

Basically, of course, the difference is not a matter of logic or truth but one of temperament and personality. As Gilbert and Sullivan sang, "Every boy and every gal, That's born into the world alive, Is either a little Liberal, or else a little Conservative." The optimist sees the bottle as half full, while the pessimist sees it as half empty. And in scientific classification we have "the lumpers and the splitters."

Some years ago, in support of the concept of presidential libraries, Herbert Hoover spoke of the advantages to be gained by distributing archives around the country. Soon afterward, I saw a collection of Smithsonian art in the western museum at Cody, Wyoming, surely the finest thing in that state outside of Yellowstone itself. We were told that this splendid exhibit was actually surplus at Washington, where there had been no room to show it.

I wanted to help encourage more of this sort of dispersal — think what it would do for the states losing population and needing tourists — but I had no means of taking on another project. And I am not sure how practicable it would be in terms of cost, maintenance, safety, and other factors. I don't believe that the extent of cooperation in science, referred to, fundamentally depends on whether we emphasize concentration or dispersal. Modern communication and transportation make either possible. We cannot know what will remain of man's present artifacts and treasures a thousand years from now, and so discussing the effects of war and destruction is perhaps futile.

Please accept my encouragement to expand this discussion to cover every angle. We shall all benefit.

Richard M. Pearl
Colorado Springs, Colorado

THE GLOSSARY

Dear Sir:

You are to be complimented on your publication *Glossary of Mineral Species 1971*, by Michael Fleischer. Now, with the revisions and additions published in Vol. III, no.3, it is the most complete reference of its kind available and I have found it useful in many ways. Here is one collector who wants you to know that your efforts to serve the collector are very much appreciated.

Harvey Wentworth
Minneapolis, Minnesota

TENNANTITE–TETRAHEDRITE

Dear Sir:

I enjoyed your article on the tennantite-tetrahedrite in the last issue of the *Mineralogical Record.* I had bought quite a bit of that material when it first came out and I believe it is coming from the El Cobre mine in Concepcion del Oro, Zacatecas, Mexico. You might have already heard all this from somebody else, but it generally is important to keep these Mexican localities straight, because usually there is very little information available.

Richard Kosnar
Aurora, Colorado

We certainly agree with the importance of correct locality data and we regret the use of the incorrect locality for this material in the article in Vol. III, no. 3. Thank you for being one of two readers who picked up this mistake. Ed.

SELLING OF CATALOGUES

Dear Sir:

I would be grateful if you would permit me to reply to Roger Harker's letter(*MR*, Vol. III, No. 3) concerning the "sin" of offering the catalogue to the Northumberland Collection as a separate lot in the July 1968 Sotheby's Auction. For obvious reasons this col-

In the next issue ...

COLOR photographs inside the magazine for the first time. Two articles about the 79 mine in Arizona.

lection had to be split up into lots for the Sale. The Manuscript catalogue was freely available for inspection before the Sale. It could only have been offered as a lot on its own. Does Mr. Harker propose that we should have included it with one of the other lots and if so which one? Perhaps he would suggest it should not have been sold and in which case what should have been done with it?

Brian Lloyd
Sotheby's Belgravia
London, England

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION

(Act of August 12, 1970: Section 3685. Title 39. United States Code):

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10. Not applicable.
11. Extent and nature of circulation:

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a) Total No. Copies Printed (Net Press Run)	4,833	5,000
b) Paid Circulation		
1. Sales through dealers and carriers, street vendors and counter sales	245	263
2. Mail subscriptions	2,904	3,087
c) Total Paid Circulation	3,149	3,350
d) Free Distribution by Mail, Carrier or other means	150	135
e) Total Distribution (Sums of c and d)	3,299	3,485
f) Office Use, Left-over, Unaccounted, Spoiled after Printing	1,534	1,515
g) Total (Sum of e and f — should equal net press run shown in a)	4,833	5,000

I certify that the statements made by me above are correct and complete.

JOHN S. WHITE, JR.
Publisher

MINERALS of PEDIGREE?

For seventeen years, I have lived totally in the business of dealing *only* in quality mineral specimens. That means, without any reservation of any kind, that my entire livelihood has been earned in acquiring and selling specimens of unusual form and beauty, and often considerable rarity. With all respect to the many valued friends and colleagues who, for one reason or another, have been part-time mineral dealers, all *my* time has been devoted to ferreting out remarkable collections, or unusual single specimens, for which I have been willing — and *still* am eager — to pay premium prices.

Frankly, there have been occasions when it has been tempting to broaden my activity. Fortunately, with the continued demand for the finest, I have been able to resist that temptation. The result has been a growing reputation for the superb and — I take pride in this — also for the unusual.

Every mineral still has a special enchantment for me. However, I buy only the finest obtainable and thus handle only the finest. I have guided new collectors in the forming of splendid small collections, and I have helped to make large collections, private and public, more distinguished through the acquisition of remarkable specimens.

That does not mean that I offer only very expensive specimens. Bringing to bear the expertise of these 17 years — and because I often buy large collections for the sake of garnering a few beauties or rarities — I frequently have available a wide range of splendid specimens that I can afford to "let go" at surprisingly reasonable prices.

Therefore, I invite you to write for my most recent list of offerings. You will see there described specimens of great pedigree that, compared to run-of-the-mill specimens, are admittedly expensive. But you will also find many specimens of notable quality that may surprise you by their comparative reasonableness. Always *my* specimens will be the top quality in their price range.

Quality! If you have progressed sufficiently in your collecting to appreciate that, you may find an inquiry to me most rewarding.

One more word: any fine mineral specimen purchased from me at any time I am ready to buy back for whatever the current rising market will command.

* * *

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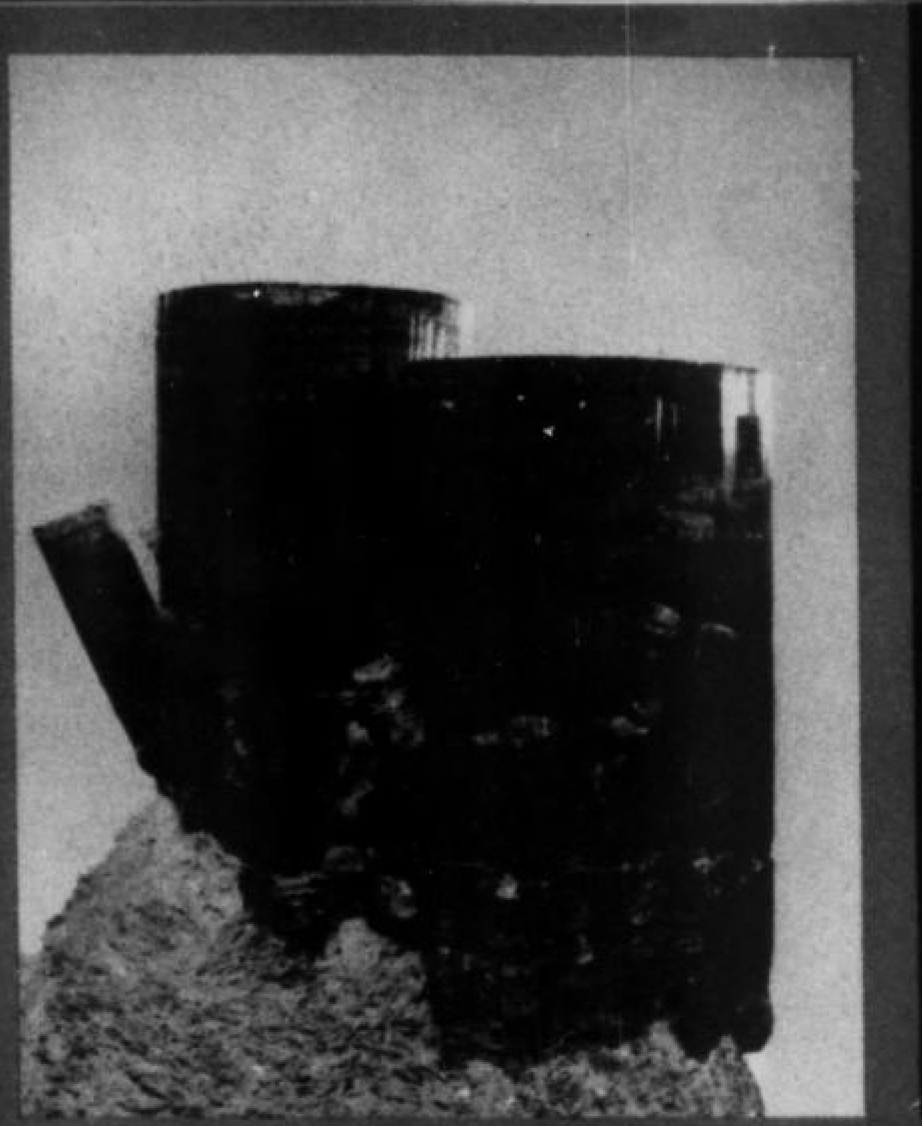

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