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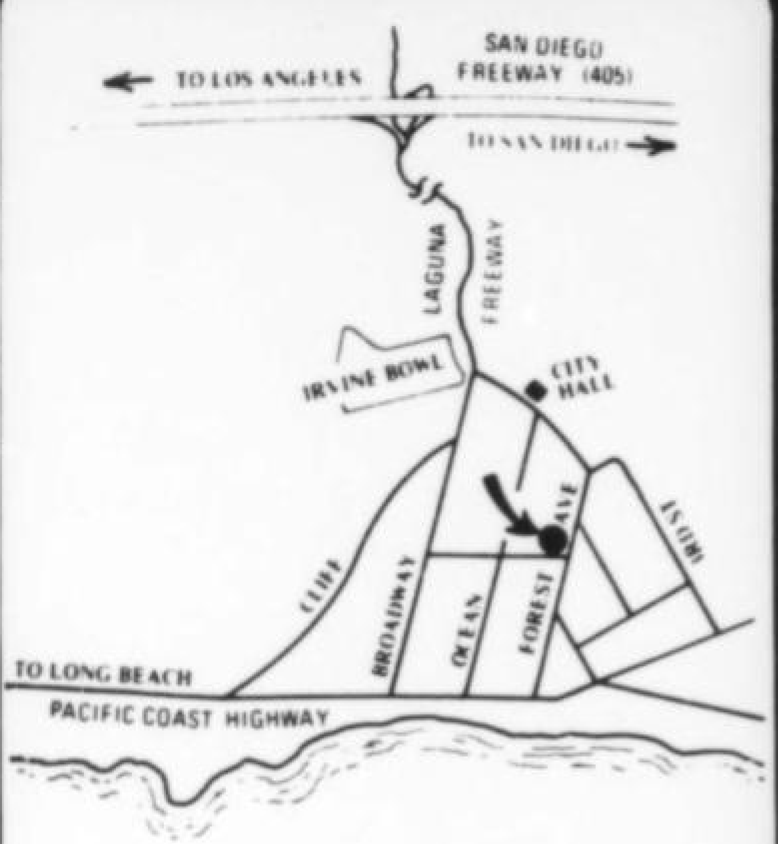

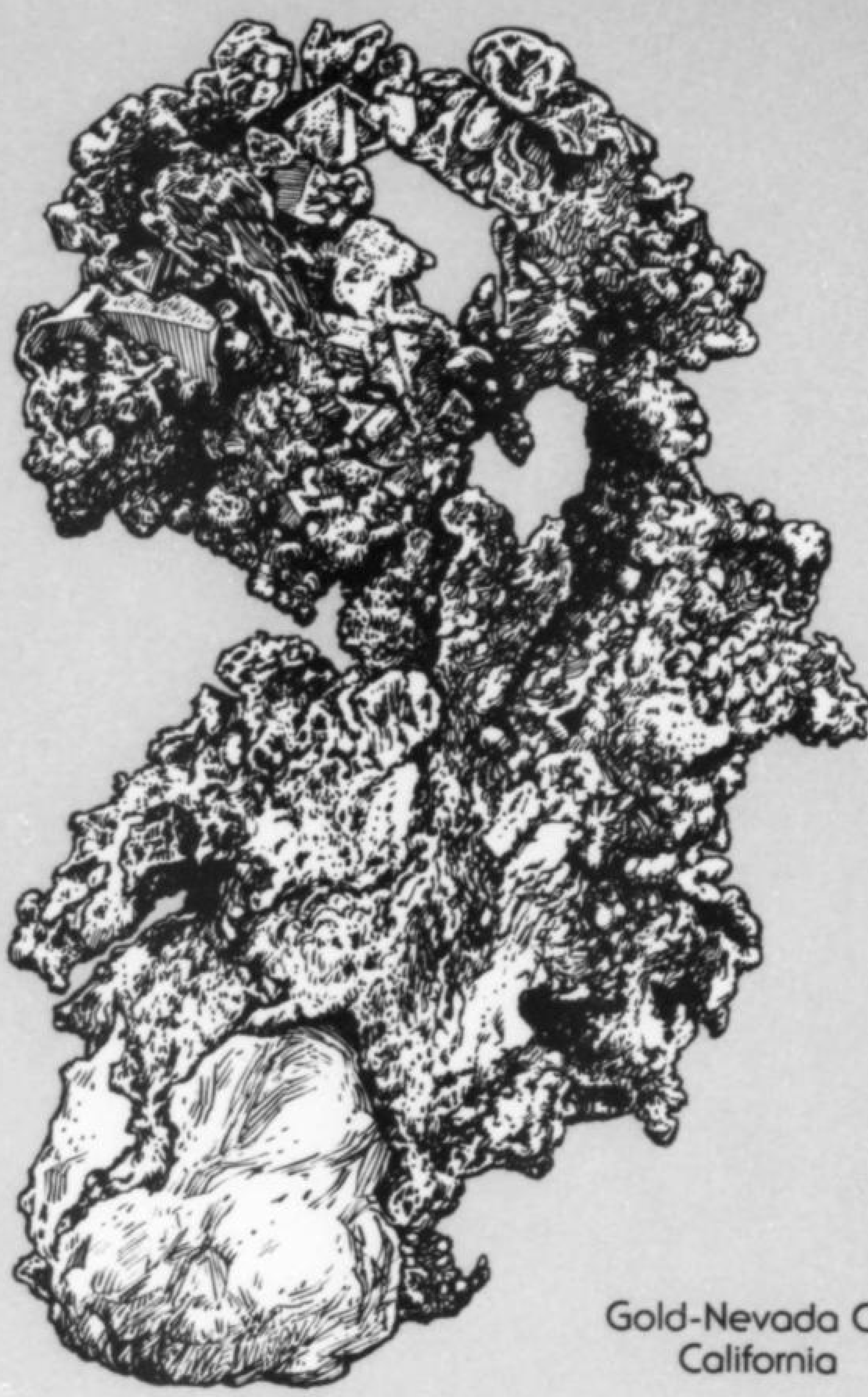

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the Mineralogical Record

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Volume Eleven, Number Two
March-April 1980

Articles

Departments

COVER: GOLD from the Eureka mine, Tuolumne County, California. This specimen, about 7 inches tall, weighs 1 pound (454.7 g) and has been nicknamed "the seaweed." Smithsonian collection; photo by Dane Penland.

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GUEST EDITORIAL

ELUSIVE MINERALS

"Mineralogists tiring of doing mineral dealers' homework" might be a more apt title for this, and perhaps closer to the point. We three, at least, are becoming a little exasperated by the extra work that is being forced upon us by commercial mineral dealers who, from time to time, supply specimens purported to contain rare minerals which elude recognition in spite of careful and reasonable examination and comparison with published and unpublished data.

Here at the Geological Survey of Canada, as at most institutions maintaining large collections of minerals, the identity of all new acquisitions is routinely established before cataloging. The method normally used is X-ray diffraction whereby a little of the powdered mineral is exposed to a beam of X-rays, which, upon diffraction, produces a characteristic pattern of lines on a photographic film. This takes time. The mineral, or what appears to be the mineral, must first be located in the specimen, then removed, ground and mounted in the camera; and the resulting film developed, measured and compared with published data. If the first mount proves to be a different mineral than expected, a second mount is normally made of some other likely prospect, and possibly even a third. In extreme cases examination with the electron probe and scanning electron microscope may be undertaken. If on commercially-acquired specimens all this is to no avail the specimens must be repacked and returned to the supplier. Multiply the foregoing by several specimens a month and you can appreciate the cost (normally to the public purse but which perhaps should be charged back to the dealer), the time lost and the unnecessary frustration of it all.

The question naturally arises: "Where does the responsibility for this problem of identification lie?" In all fairness it lies partly with the purchaser. Certainly, in our case some unquestionably sound minerals have eluded identification, mainly because of their fine-grained nature or similarity to associated minerals. Recognition might ultimately be possible but could constitute a minor research project for which we do not have the time. Such specimens may be retained in special instances but are more often returned with the prospect of eventually securing better material, or enabling us to put our modest budget to work elsewhere. The responsibility, however, is attributable mainly to the dealers themselves. They are selling the specimens and they are the ones who must guarantee their product.

Admittedly, dealers are not normally equipped with X-ray diffraction or other esoteric equipment to carry out the necessary confirmations, nor can they go to the time or expense of having every specimen checked by a consulting laboratory without passing the cost along. However, in lot purchases or doubtful cases they could have selected specimens examined, at least to the point where they themselves are sufficiently familiar with the mineral to be able to sell it with confidence and to preclude unnecessary replacements or refunds. If the minerals are not obvious on the specimens then they should be clearly marked with small arrows, or sketched in sufficient detail that their recognition should present no real problem. Obviously the dealer who is not also a collector must rely on his experience and on his supplier, from whom he should demand the same guarantee of identity and markings. Dealers must not, however, act simply as outlets for their suppliers and use them as a cover when things go awry. Dealers have a responsibility to themselves and their customers to be certain of material which passes through their hands.

This is not a blanket criticism of dealers. They are a hard-working, dedicated group who provide a marvelous service that collectors and collections could not do without. Rather it is a plea for them to exercise a little more care with new and rare species, to be certain of what they are selling and, where necessary, to mark the minerals in such a manner that their recognition will present no problem, nor consume unnecessary time or study, nor elude the purchaser. Let's keep "elusive minerals" to a minimum.

H. R. Steacy
H. G. Ansell
A. C. Roberts
Mineralogy Section
Central Laboratories and
Administrative Services Division
Geological Survey of Canada
October 1979

notes from the EDITOR

MORE ON DISTRIBUTION

A number of people wrote in regard to the map published here in volume 10, number 5, which showed the distribution of *Record* subscribers by state. They were all curious about how the map would look corrected for population. So, using the most recent circulation data, I have prepared a map (Fig. 1) showing the *per capita* distribution of the *Record* in the United States.

The winner of the per capita sweepstakes is Arizona (12.7 subscribers per 100,000 population), followed closely by Colorado (12.4), then Nevada (9.0), New Hampshire (6.1), Alaska (5.6) and New Mexico (5.5). The lowest per capita circulation is in Mississippi and West Virginia (0.5). Most of the central states rate between 1.0 and 2.0, and most of the New England states rate between 2.0 and 4.0.

The trend of this distribution seems to favor the mountain states rather clearly, and anomalies present on the previous (direct circulation) plot seem to have disappeared. Michigan is not a mountain state, but nevertheless includes "Copper Country" which apparently compensates.

The Appalachian Mountains, older geologically and culturally, are not the center of metal mining that they once were, and are certainly not as prolific of metal deposits as the Rockies. Evidence seems to indicate, therefore, that the per capita distribution of the *Mineralogical Record* is largely a function of orogeny (and the associated non-ferrous base metals economic geology).

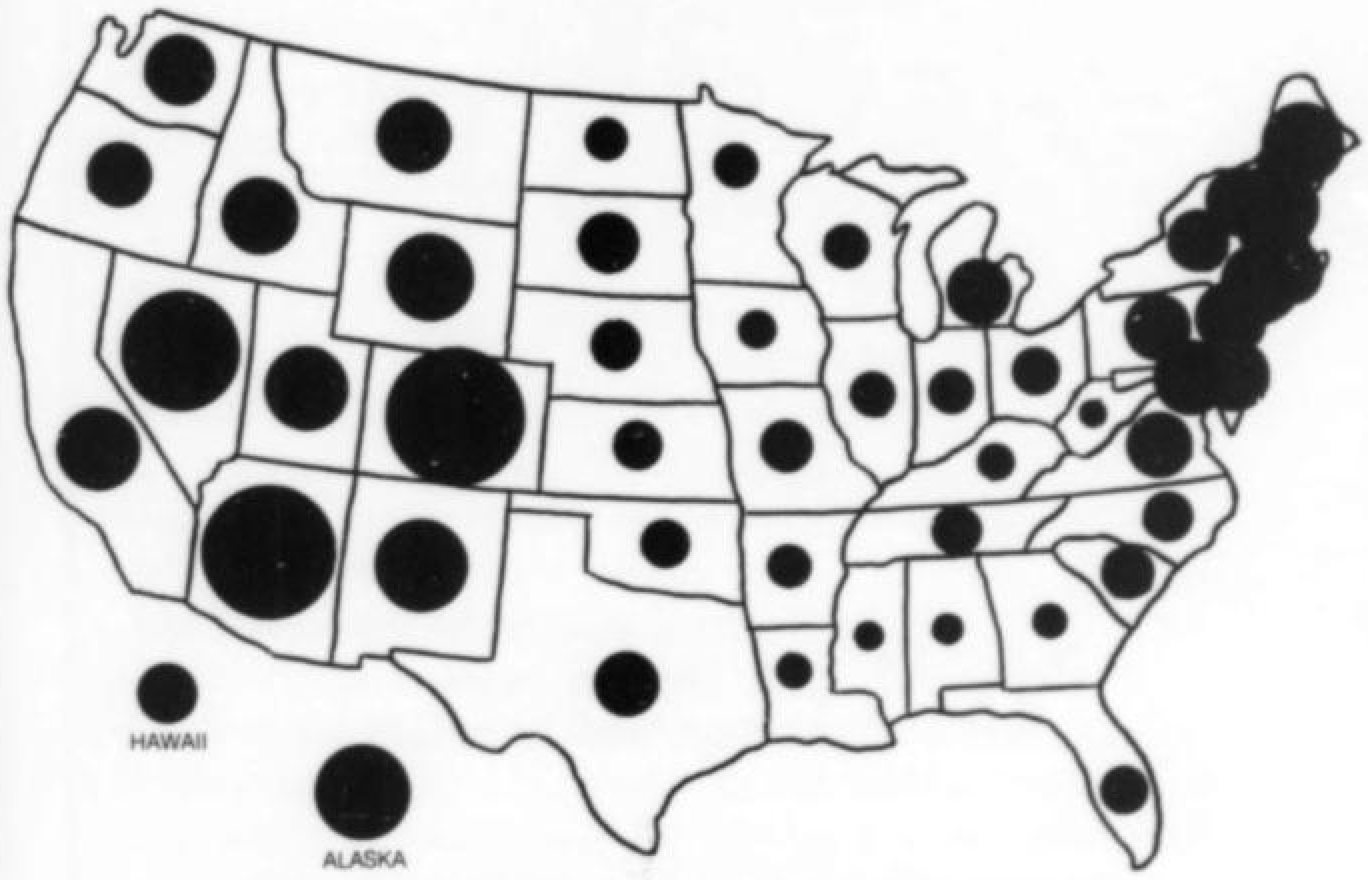

Figure 1. **Per capita distribution of the *Mineralogical Record* in the United States.**

INTERNATIONAL DIRECTORY OF MICROMOUNTERS

The *International Directory of Micromounters* is published biennially (in "even" years) by the Baltimore Mineral Society at the time of its annual Micromount Symposium in September. The 10th edition will be published in September of 1980, and in order for it to be as correct and up-to-date as possible the following information is needed.

1. The full name, address and zip code of each micromounter who wishes to be listed without charge in the 10th edition and who was not (or who does not remember if he or she was) listed in the 9th edition—B.M.S. will do the checking if you are not sure. If a listing is to be for both husband and wife, please also furnish the wife's first name.

2. The new (and old) address and/or name of each person listed in the 9th edition who has moved and/or changed his or her name since it was published.

3. Identification of each person listed in the 9th edition whose mail is undeliverable at the address shown therein. Furnishing the face of one or more envelopes returned by the post office would be as easy a method as any of doing this.

4. The zip code of each Canadian micromounter (and the equivalent for each English one) listed without zip code in the 9th edition (there are lots of them).

5. If you are a member of a micromount group or society please send, or ask your secretary to send, an up-to-date list of your members showing the name and address of your organization and also indicating which one of your members is the best contact person. With this 10th edition, included in the Directory for the first time will be a listing of all mineral clubs which specialize in micromounting or which have at least five members who are active micromounters. But this cannot be done if you do not send in this information.

6. The full name and address of each dealer in micromounts, micromount material and/or tools who would like to be listed, without charge, in the *Director of Dealers* which is a part of the *Directory of Micromounters.* If each dealer who purchases the Directory and uses it for business purposes would comply with item 3, above, by contacting the editor named below, it would be most helpful.

The cost of each copy of the 10th edition will be $1.00; by mail, $1.75 (a bit higher—but not much—than the price of the 9th edition); this applies to the United States and Canada; for all other countries the mail costs are higher and the price will vary accordingly. All information and checks for copies to be mailed should be sent to the editor: Randolph S. Rothschild, 2909 Woodvalley Drive, Baltimore, Maryland 21208, U.S.A.

The *Record* Needs Volunteers

As mentioned in the November-December issue, the *Record* has acquired a complete set of Goldschmidt's classic work, *Atlas der Krystallformen,* published in Heidelberg between 1913 and 1923. The work is a compilation of crystal drawings of minerals, taken from many sources published before and after the turn of the century. The crystal drawings fill nine volumes, and another nine volumes contain information about each of those drawings.

What we would like to produce is a clean, Anglicized, updated list of those minerals and localities, by volume and figure number. Once this is done, we can have it computer-processed to provide a *cross-reference by locality* of the thousands of crystal drawings. Such a cross-reference would be of enormous value to us in efficiently utilizing this great reference, and we would provide duplicate copies at cost to libraries (public or private) and mineralogy departments who might request them.

We need volunteers who (1) have a set of Goldschmidt available to them from which to work (their own or a library copy), and (2) who are reasonably familiar (not necessarily *expert*) with old European localities and spellings to update and Anglicize them. I will issue format guidelines and make sure that efforts are not duplicated among the volunteers. Volunteers will be assigned one volume at a time, and may call upon us for assistance as needed.

This promises to be an interesting and educational experience for everyone involved, and a chance to help out the *Record* and the science as well. People interested in volunteering some of their time to work on this project should contact the editor, P. O. Box 35565, Tucson, AZ 85740.

The Red Cloud Mines
Gallinas Mountains, New Mexico

By **R. S. DeMark**
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The Red Cloud mining district, situated in the Gallinas Mountains of central New Mexico, is of considerable interest to micromineral collectors due to the occurrence of rare and colorful mineral species. Of particular interest are the Red Cloud fluorite and copper mines located in the center of the district.

The Red Cloud fluorite and copper mines are adjacent to one another (within 100 meters) and separated by National Forest Road 99. The location of these mines in an area heavily forested by Ponderosa pines and adjacent to a well maintained National Forest road makes this a pleasant collecting area which is readily accessible even to passenger cars.

The Gallinas Mountains occupy a part of the southern section of the divided Cibola National Forest, west of the town of Corona (Fig. 1). They were formed by Tertiary intrusives which penetrated a basement of Precambrian granitic rocks overlain by Permian sedimentary rocks.

Mining for iron, copper and fluorite in the Red Cloud district has taken place sporadically from near the turn of the century until the late 1940's when mining operations ceased. From all available indications, the low reserves of ore in this district preclude any significant mining activity in the future.

The Red Cloud copper mine is on the west side of the forest road and was originally mined for lead, copper, silver and gold. All that remains of the original mine workings is a fenced vertical shaft and the mine dumps (Fig. 2). Access to the underground workings is not possible. The host rock for the ore is a fractured sandstone breccia. The minerals discussed in this article were all recovered from the dumps. The vertical shaft of the Deadwood mine is immediately south of the Red Cloud copper mine shaft but the dumps at this site are not particularly noteworthy from a collector's point of view.

The Red Cloud fluorite mine is on the east side of the National Forest road about 100 meters south of the Red Cloud copper mine. This mine, also known as Conqueror No. 9, was operated as an underground mine from 1943–1944 but was subsequently operated as a surface working; it consists of a trench about 30 meters wide by 100 meters long up the side of a hill (Fig. 3). Fluorite and bastnaesite were mined from a mineralized fracture breccia along a fault zone.

MINERALS

The minerals from these adjacent mines are quite distinctive. The mineral species of the fluorite mine are less numerous but more interesting than those occurring at the copper mine so these will be covered first.

Bastnaesite. This rare-earth carbonate is ubiquitous, abundant and easily recognized at this location. The roughly hexagonal crystals are flattened parallel to the *c*-axis and are usually thin (less than 2 mm). The crystals are uniformly a waxy yellow, transparent to translucent and range in size from 1 to 10 mm. A well developed basal parting gives them an appearance similar to mica. They occur embedded in a fine grained, purple fluorite matrix.

Agardite. Agardite has been positively identified by X-ray diffraction and microprobe analysis. This analysis is continuing in order to refine the rare earth element composition. It occurs in a fluorite matrix in association with bastnaesite and is found as small yellow-green tufts of acicular crystals. Individual crystals are generally less than 0.1 mm.

Fluorite. Most of the fluorite at this location is massive although some purple cubes about 0.5 mm in size can be found in the interstices of the breccia.

Barite. The barite here is usually found in altered and partially dissolved white crystals that have an acicular appearance due to the state of their deterioration. They are generally found in cavities and spaces within the breccia associated with the fluorite.

Pyrite Pseudomorphs. Pyrite here has been completely replaced by goethite and hematite. The crystals are abundant and occur in well developed cubes and pyritohedrons. They are usually embedded in massive fluorite and average about 2 to 4 mm in size. The replacement has been quite faithful and the growth lines of the pyrite have been preserved.

The Red Cloud copper mine minerals are varied and colorful, making this location particularly enjoyable for the micromineral collector. It features many of the more esthetic microminerals.

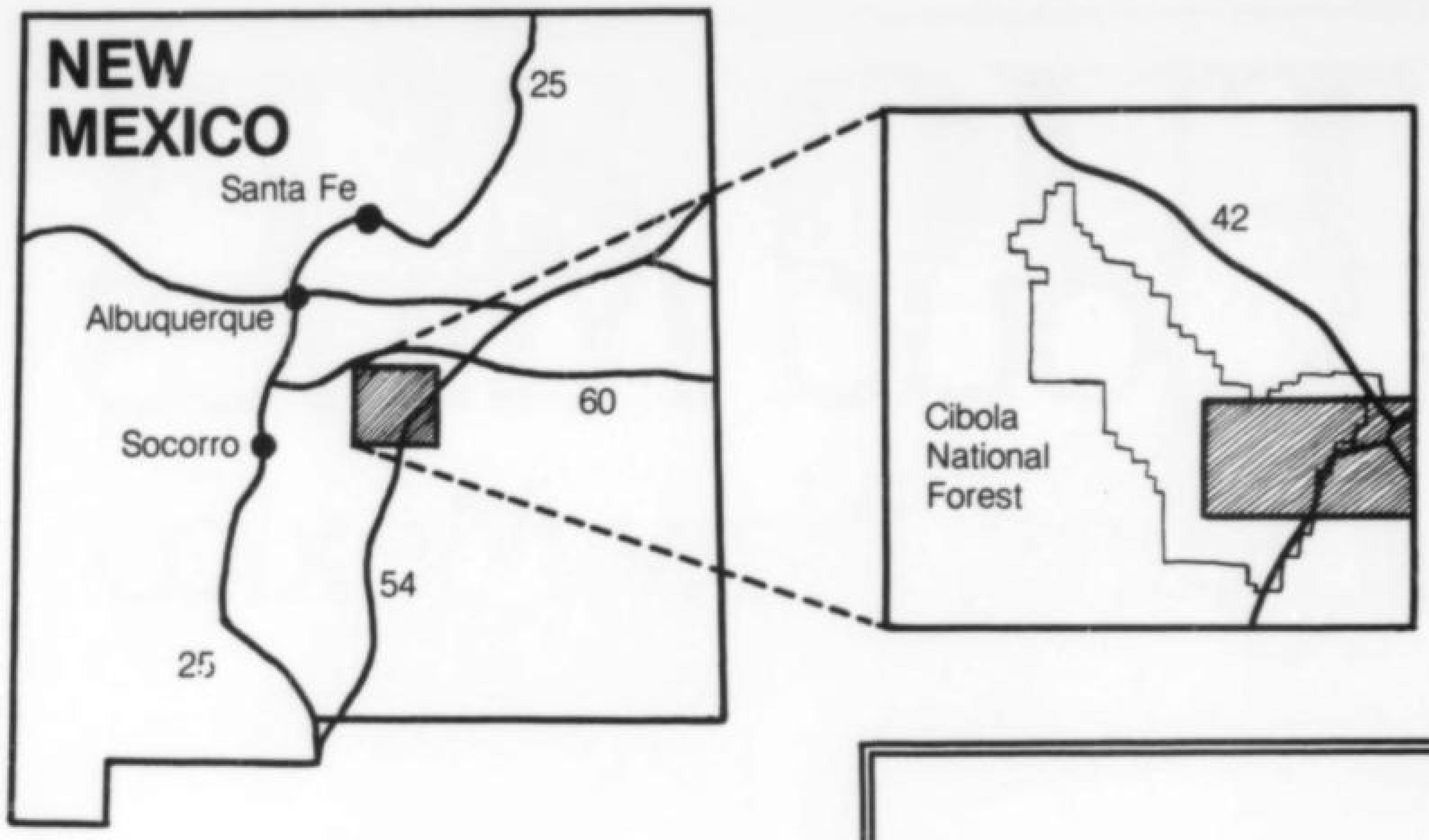


Figure 1. **Location of the Red Cloud fluorite and Red Cloud copper mines in New Mexico. Highway numbers indicated.**

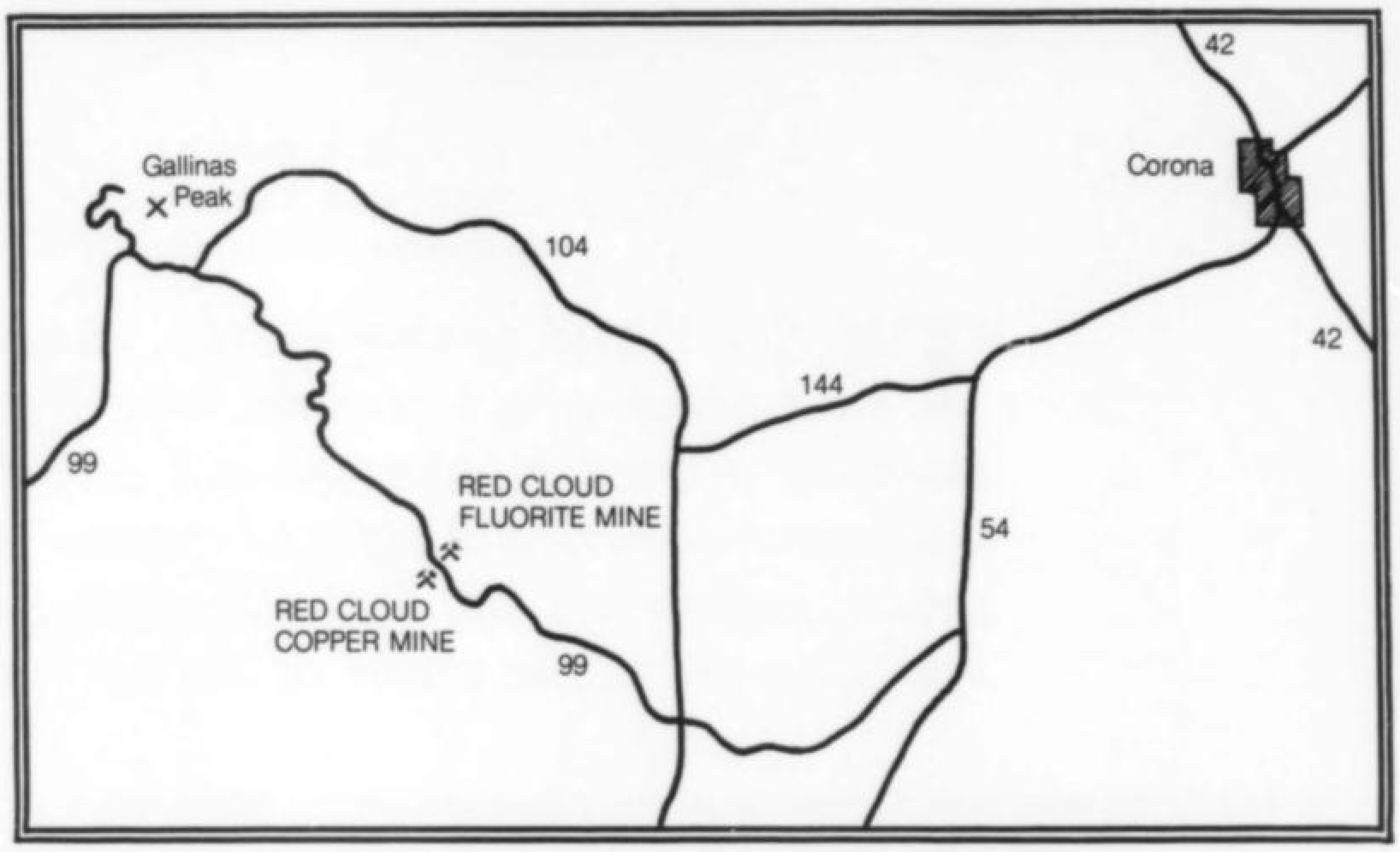
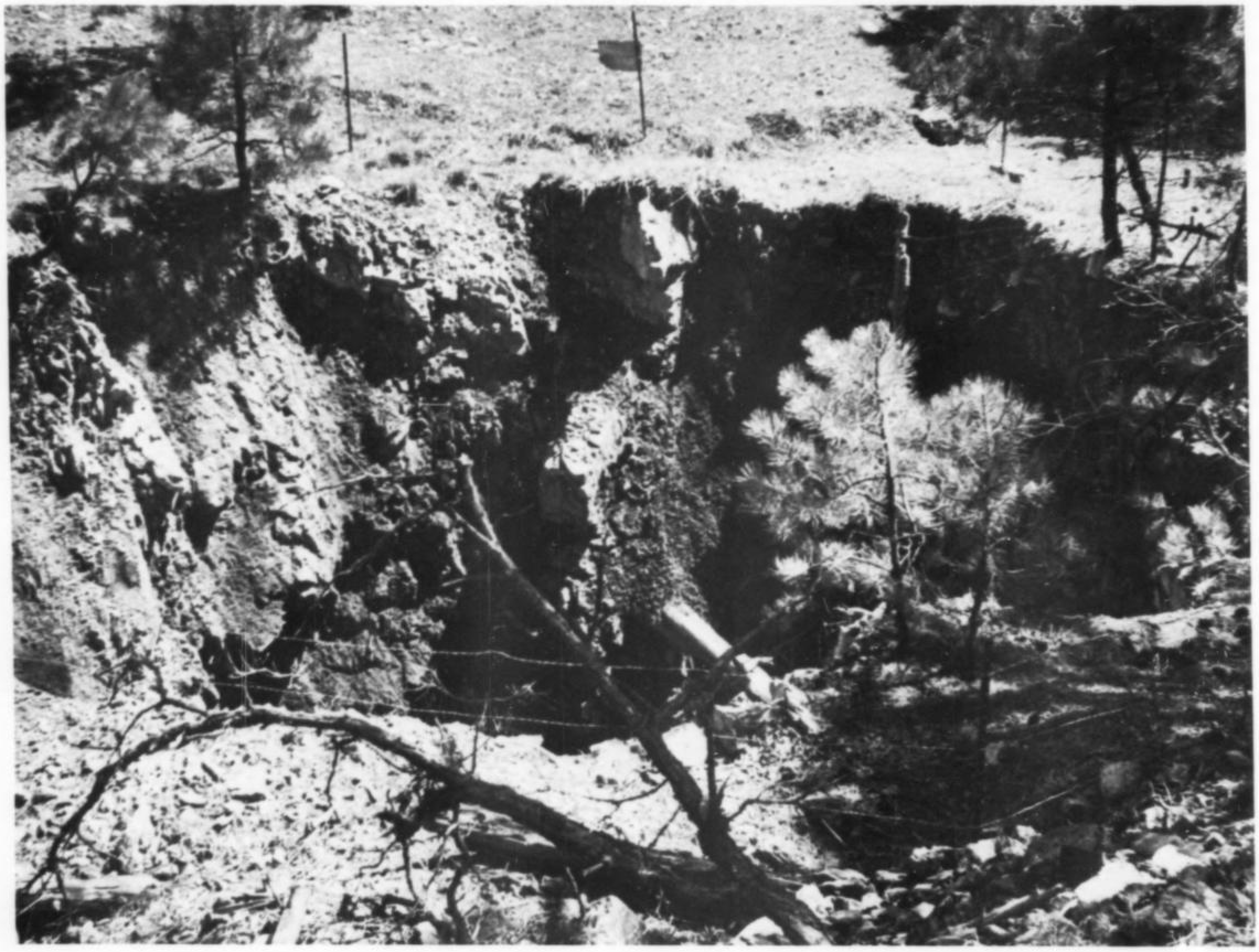


Figure 2. **The Red Cloud copper mine. Photo by the author.**



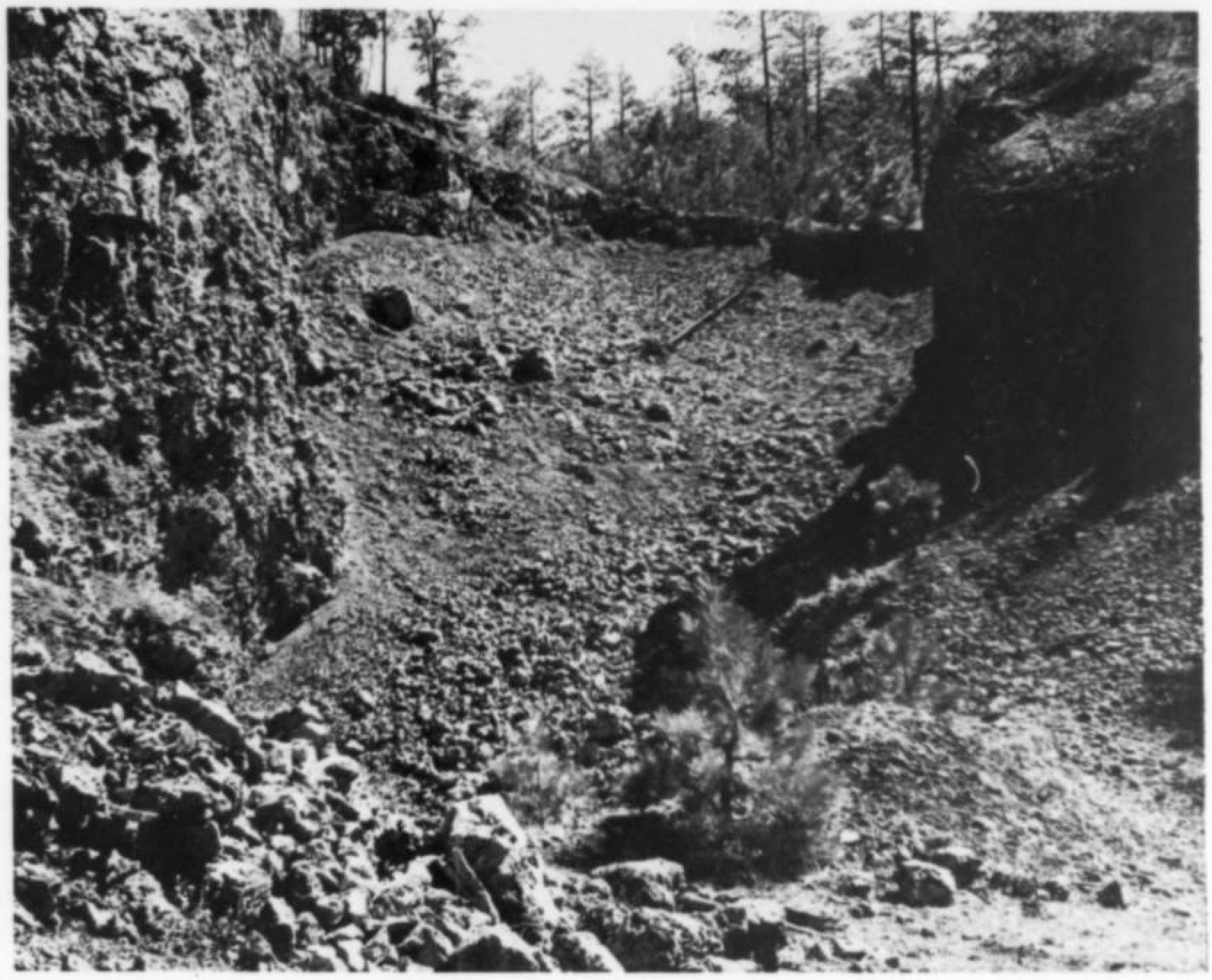


Figure 3. **The Red Cloud fluorite mine. Photo by the author.**

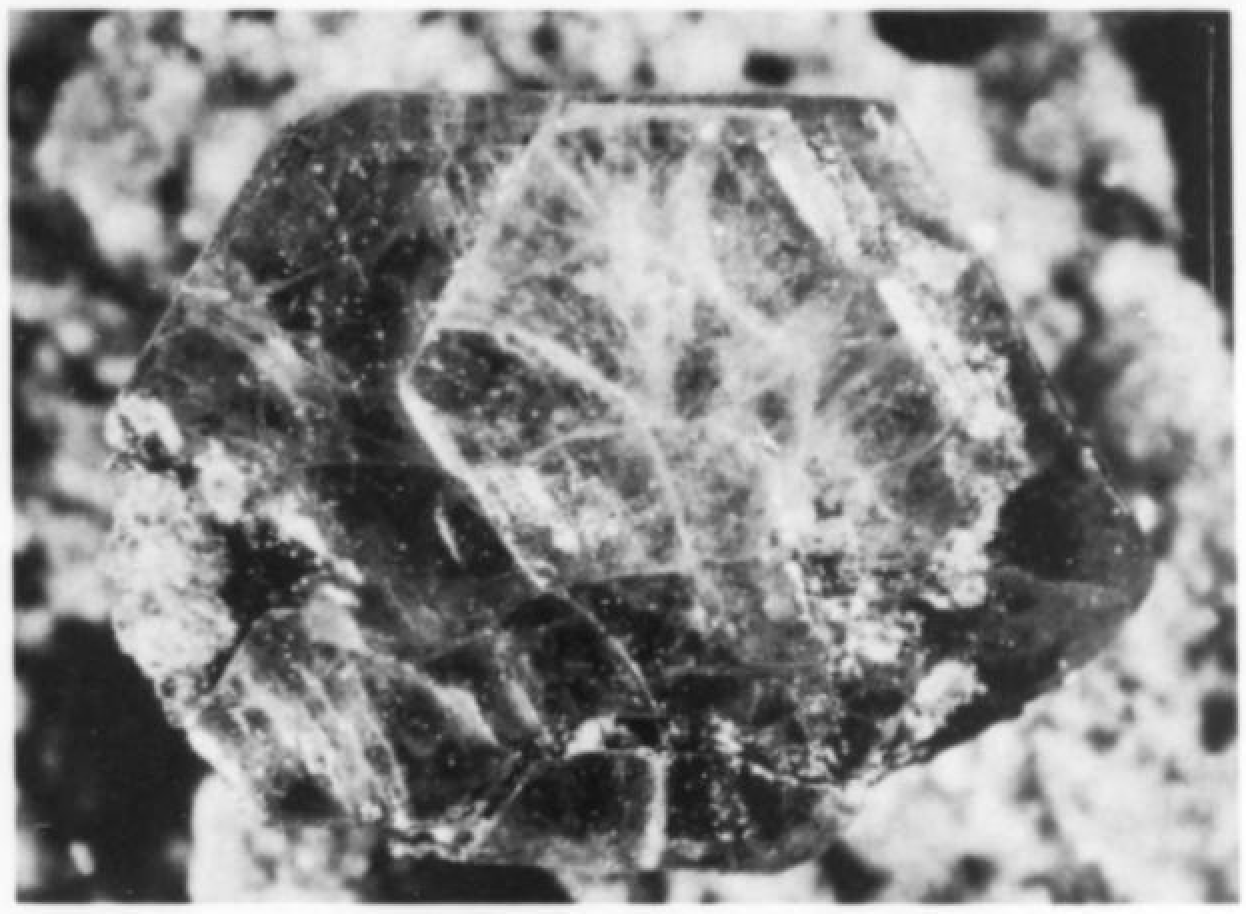


Figure 4. **A golden yellow bastnaesite crystal 1 mm across from the Red Cloud fluorite mine. Photo by Julius Weber.**

Figure 5. **Bright grass-green acicular crystals of agardite in a 0.5-mm mass from the Red Cloud fluorite mine. Photo by Julius Weber.**

Mimetite. Most mimetite is found in association with chrysocolla as bright yellow, transparent crystals usually less than 0.5 mm in size. The prism faces are generally striated perpendicular to the *c*-axis and all of the crystals are terminated by a low angle pyramid. In some cases the prisms are tapered. These are attractive specimens. Mimetite has not previously been described from this location.

Conichalcite. Conichalcite can be found as typically rounded balls and botryoidal crusts on the host rock of brecciated sandstone. Specimens range in color from a grass-green to pistachio-green and can be quite attractive when in association with chrysocolla.

Wulfenite. Wulfenite is abundant, and coats fractures in the sandstone with bright orange crystals ranging from translucent to transparent and averaging 1 to 2 mm. In general, the crystals are thin and tabular, some with flat vicinal pyramidal faces.

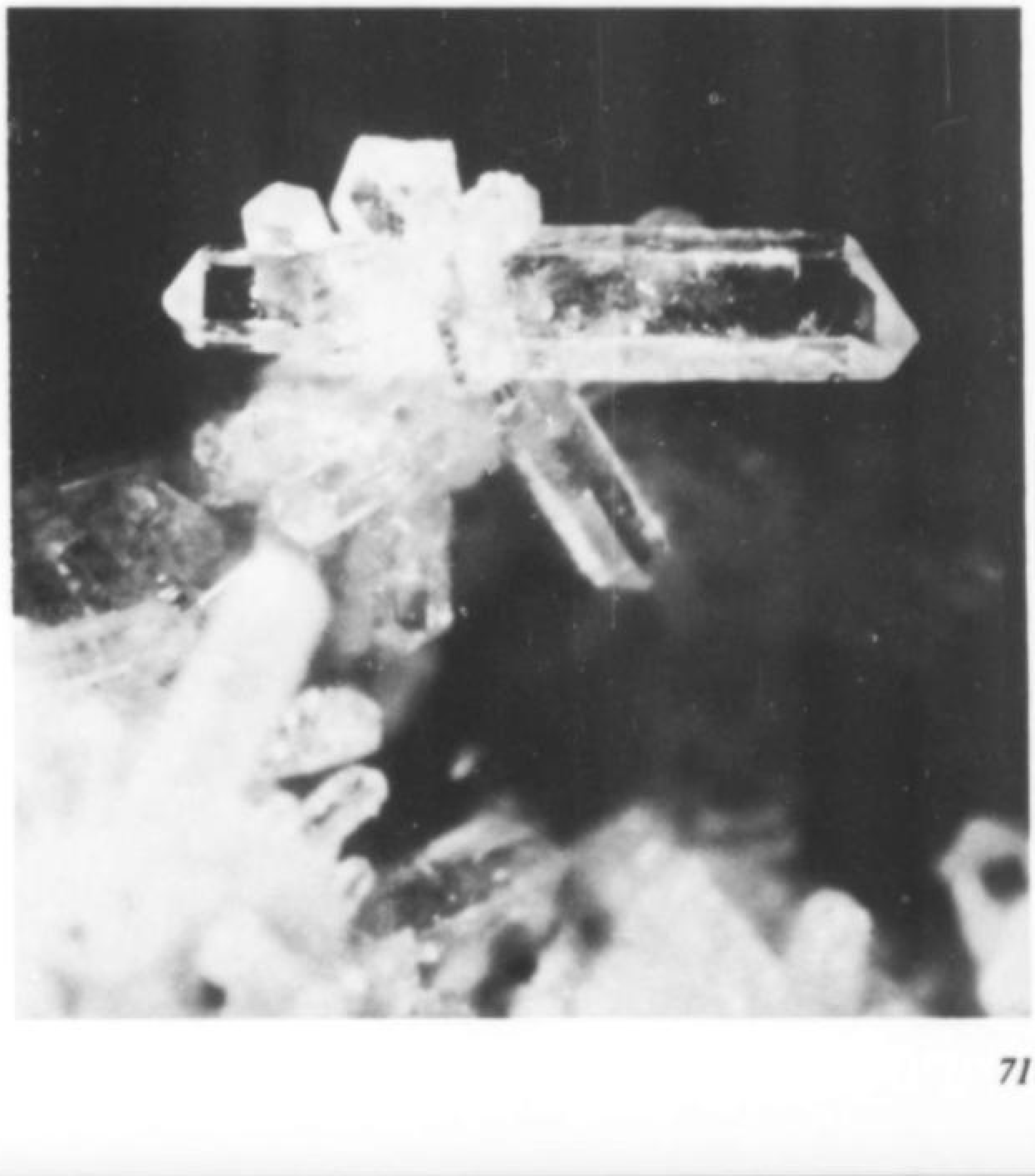


Figure 6. **Bright yellow, gemmy mimetite crystal about 1 mm long from the Red Cloud copper mine. Photo by Julius Weber.**

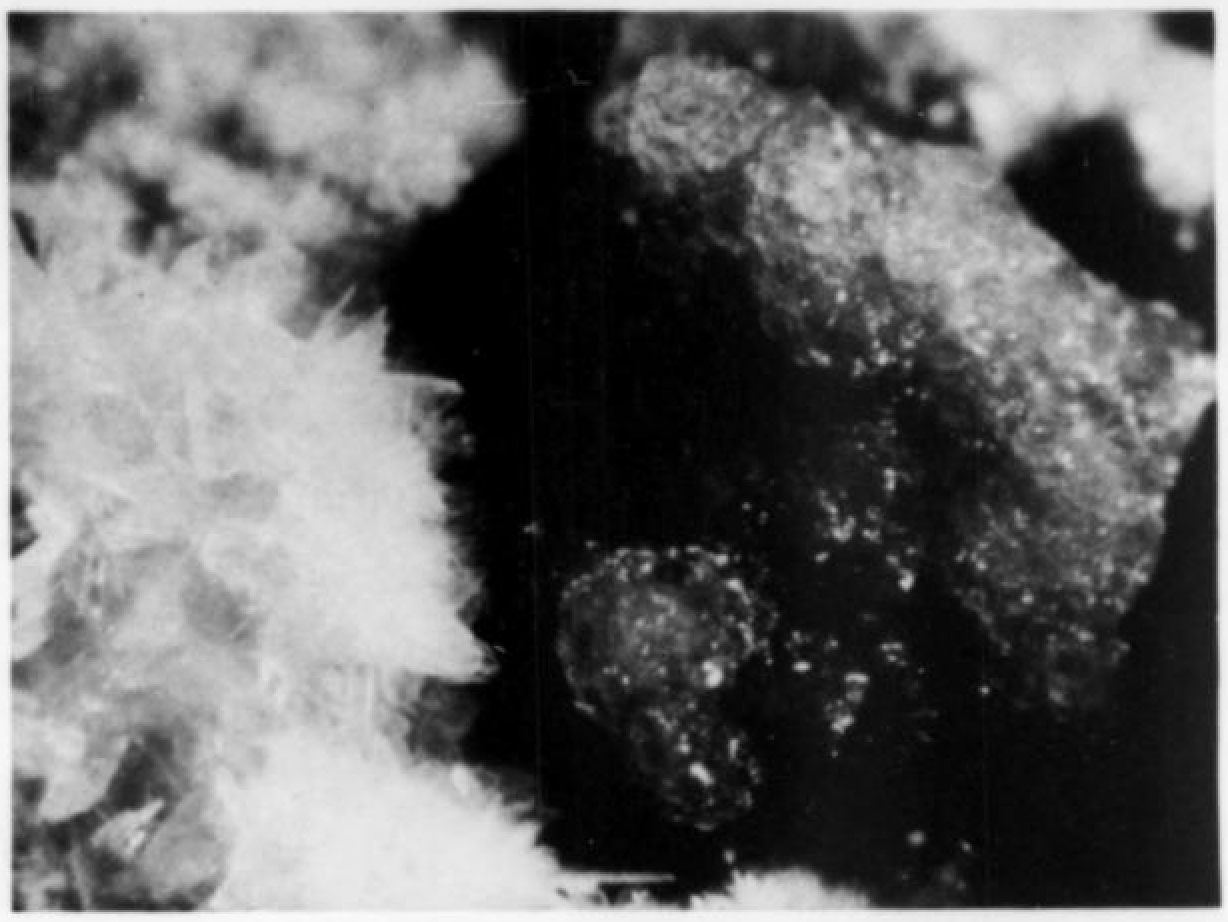


Figure 7. **White barite crystals (left) with deep green mass of conichalcite about 1 mm across from the Red Cloud copper mine. Photo by Julius Weber.**

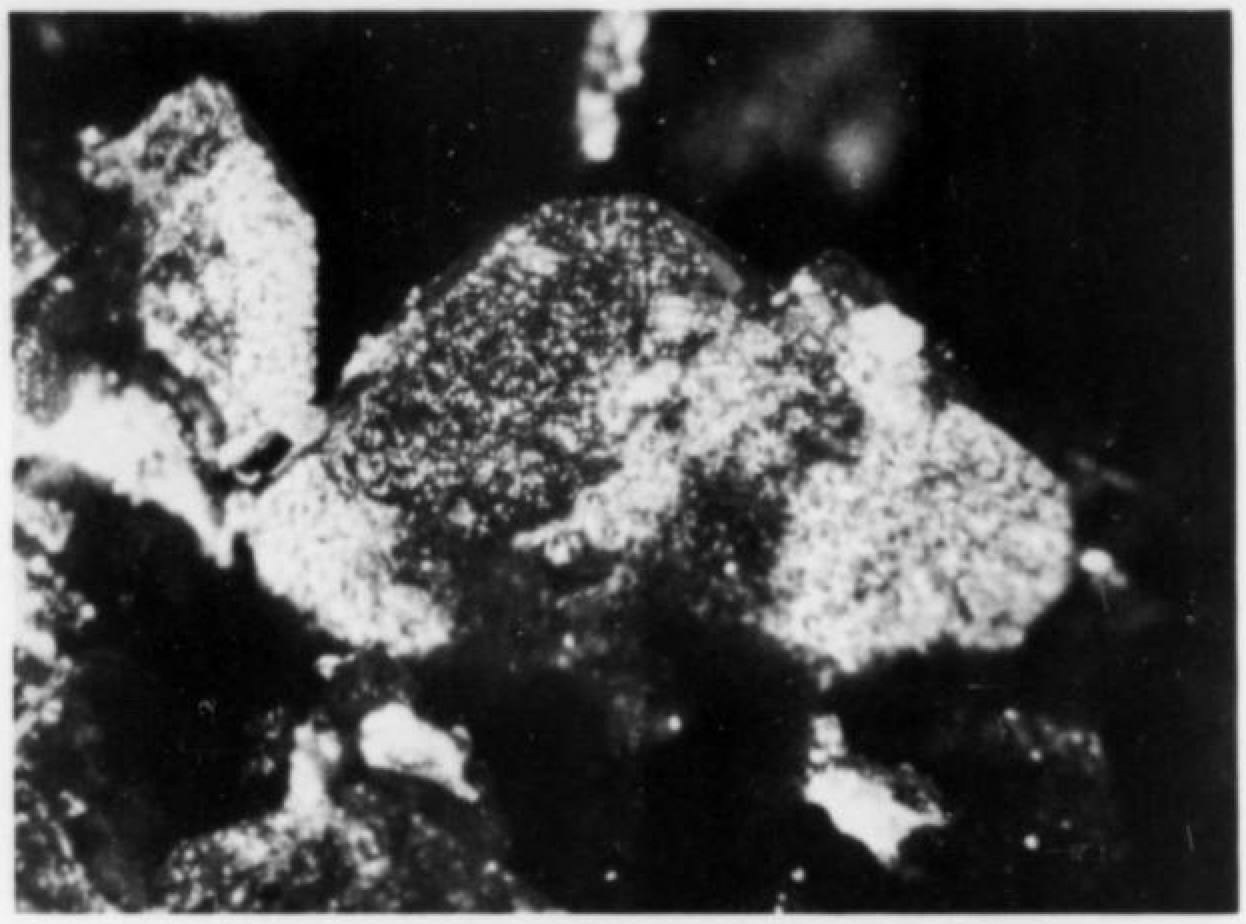


Figure 8. **Yellow-orange wulfenite crystals about 1 mm in size on matrix from the Red Cloud copper mine. Photo by Julius Weber.**

Vanadinite. Vanadinite is found in typical hexagonal prisms terminated by the basal pinacoid. The crystals are reddish brown, translucent and usually associated with a groundmass of small mottramite crystals. The vanadinite crystals average about 2 mm.

Mottramite. Mottramite is widespread throughout the mine dump and occurs as small (less than 1 mm) black crystals. The crystals are generally pyramidal and may be quite lustrous.

Cerussite. Cerussite is found in distinct gray crystals that are commonly twinned. It is not abundant at this location but can be found in association with chrysocolla and mimetite.

Chrysocolla. Chrysocolla is widespread and is found primarily as sky-blue botryoidal masses and vein fillings. It is also found replacing an unknown mineral in prismatic, chisel-shaped crystals about 1 mm in size.

The Red Cloud fluorite and copper mines offer the micromineral collector a varied assemblage of attractive and rather uncommon minerals. The occurrences at the mines of agardite, conichalcite, mimetite, vanadinite, wulfenite and mottramite are reported here for the first time. Additionally, the agardite and conichalcite[1] are the first reported occurrences for New Mexico. The natural beauty of the surrounding Gallinas Mountains and the invigorating mountain air are bonuses to collecting at this fascinating New Mexico location.

ACKNOWLEDGEMENTS

Many thanks are extended to Bob North and the New Mexico Bureau of Mines and Mineral Resources for their help in X-ray identification of specimens. I would also like to thank Pete Modreski for his microprobe analysis of specimens and his valuable comments relating to the development of this article.

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[1] Joe Taggart reports that he has made a positive identification of conichalcite at a mine on Copper Hill in Taos County, New Mexico. This would be the second reported occurrence of conichalcite in New Mexico.

Malachite Pseudomorphs from the Sir Dominick Mine, Arkaroola, South Australia

by **Brian M. England**
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The Sir Dominick mine is located high on the precipitous western bank of Daly Creek, just within the northern boundary of Arkaroola Station in the North Flinders Range, South Australia. Malachite pseudomorphs after azurite from this locality have been known to Australian collectors for some years but, recently, these specimens have begun to appear on the world market following visits to the mine by foreign dealers. The pseudomorphs are found scattered sporadically through dump material and can still be collected **in situ.**

THE REGION

Situated some 350 miles north of Adelaide, in some of the most rugged mountain country in Australia, Arkaroola has seen a difficult and checkered pastoral and mining history dating back to the early 1860's. The region's low and unpredictable rainfall and its rugged topography were unsuited for sheep grazing: consequently pioneer pastoralists, most notably the Greenwood family, often turned to prospecting and mining in lean years. Numerous deposits of copper carbonates were discovered in the 1870's but most proved small and low grade. In 1910 deposits of torbernite were discovered near Mt. Painter and these were worked on a small scale. In 1968 the Arkaroola property was purchased by Reginald Sprigg, former geologist with the South Australian Mines Department, and the station is now operated as a unique experiment in conservation and controled tourism.

Arkaroola covers much of the Mt. Painter Mineral Province, an area of considerable geologic antiquity with intrusive alkali granites, volcanics, and metasedimentary rocks dating back to the Precambrian. It is an area of great diversity in geology and structure, with numerous pegmatites and diapiric structures, accompanied by strong folding and faulting. The province is regarded as one of the most intense and diverse areas of mineralization in Australia.

THE SIR DOMINICK MINE

The Sir Dominick mine (Fig. 1) was one of the larger and more productive of the many small copper deposits in the North Flinders Range. The deposit was first explored in 1862 by a party calling themselves the Northern Mineral Association. From 1866 to 1868 the mine was one of several worked in the vicinity by the Daly-Stanley Mining Company. It was then taken over by the Tasmanian Copper Company and was subsequently worked by tributors.

Figure 1. **Dumps of the Sir Dominick mine, from the bed of Daly Creek.**

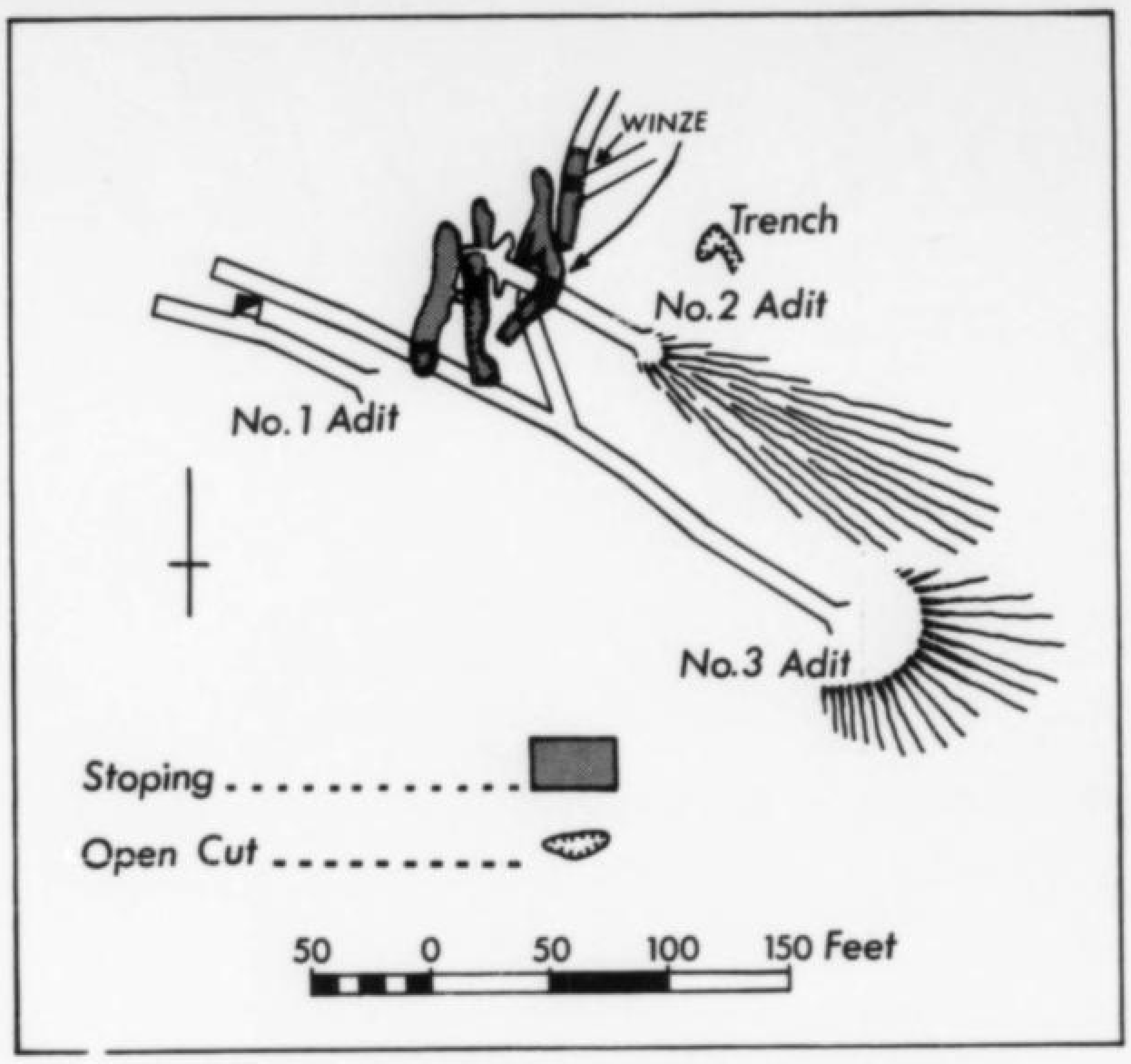

Figure 2. **Plan of underground workings of the Sir Dominick mine.**

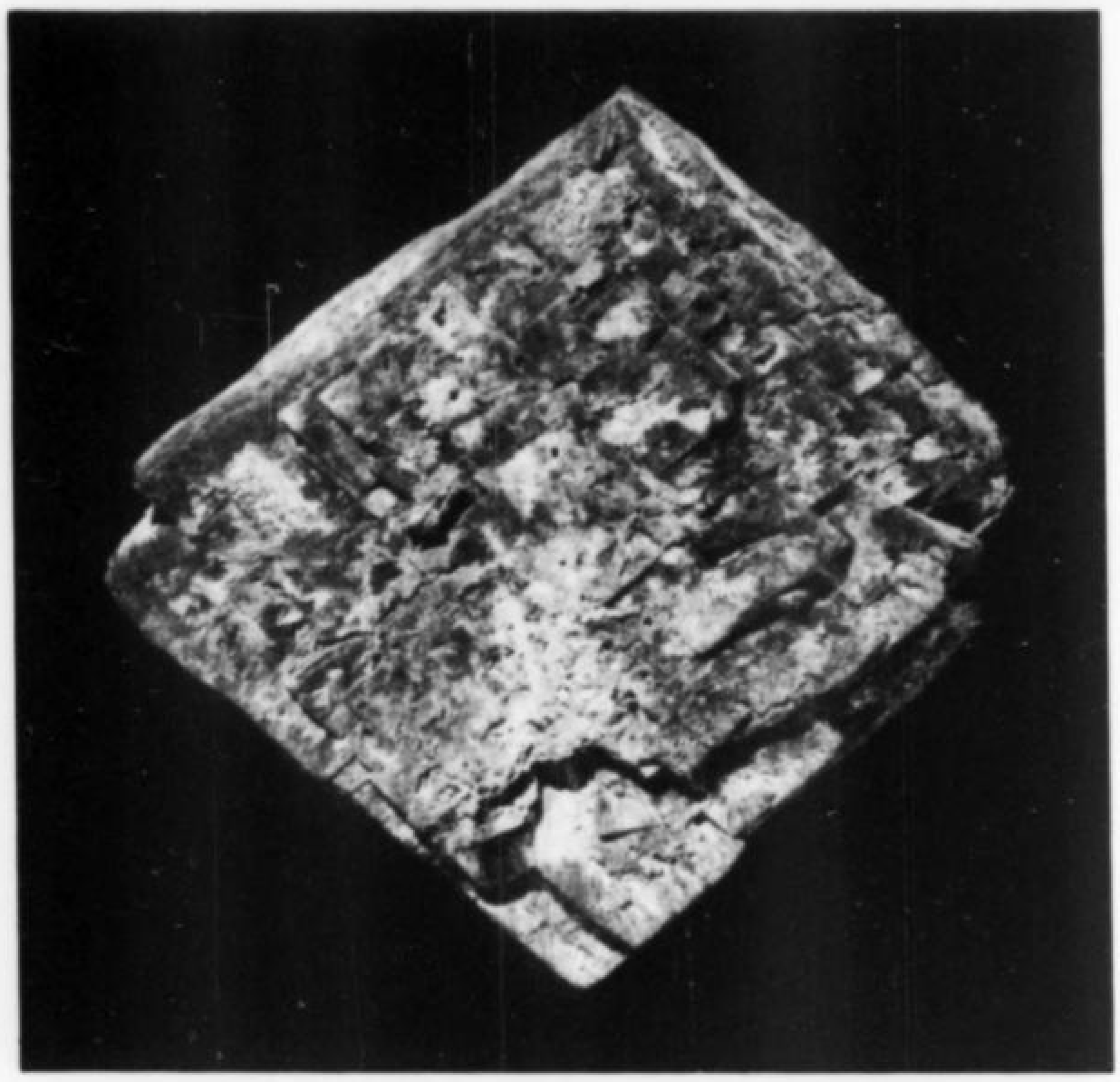

Figure 3. **Tabular single crystal of azurite replaced by malachite; 1 inch across.**

Around 1910, further exploration of the deposit was carried out and by 1914 the mine was being operated by the Flinders Copper Mining Company.

Work at the mine finally ceased in 1920, although in recent years considerable work has been done, both in the surface and underground workings, by collectors searching for fine malachite pseudomorphs for which the mine is famous.

GEOLOGY

The deposit lies immediately to the north of the Jubilee fault, one of the major fault zones in the region. The host rocks comprise sheared and fractured scapolite-actinolite rocks, schists, and quartzite of the Precambrian Wywyana formation overlain by green schistose lavas of the Wooltana volcanics and finally by the metamorphosed arkosic Blue Mine conglomerate. The rocks have been silicified and are cut by a 150-ft-wide band of kaolinized shear and crush zones trending approximately east-west and dipping steeply to the north or south. The economic concentrations of copper mineralization lie within these crush zones.

Figure 4. **Prismatic single crystal of azurite replaced by malachite, showing the hemi-pyramid (*h*) faces. This is one of the largest single crystals recorded from the deposit: 1⅜ x 1¾ inches.**

MINE WORKINGS

The mineralized shear zones have been developed by a series of open cuts, trenches and shafts near the peak of the ridge and also by four adits driven into the steep slopes of the ridge at various levels (Fig. 2).

The most northerly of the three major shear zones has been stoped to 20 ft below No. 3 adit, i.e. to about 160 ft below the outcrop. The other two have been worked from the outcrop almost to the level of No. 3 adit. Much of these underground workings have since collapsed. No. 4 adit was driven almost 500 ft from a point 40 ft above the bed of Daly Creek, but it is not known if copper ore was intersected as this level is no longer accessible.

No accurate records were kept of mine production, but it appears that a considerable tonnage of high-grade carbonate ore was extracted prior to 1910. Only small parcels of ore have been produced since then by hand sorting and jigging material from the crush zones. Rainfall is infrequent in the region and lack of water hindered development of the mine.

MINERALIZATION

Azurite and malachite appear widely disseminated throughout the host rocks, including the lower part of the Blue Mine conglomerate, but are concentrated in the three major crush zones. The rocks between the crush zones are cut by numerous irregular stockwork veins of white quartz, often stained with copper carbonates. No primary sulfide minerals have been detected anywhere in the workings and it is probable that the carbonates were deposited in the crush zones and surrounding rocks by percolating groundwater charged with copper ions originating from the overlying Blue Mine conglomerate, or perhaps some pre-existing rock

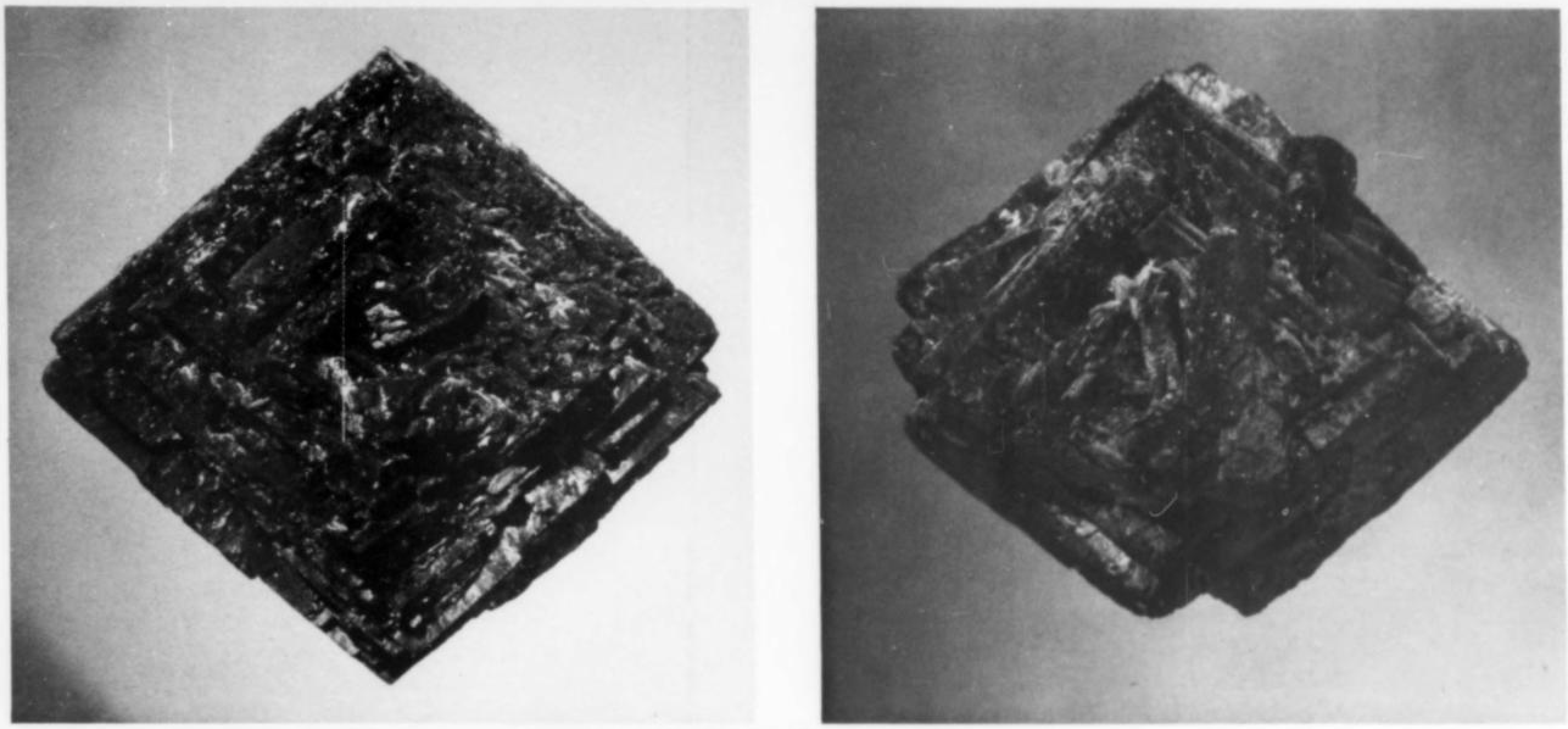

Figure 5. **Rosettes of sub-parallel azurite crystals replaced by malachite; a = 1½ inches, b = 1⅛ inches.**

formation now totally removed by erosion. The highly permeable crush zones would have acted as ideal channels for descending copper-rich solutions. The fact that the quartz stockworks contain no primary sulfides would seem to indicate an external source for the copper mineralization.

Within the crush zones the exceedingly fine kaolinitic lode material has provided an ideal growth medium for crystal groups and single crystals of azurite, most of which have subsequently altered to malachite.

The relationship between azurite and malachite can be represented by:

$$\underset{\textit{Azurite}}{2Cu_3(CO_3)_2(OH)_2} \underset{+2(OH)}{\overset{+CO_3}{\rightleftharpoons}} \underset{\textit{Malachite}}{3Cu_2(CO_3)(OH)_2}$$

Azurite and malachite usually coexist in any one deposit. But it would appear that (although malachite is favored by a wet alkaline environment) the present lack of carbonate in the host rocks of the Sir Dominick mine has counteracted the effect of low rainfall to favor gradual malachite replacement of the original azurite crystals, unless the flow of groundwater was considerably greater in the past than it is today.

MALACHITE PSEUDOMORPHS

There are three major morphological types, showing sharply defined crystal faces. All have an internal radiating fibrous structure.

(a) Single Crystals

The single crystals from the Sir Dominick mine show distinct monoclinic symmetry and vary in habit from thin tabular (Fig. 3) to prismatic barrel-shaped crystals, both types consisting of simple combinations of hemi-prism and basal pinacoid faces. The convex appearance of the prismatic crystals is due to the presence of quite prominent hemi-pyramid faces (*h*) (Fig. 4). Most single crystals actually comprise a number of individuals in parallel growth, made evident by the presence of multiple termination faces (see Fig. 3). Many of the tabular crystals show unaltered azurite centers.

(b) Rosette Groups

Tabular crystals commonly occur in sub-parallel to divergent groups, giving the appearance of malachite rosettes, ranging from ¼ inch to almost 2 inches in diameter (Fig. 5 a and b).

(c) Spherical Aggregates

These are probably the most common of the pseudomorph types. Specimens comprise irregular to spherical aggregates of prismatic to tabular crystals (Fig. 6) occasionally exceeding 4 inches in diameter. Individual crystals in the aggregates range up to ¾ inch in diameter.

AZURITE

Isolated pockets of unaltered azurite crystals occur throughout the workings but these crystals rarely exceed ½ inch in diameter. An interesting occurrence in the walls of the open cut above No. 2 adit is the presence of azurite crystals with malachite-replaced centers. This would indicate an apparent additional short period of azurite growth after replacement of the original azurite crystals. Perhaps this was favored by a recent lack of groundwater movement in some sections of the deposit.

The azurite usually occurs as single isolated crystals or small groups. In the open cut above No. 2 adit, exceptionally fine chain-

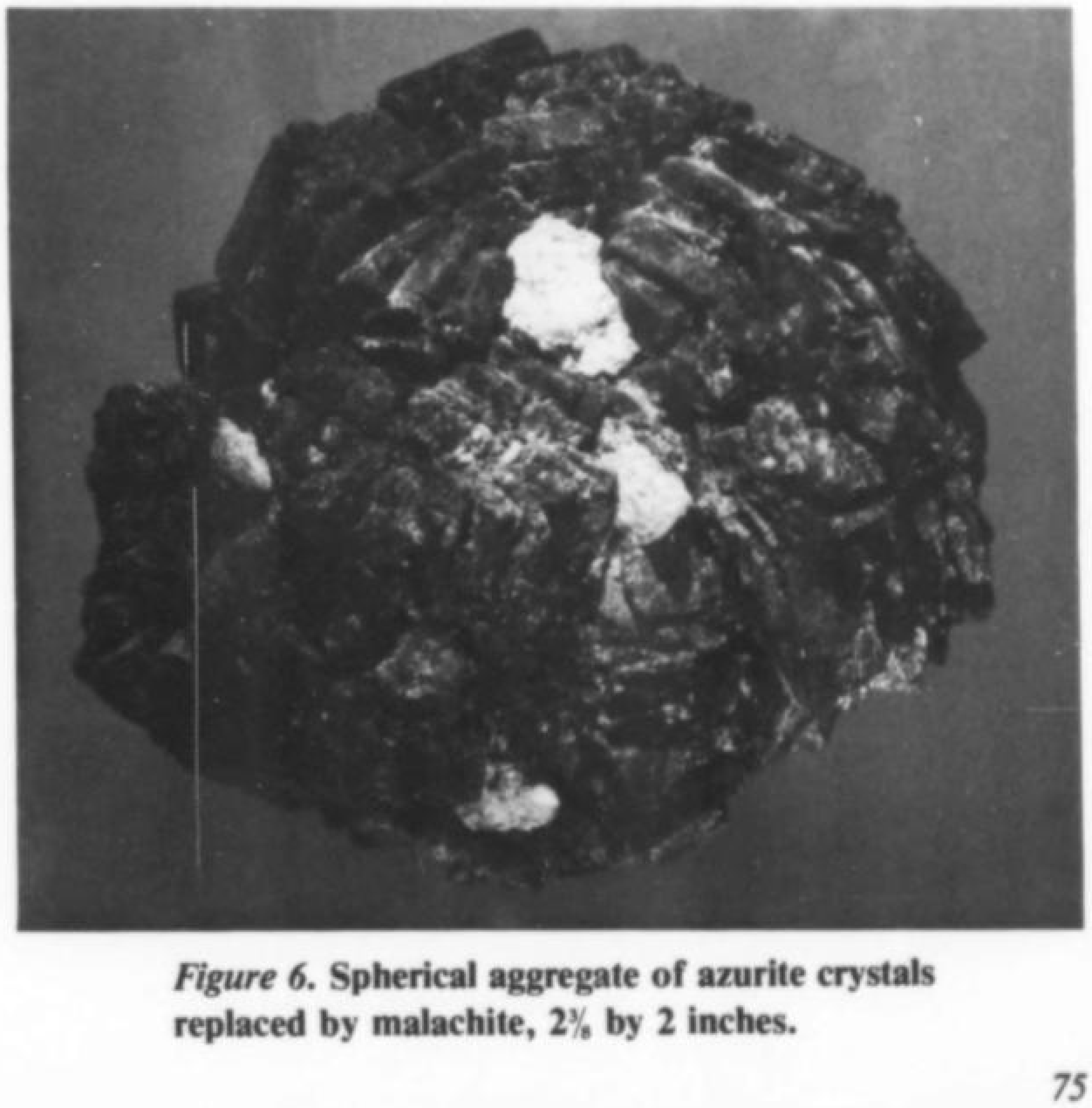

Figure 6. **Spherical aggregate of azurite crystals replaced by malachite, 2⅜ by 2 inches.**

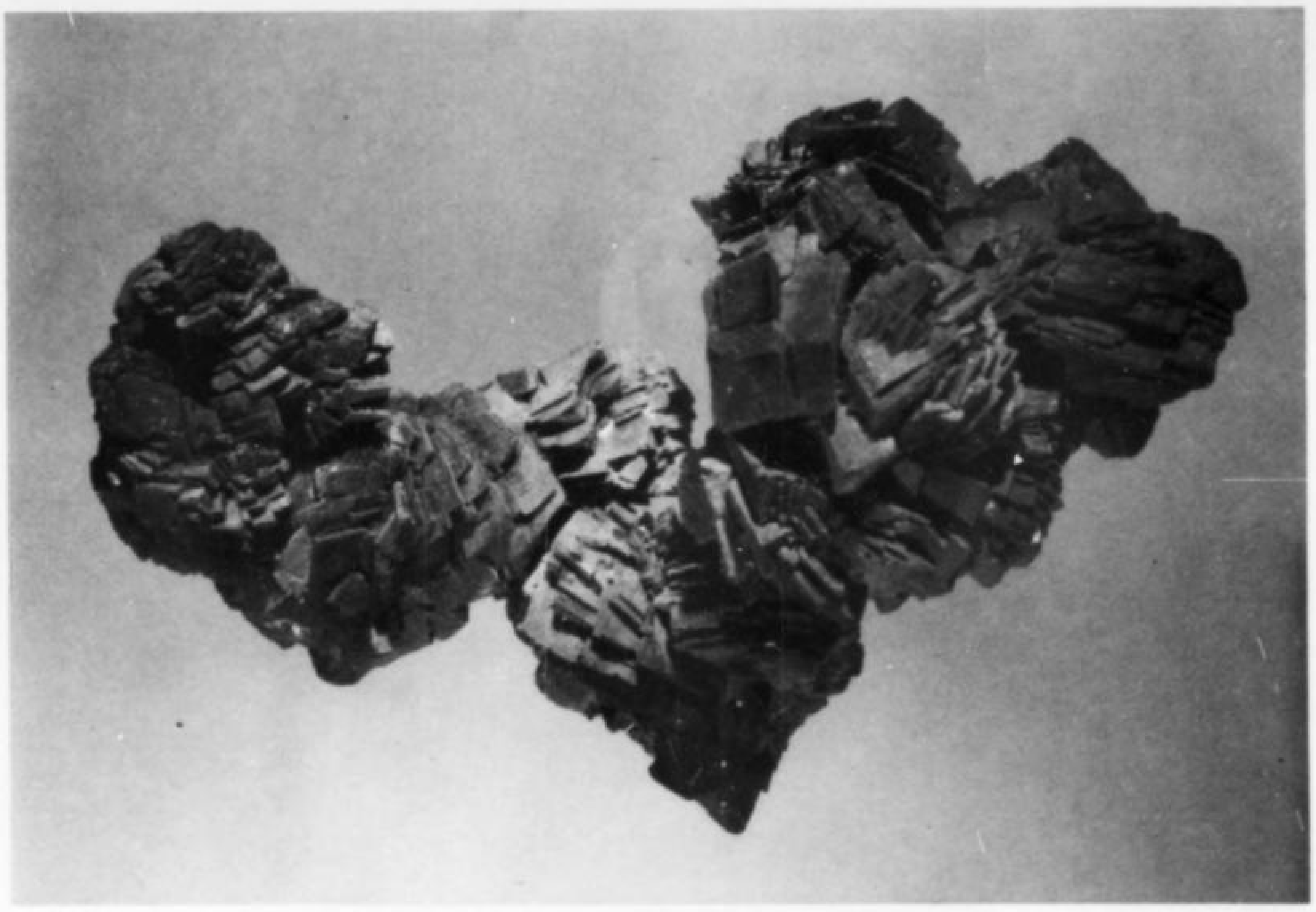

Figure 7. **Chain-like group of azurite crystal rosettes, 2⅜ inches long.**

like groups of prismatic crystals (Fig. 7) were found in a soft claystone in a small and apparently unique pocket. Cleaning of these specimens required several hours painstaking work and in many cases careful repair was essential to preserve these unusual groups intact.

MALACHITE CRYSTALS

Isolated, small, vuggy, dark gray quartz pods in the kaolinitic crush zones, particularly in the open cut above No. 2 adit, contain tufted groups of acicular malachite crystals to ¼ inch long. These provide exceptional micromounts.

PRESENT STATUS OF THE LOCALITY

Only the richest of the ore from the workings was sold to the smelters and much still remains in the mine dumps. Small reserves of high-grade carbonate ore are known to exist in parts of the underground workings, although the mine is in various stages of collapse and the workings present an extremely dangerous collecting environment.

With the relatively extensive mine dumps, underground reserves, and the general inaccessibility of the area, it is envisaged that the Sir Dominick mine will continue to provide these outstanding specimens for some time to come.

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Figure 8. **Working at the face of No. 2 adit, Sir Dominick mine. The large stope connecting levels two and three is immediately to the right of the ladder.**

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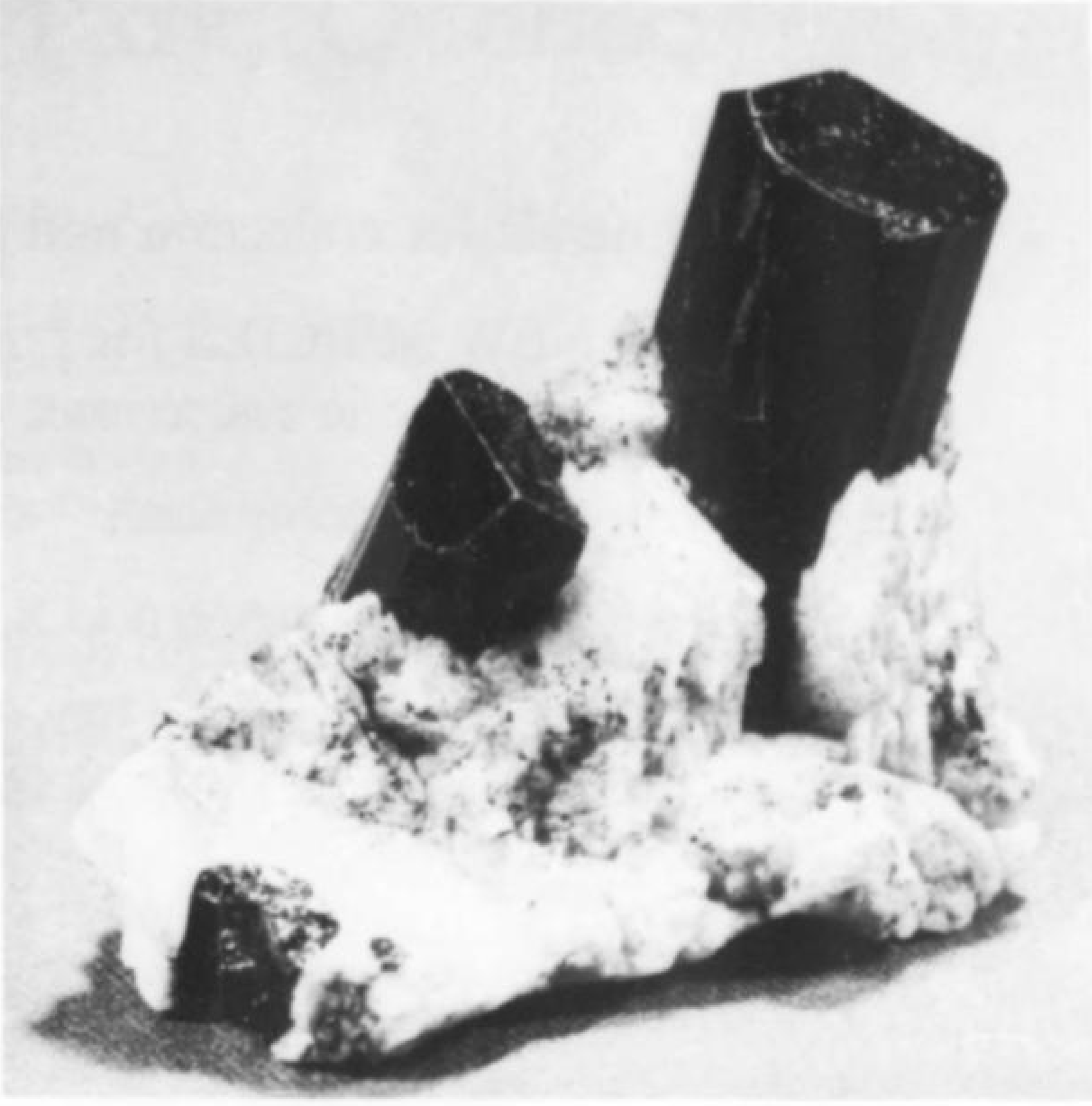

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URANINITE

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by **R. Gault** and **R. Waller**
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Excellent octahedral crystals of uraninite have recently been collected from an old molybdenite prospect about 16 km northwest of the cities of Ottawa-Hull.

LOCATION

The locality, known as the Chaput-Payne prospect, lies in Lot 1, Range VII, Eardley Township, Gatineau County, Quebec, within Gatineau Park, an area administered by the National Capital Commission. This commission administers parkland areas in the National Capital region. Permission to collect must be obtained in writing from their office.

The area is easily accessible from Hull by the Gatineau and Fortune Lake Parkways which terminate at the Champlain Lookout. From this point a footpath leads to the deposit, 30 m below the lookout. The lookout is near the top of the Eardley escarpment, a fault scarp that rises about 270 m above the Ottawa River valley.

GEOLOGY AND HISTORY

The deposit lies within the Precambrian Grenville geological province of the Canadian shield. The Grenville forms a belt of highly complex and contorted metamorphic and igneous rocks 250 km wide and 1200 km long extending through Ontario, Quebec and upper New York state.

Metamorphic rocks exposed at the locality include calc-silicate rock and paragneiss. These form part of a roof pendant to the syenitic Wakefield batholith (Hogarth, 1970; Hogarth *et al.*, 1972). Associated with the pendant are numerous small dikes of aplite, granite and calcite. It is in one of the calcite dikes that the uraninite crystals are found.

The uraninite-bearing dike is highly irregular, pinching and swelling to a maximum width of 2 m. It can be traced on the surface for approximately 70 m. The dike contains well developed crystals of country rock minerals that grew freely from the wall into what is now the calcite core. At the contact with calc-silicate rock, crystals of diopside, phlogopite, uraninite and molybdenite are found, whereas at the contact with granite gneiss, crystals of microcline, actinolite and titanite occur. This relationship between the mineralogy of the calcite dike and that of the country rock is typical of most calcite dikes of the Grenville region. The central portion of the dike is mostly salmon to cream-colored calcite containing euhedral uraninite, molybdenite and phlogopite crystals.

Molybdenite was first observed at this prospect by John Lusk in 1900, but no development took place until World War I when the price of molybdenum, as a strategic metal, was high. During the war the property was worked by A. Payne and E. Chaput, at first independently, then as partners in the National Molybdenum Company. Together they opened ten test pits and shipped 35 tons of ore for bulk analysis (Eardly-Wilmot, 1925). During World War II, Norwin Molybdenite Mines Ltd. cleaned out the existing test pits and sent four tons of ore for analysis (Ingham, 1942).

In 1977 The National Museum of Natural Sciences obtained permission from the National Capital Commission to collect at the property. At first the dumps around the main test pit were searched with a scintillometer (McPhar Model TC-33), which could detect 1

Figure 1. **Uraninite octahedron (NMNS #41959) from Gatineau Park. The crystal as viewed is 17 mm across.**

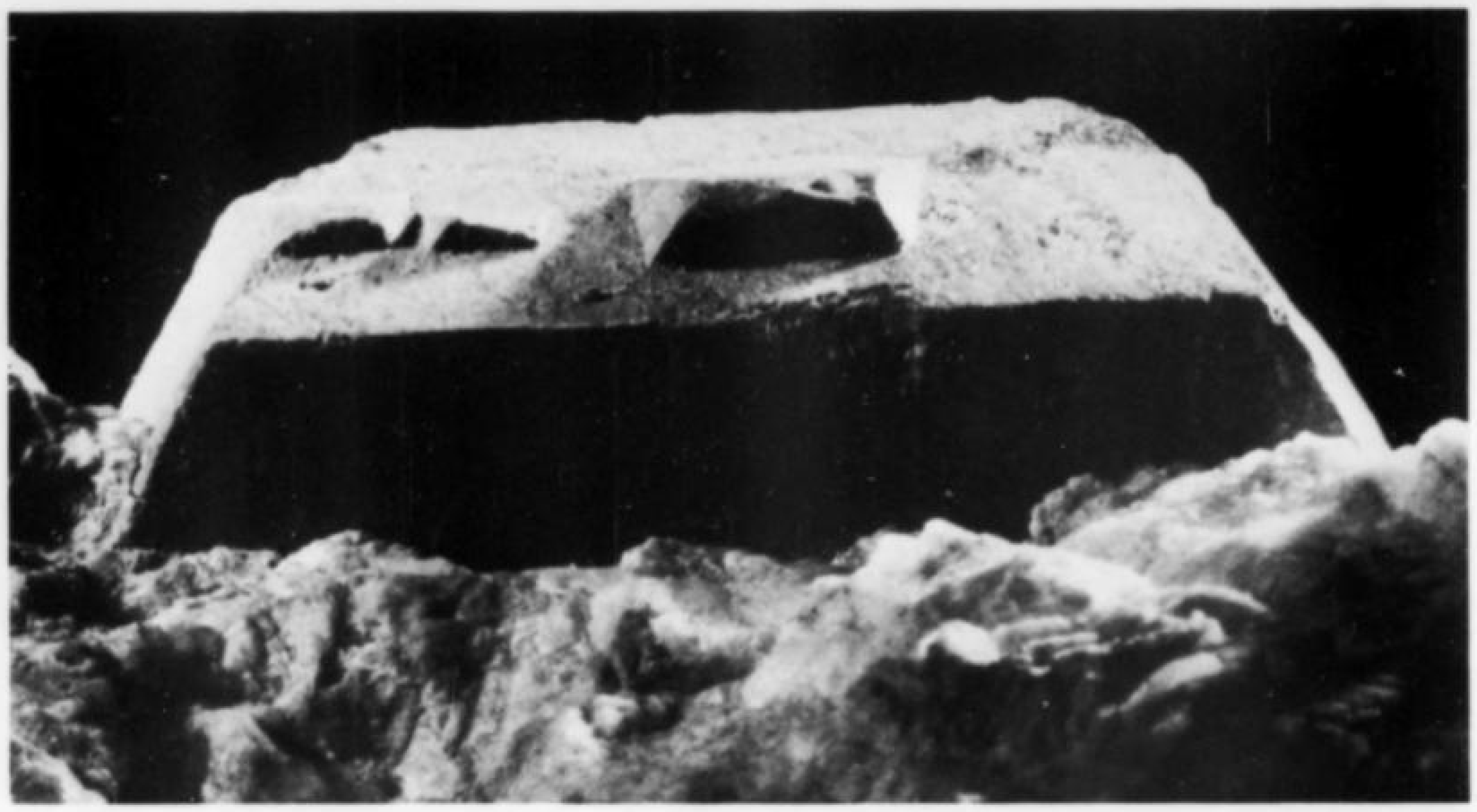


Figure 2. **A flattened and twinned uraninite crystal in calcite matrix (NMNS #41960). The crystal as viewed is 20 mm across.**

cm uraninite crystals at depths of up to 15 cm in soil and 6 cm in rock. The dike was then further exposed through trenching and blasting. The finest uraninite specimens were collected from loose soil although a few were collected from *in situ* rock. In total, over 300 uraninite crystals 1 cm or larger were collected.

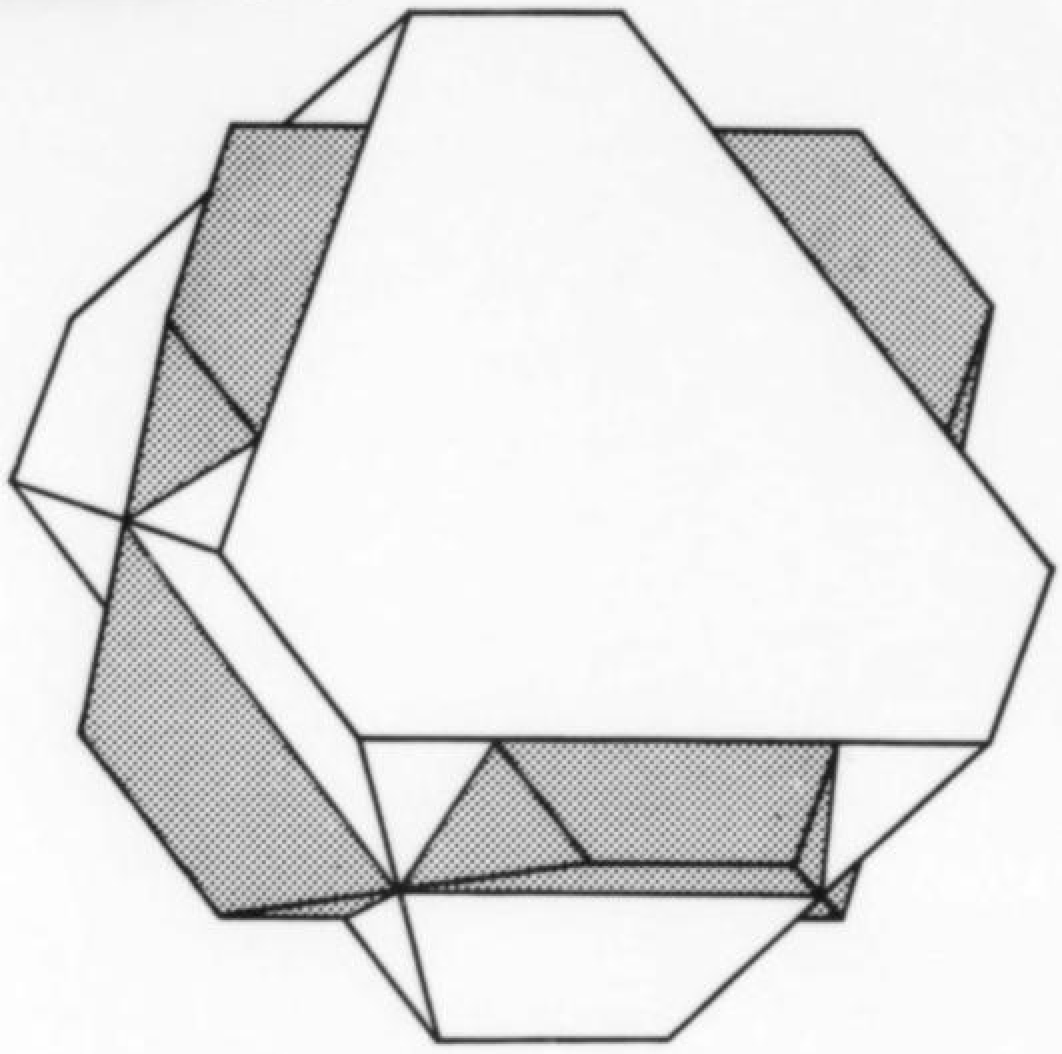
MINERALOGY

Uraninite occurs as single (Fig. 1) and interpenetrating octahedra up to 7 cm. Although some crystals are perfectly equant, many are flattened on {111}. Most of these flattened octahedra are interpenetration twins along the [111] axes (fluorite law) (Figs. 2, 3). The cube {100} and trapezohedron {114}, alone or together, are occasionally found modifying the octahedra (Fig. 4). Microprobe analysis of one crystal indicated the U:Th ratio to be 13:1, slightly higher than most uraninites of Grenville pegmatites and calcite dikes (Robinson & Sabina, 1955). The only compositional zoning detected was a slight increase in calcium content from the core to the outer edge.

Diopside is the most abundant of the well crystallized minerals in the dike. Chemical analysis (Table 1) showed the composition to be within the salite range (Deer, Howie, Zussman, 1962). It occurs as well formed, dark green prisms up to 20 cm across. Many are partially altered to amphibole, dulling their luster, but sharp, unaltered crystals are also abundant.

Figure 4. **Uraninite showing cubic, trapezohedral and octahedral faces (NMNS #41961). The crystal as viewed measures 15 x 12 mm.**

Figure 3. **An idealized drawing of an octahedron flattened on {111} and twinned about [111].**



Titanite is relatively uncommon, occurring as brown, lustrous, wedge-shaped crystals to 10 cm.

Phlogopite occurs as excellent tapering prisms to 8 cm across. It is dark-brown in color. Chemical analysis (Table 1) placed this mica well within the phlogopite compositional field (Deer, Howie & Zussman, 1962) with an Mg:Fe ratio of 9.53:1.

Amphibole occurs commonly as dark green, equant, prismatic crystals up to 3 cm across. Chemical analysis (Table 1) indicated these to be fluor-tremolite (Leake, 1978). Amphibole is also found as compact aggregates of blue acicular crystals and as thin fibrous coatings on pyrite crystals. EDS analyses of all three amphibole types indicated similar compositions except that the type associated with pyrite has a higher iron content making it actinolite.

Microcline is present as translucent, cream-colored blocky crystals to 4 cm.

Molybdenite occurs as small flakes throughout the calc-silicate rock and as tabular well formed crystals up to 8 cm across and 2 cm thick in the calcite dike.

Powellite is present as a green pulverulent replacement of molybdenite.

Wulfenite is occasionally observed as a white powdery coating on some uraninite crystals. This is an interesting occurrence, for it seems likely that wulfenite formed as an alteration product through the action of molybdic acid on radiogenic lead, although without an isotopic analysis this is uncertain.

Zircon is quite rare but can be found as sharp barrel-shaped crystals to 1 cm.

Other minerals that occur at the prospect include gypsum, pyrite, calcite, apatite, pyrrhotite and quartz.

Table 1. **Chemical Analyses of Gatineau Park minerals.**

Mineral	NMNS#	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	FeO	Fe_2O_3	MnO	TiO_2	P_2O_5	H_2O	F	O≡F	Sum
Diopside	**41975**	53.0	0.55	22.9	15.0	1.01	0.04	2.60	4.19	0.45	0.05	0.01	—	—	—	99.80
Phlogopite	**41654**	42.6	11.0	0.00	24.3	0.31	10.0	1.90	2.93	0.16	0.65	0.01	0.32	3.70	1.56	96.32
Tremolite	**41976**	54.8	1.47	10.2	20.7	3.04	0.96	2.60	3.93	0.35	0.08	0.06	0.65	2.33	0.98	100.19

ACKNOWLEDGEMENTS

The authors would like to thank the following staff members of the National Museums of Canada for their assistance: J. D. Grice for guidance and helpful suggestions, R. Williams for a critical review of the manuscript and G. Runnells for the mineral photographs. We appreciate the helpful assistance of George Plant of the Geological Survey of Canada for his microprobe analyses of the uraninites. The authors are indebted to the three collectors who first brought to the Museum's attention the existence of fine uraninite crystals at this locality: P. Collins, A. Hamilton and G. Van Velthuizen. We would like to express our appreciation as well to the National Capital Commission for allowing the Museum to collect in the park.

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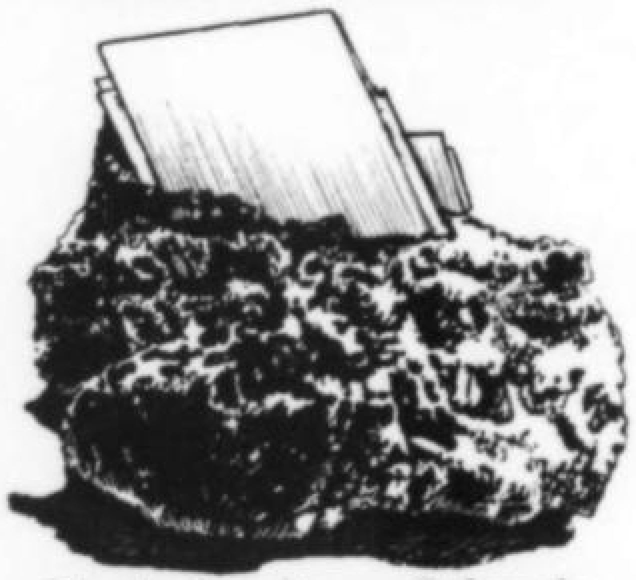

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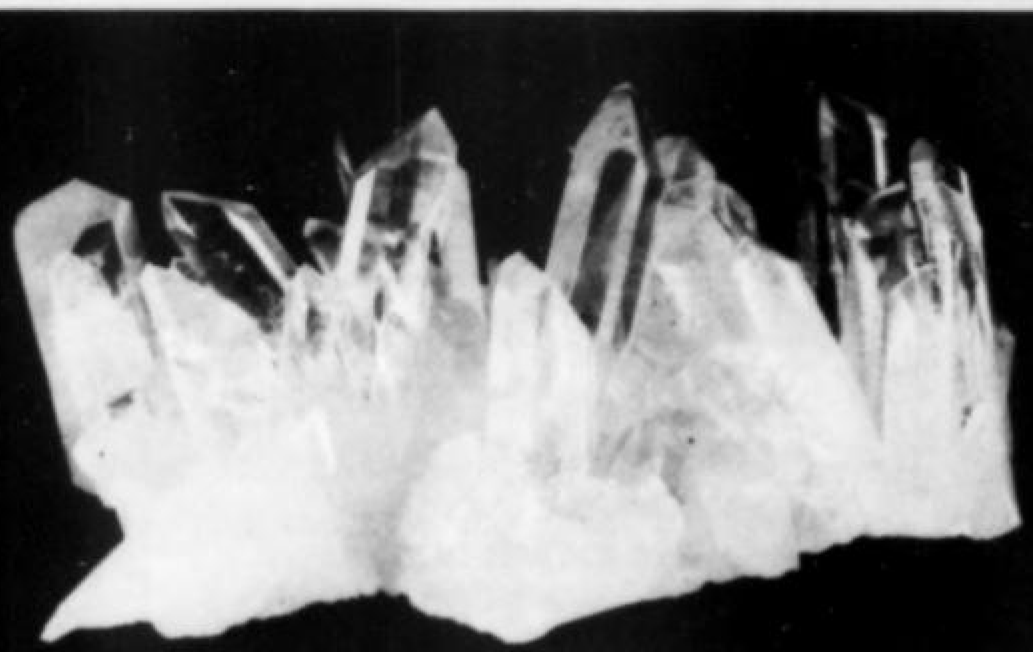

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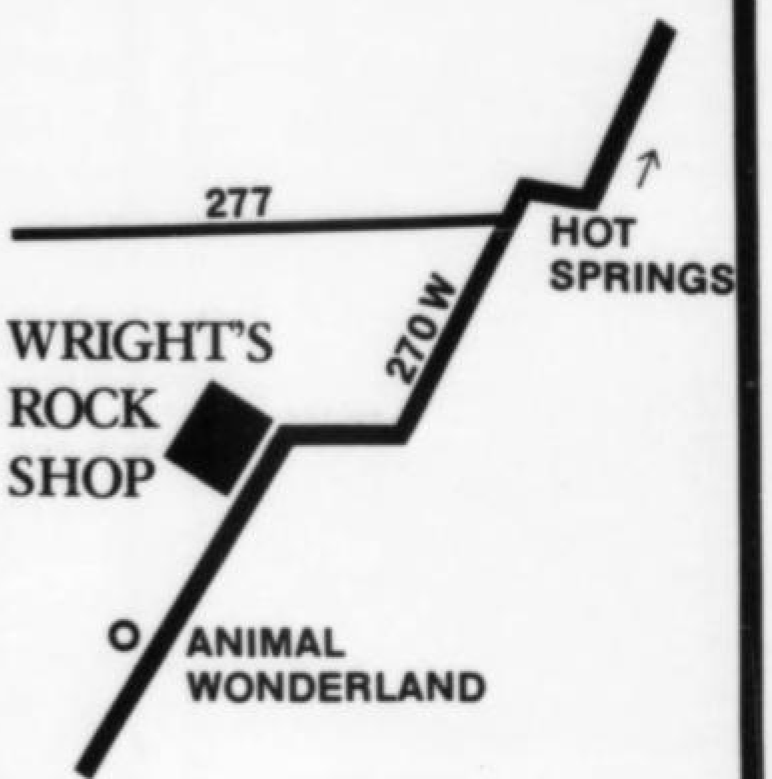

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Rare Fluorides
from a soda granite in the Oslo Region, Norway

by **Gunnar Raade**
Institutt for Geologi
Universitetet i Oslo
Blindern, Oslo 3, Norway

and **Jan Haug**
Elstadlia
2080 Eidsvoll, Norway

INTRODUCTION

A survey of the mineralogy of the miarolitic cavities in the plutonic rocks of the Oslo Region, Norway, has been published previously by Raade (1972). The present paper describes the interesting fluoride association of the soda granite (ekerite) in more detail. Since the 1972 paper appeared, three additional fluoride species were identified: pachnolite, ralstonite and neighborite. Apart from presenting a study of the fluorides by scanning electron microscopy (SEM), a comparison is also made with similar parageneses from Ivigtut (Greenland), Miask (the Urals) and St. Peter's Dome (Colorado). The fluorides reported from these occurrences are listed in Table 1. The term "rare fluorides" as used in this paper refers to the group of aluminofluorides, including some other associated fluorine-bearing species.

FLUORIDES FROM THE EKERITE

Ekerite is a local name from the Oslo Region for an alkali granite carrying aegirine and riebeckite. The fluoride mineralization is restricted to a small area along the border of an ekerite massif situated in the vicinity of Lake Gjerdingen, Nordmarka, north of Oslo. The ekerite is particularly rich in elpidite and astrophyllite at this locality and contains numerous miarolitic cavities and occasionally some pegmatitic patches. No detailed field work to determine the extension of the mineralized area has been made. The fluorides (Table 1) were all identified by the X-ray powder method. Other cavity minerals recently found at this locality (not listed by Raade, 1972) include sulfur, galena, marcasite, hematite, pyrophanite, rutile, goethite, rhodochrosite, bastnaesite, phlogopite, montmorillonite, a mineral related to nenadkevichite and a new mineral which, according to microprobe analysis, has the composition $Na_4Mn_4Ti_3Si_5O_{21}F_2$. The presence of titanite, catapleiite and zeophyllite as reported by Dietrich *et al.* (1965) has not been confirmed by us.

The individual fluorides and some other important fluorine-bearing minerals are described in more detail below. The size ranges of the crystals are not specifically mentioned in the text, but an idea can be gathered from the magnification of the pictures. Several of the mineral species found at Gjerdingen are well-suited for micromounting. All the fluorides are of late formation in the cavities, and can be considered equivalent to the zeolite suite found in cavities in syenites and biotite granite (Raade, 1972).

Sellaite is a very rare mineral at Gjerdingen. It is white and occurs in masses or sometimes as rough crystals in the form of flat, tetragonal bipyramids. It was unfortunately not possible to obtain a good SEM photograph of this mineral. The microcrystalline coatings on many of the cavity minerals were previously thought to be sellaite (Fig. 4 in Raade, 1972), but have later been shown to consist of ralstonite. Sellaite is otherwise a rather uncommon mineral, but has been reported from a variety of environments. In other occurrences it forms stubby prismatic to acicular crystals or fibrous aggregates.

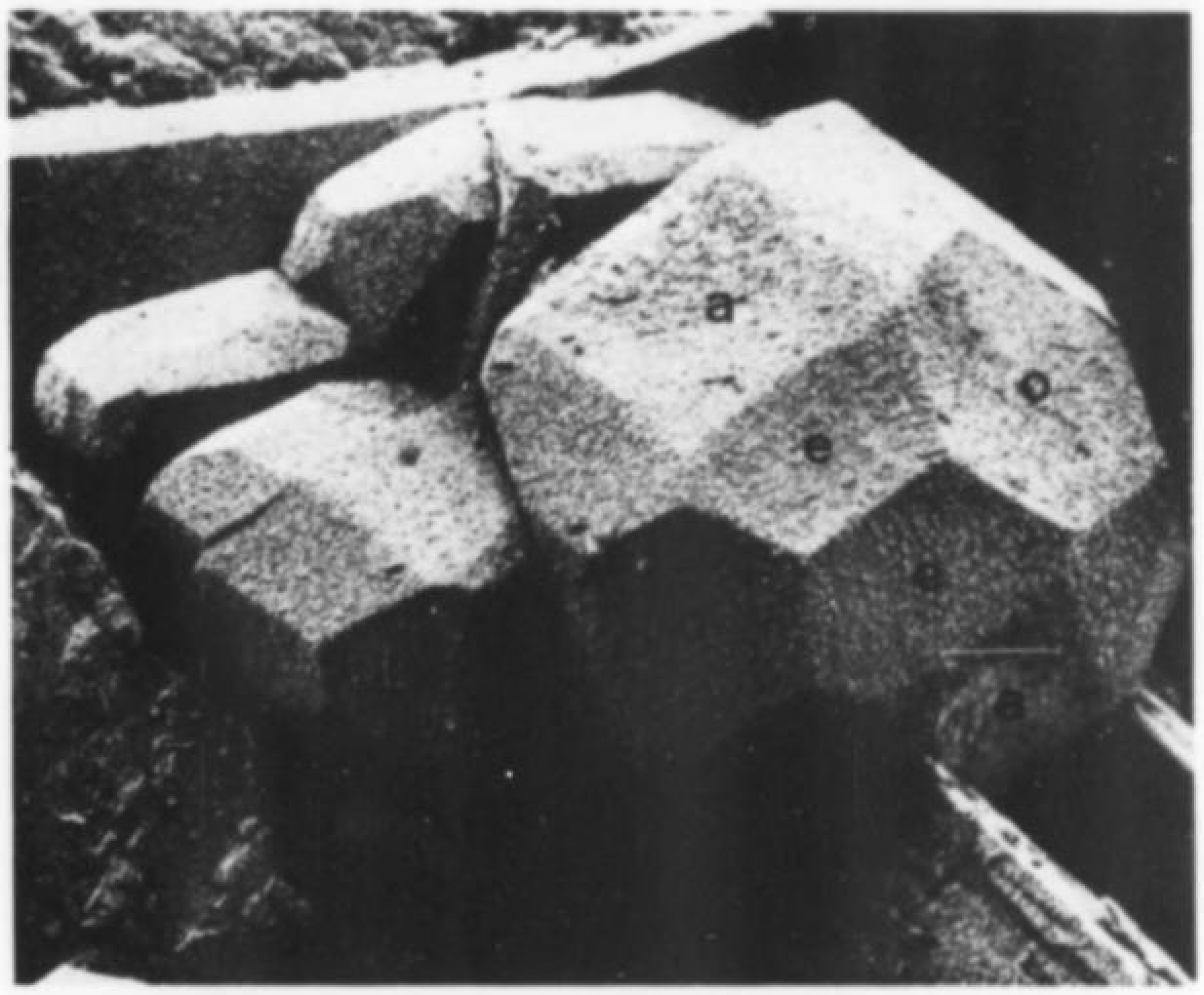

Figure 1. **Highly modified fluorite crystals (violet) showing cube *a*{100}, octahedron *o*{111} and a tetrahexahedron {hk0}, which is possibly *e*{210}. (SEM photo at 134x).**

Fluorite is of rather restricted occurrence; it is in fact less common than the aluminofluorides. It occurs as crystals with the octahedron dominant or may show more complex forms (Fig. 1). It is normally violet, but is sometimes colorless.

Gagarinite was originally described from granitic, metasomatized rocks in the U.S.S.R. It has recently been found in a riebeckite granite at Washington Pass, Okanogan County, Washington (un-

Figure 2. **A platy gagarinite crystal with irregular base $c\{0001\}$ and two hexagonal prisms, taken as $m\{10\bar{1}0\}$ and $a\{11\bar{2}0\}$. (SEM photo at 178x).**

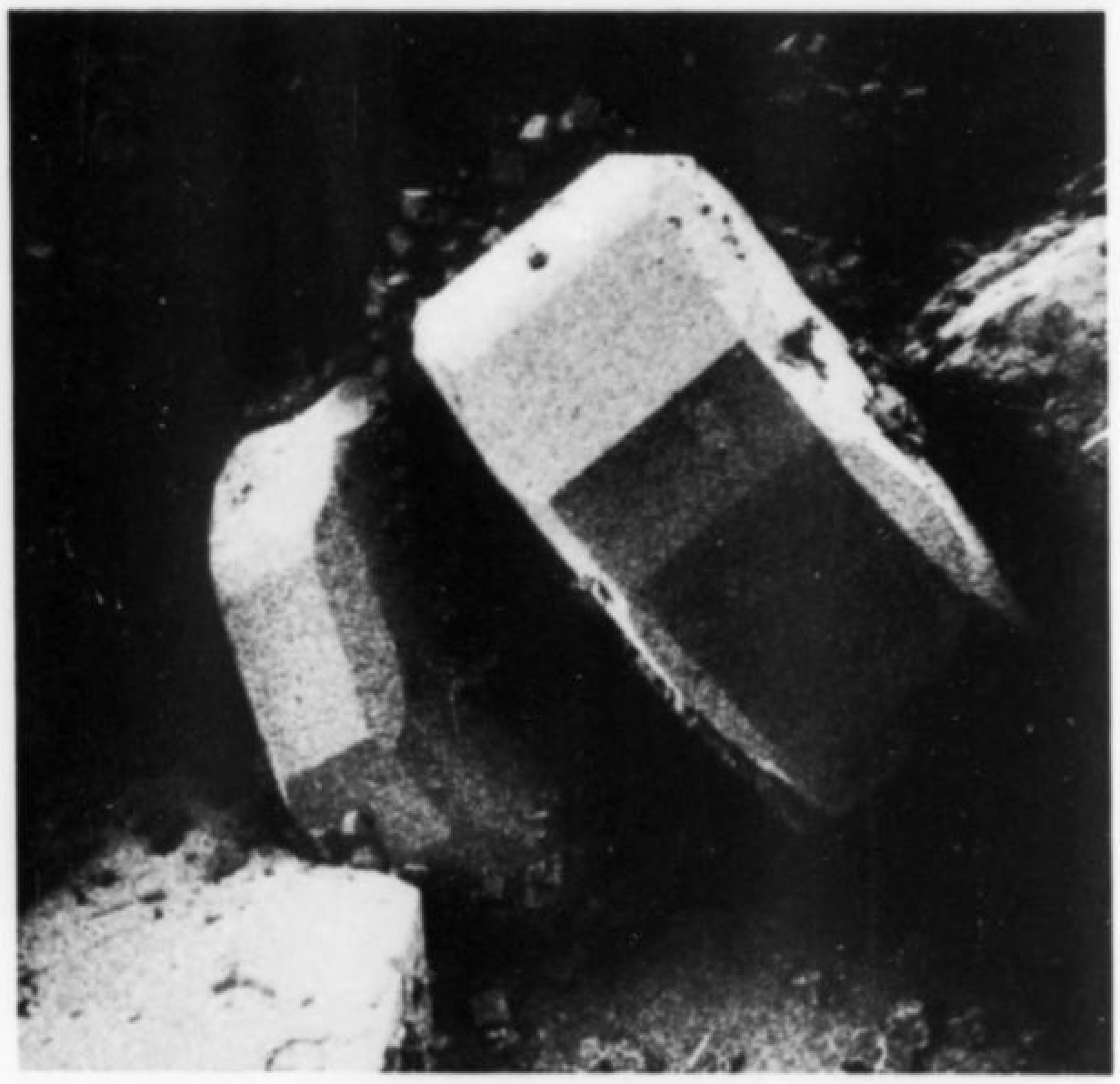

Figure 3. **Tabular gagarinite crystals displaying two hexagonal prisms and rhombohedral faces. The base is not developed (as seen on photos taken at other angles). The cubic mineral partly growing on gagarinite is probably ralstonite. (SEM photo at 204x).**

published, but advertised in this journal by Bart Cannon of Seattle, Washington). Gagarinite is quite wide-spread at the Gjerdingen locality. The color is typically a pale rose, in rare cases colorless. It occurs almost exclusively as crystals, only rarely is it found in massive form. The outline is always 12-sided, 6 alternating prism faces being normally less prominent than the other six. The crystals may be platy to tabular with somewhat irregular bases (Fig. 2), tabular to short-prismatic (Figs. 3, 4) or long-prismatic (Fig. 5). Rhombohedral faces are only partially developed, and none of the photographed crystals showed a complete termination, even where the crystal ends are apparently unattached to the matrix.

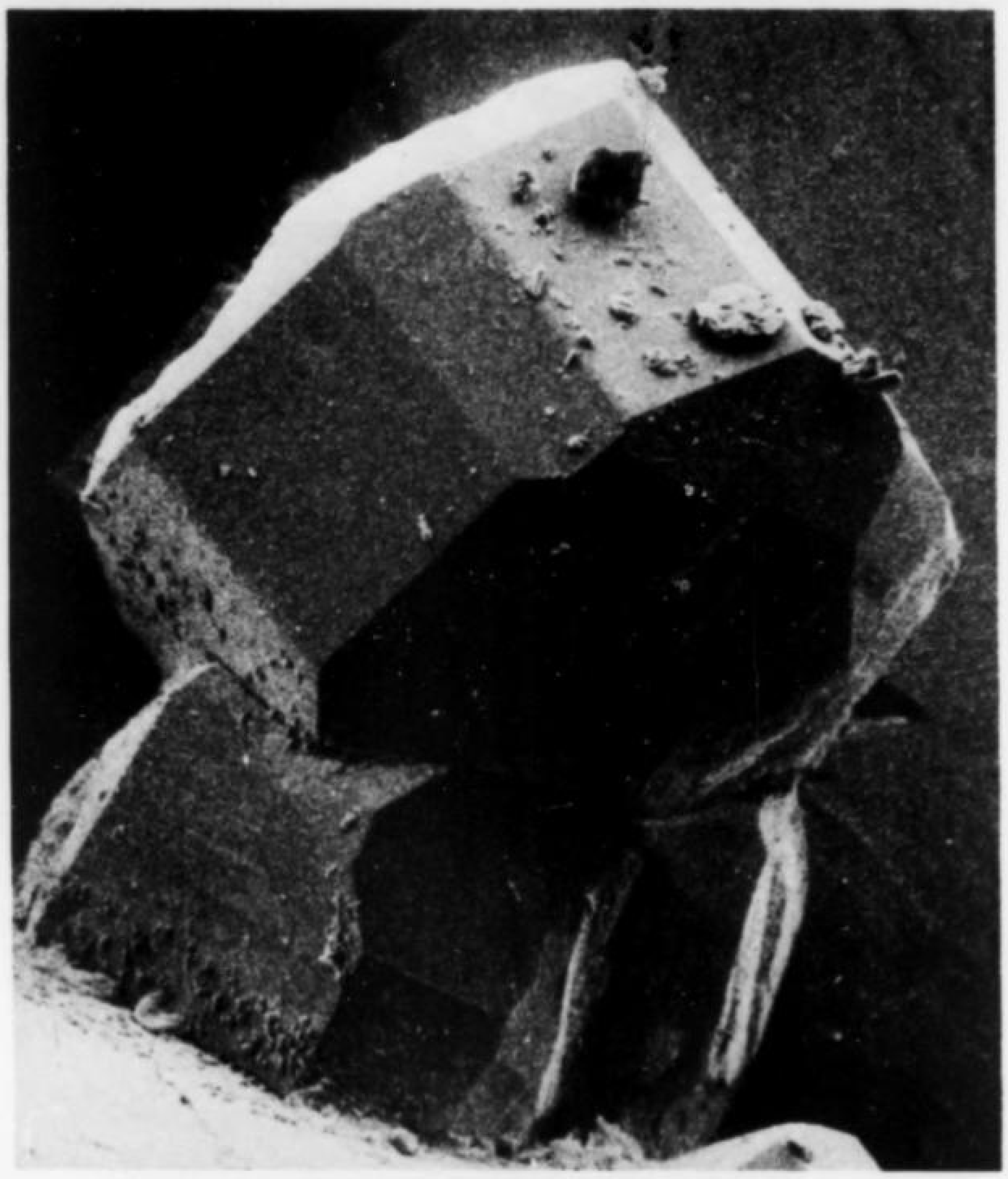

Figure 4. **Short-prismatic crystals of gagarinite with the same forms as in Figure 3. The crystals show no complete terminations. (SEM photo at 194x).**

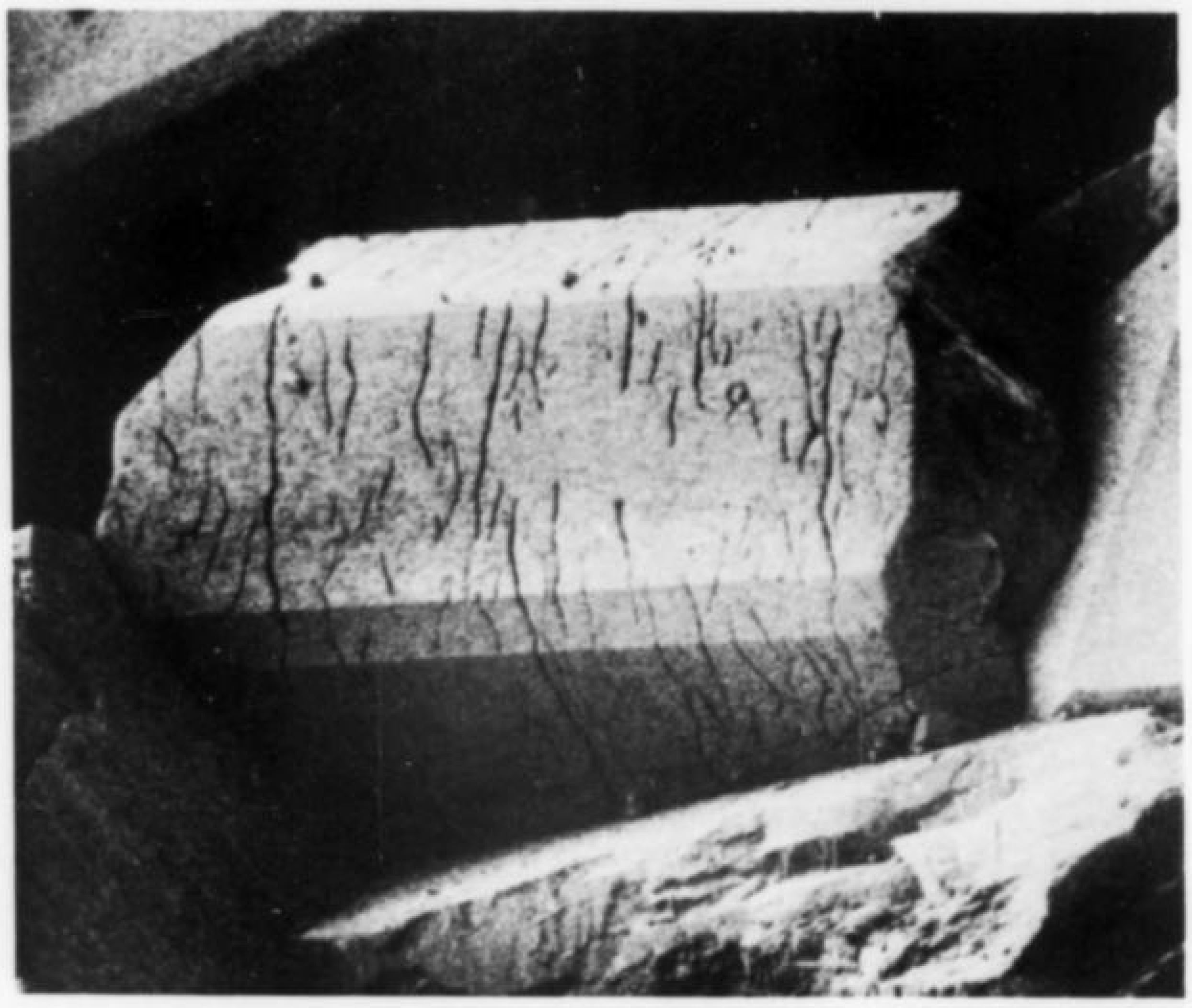

Figure 5. **A long-prismatic crystal of gagarinite with two hexagonal prisms, but non-terminated. Note natural cracks semi-parallel to (0001). (SEM photo at 148x).**

A special feature of the Gjerdingen paragenesis is the very common association of gagarinite and monazite. In a number of cases a single gagarinite crystal and a platy aggregate of monazite crystals can be observed in close proximity or even interpenetrating (Fig. 6).

***Figure 6.*A gagarinite crystal, long-prismatic, non-terminated as usual, in typical association with a group of platy monazite crystals (left). (SEM photo at 46x).**

This is an example of the natural separation of the rare earth elements, the monazite structure preferring the large cerium earths, while the smaller yttrium earths are taken up by gagarinite.

Gearksutite occurs rather commonly as white, chalk-like masses. In rare cases the color may be light rose. Individual crystals are not visible with a common microscope, and can only be seen at a magnification above approximately 2000x. The crystals are in the form of laths (Fig. 7).

***Figure 7.* Lath-shaped crystals of gearksutite as seen at high magnification. (SEM photo at 12,200x).**

Thomsenolite forms groups of tabular, white crystals (Fig. 8), similar to those from the Urals (Bøggild, 1913). From other localities, however, the crystals are usually columnar or may resemble cubes. Thomsenolite is often associated with younger ralstonite (Fig. 9). The association of thomsenolite with sellaite has also been observed.

Pachnolite crystals are columnar with basal terminations. They form a network with two different orientations of the crystals at right angles (Fig. 10). Pachnolite and thomsenolite, which are dimorphous and may resemble each other very much, are thus at this locality easily distinguished by their crystal shapes and the appearance of the aggregates. Small crystals of ralstonite are almost ubiquitously grown on pachnolite prisms. General forms {hkl}, commonly developed on pachnolite from other occurrences, are

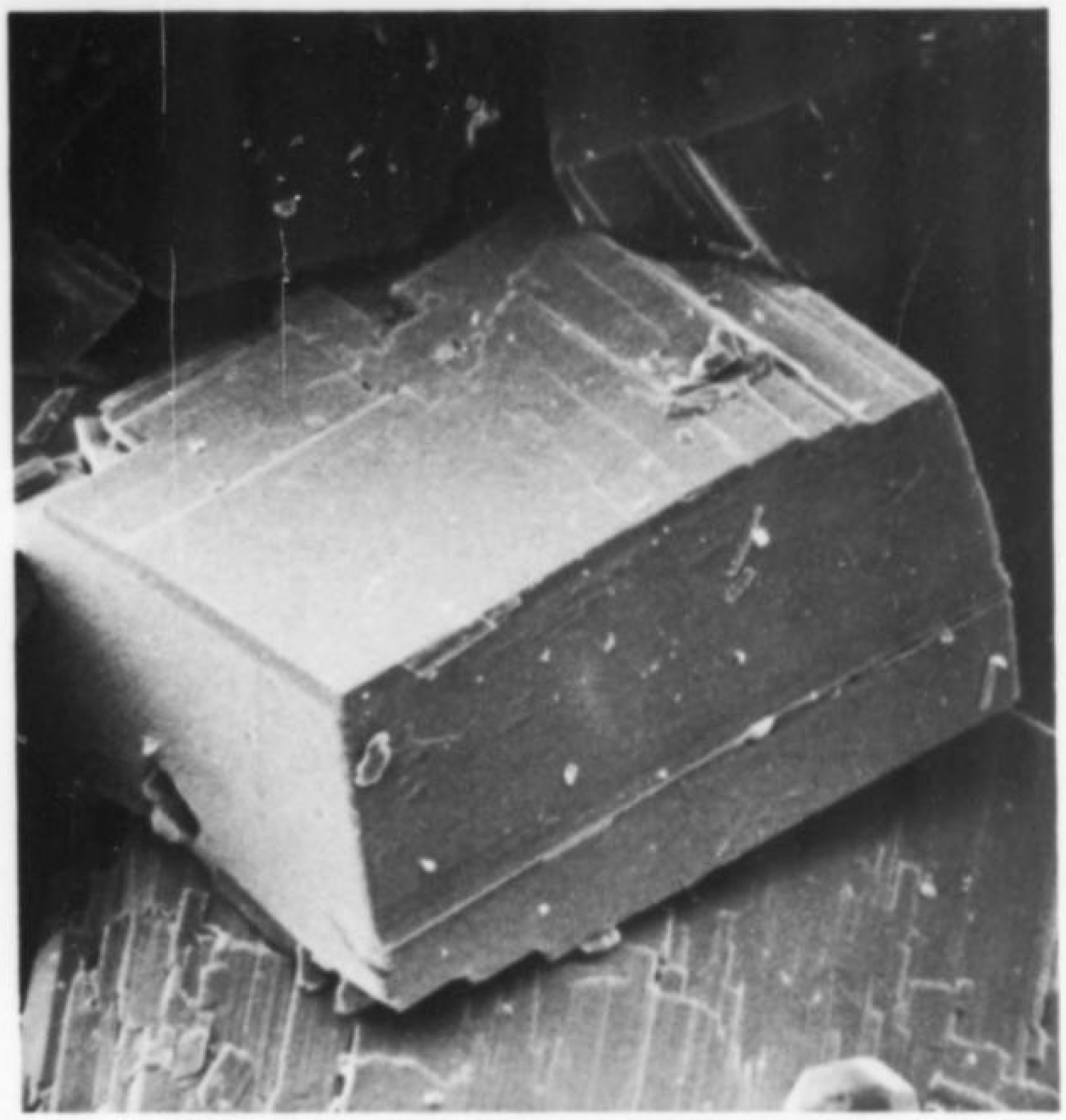

***Figure 8.* A tabular thomsenolite crystal showing basal pinacoid *c*{001} and prism *m*{110}, modified by a general prism {hkl}. The "spherical crystal" in the foreground is ralstonite. (SEM photo at 1730x).**

***Figure 9.* Blocky thomsenolite crystals in association with ralstonite of unusual habit: cube *a*{100} and dodecahedron *d*{110}. (SEM photo at 1330x).**

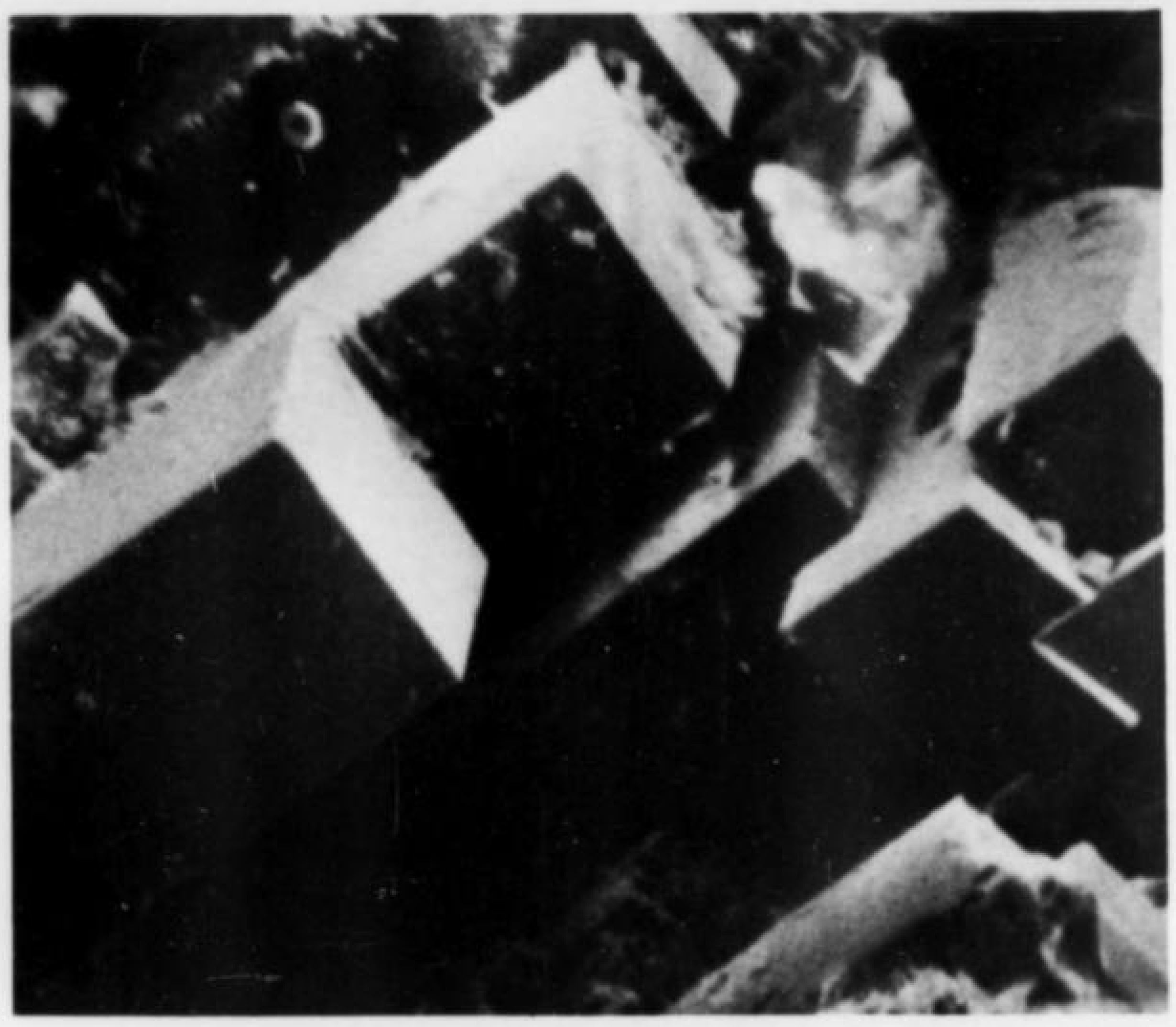

***Figure 10.* Columnar crystals of pachnolite with two different orientations, forming a network. Crystals show basal pinacoid *c*{001} and prism *m*{110} and are apparently untwinned. (SEM photo at 1870x).**

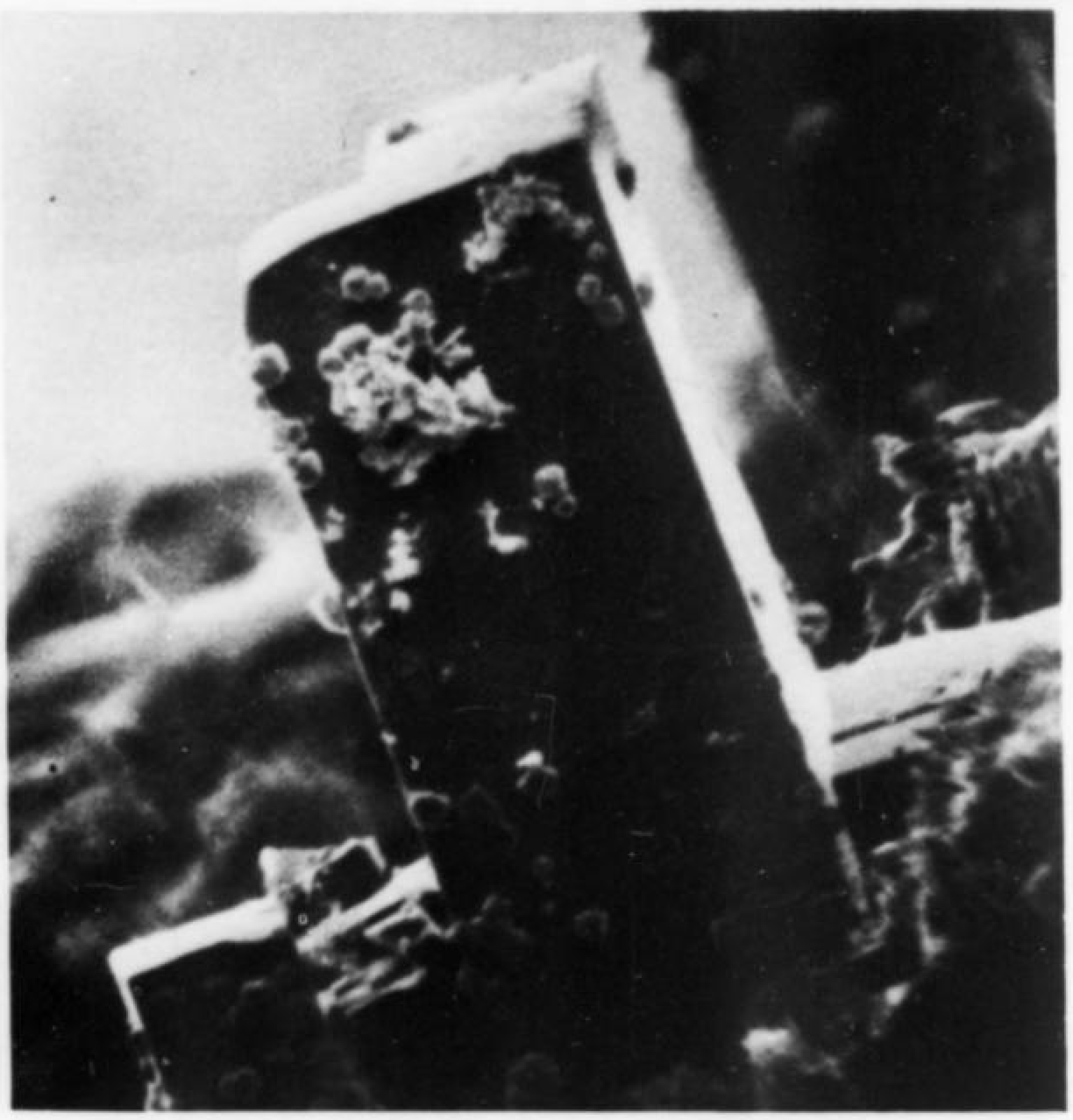

***Figure 11.* Pachnolite crystal modified by faces of general form {hkl} (upper left edge). Small ralstonite crystals are seen on the surface. (SEM photo at 2040x).**

only rarely seen on the Gjerdingen material (Fig. 11). Since these faces are not repeated on all four sides of the crystals, it can be inferred that the Gjerdingen crystals are untwinned (pachnolite has crystal symmetry 2/*m* or *m* and is often twinned on {100}). The crystallography of thomsenolite and pachnolite has been treated in great detail by Krenner (1883), Bøggild (1913) and Ferguson (1946).

Ralstonite is the most common fluoride of the Gjerdingen locality. Three major modes of occurrence may be distinguished. *(1)* Ralstonite occurs in massive form filling interstices between feldspar crystals. The color is usually various shades of green, occasionally white. Natural surfaces may be microcrystalline (Fig. 12). It also forms white, botryoidal growths, sometimes resembling

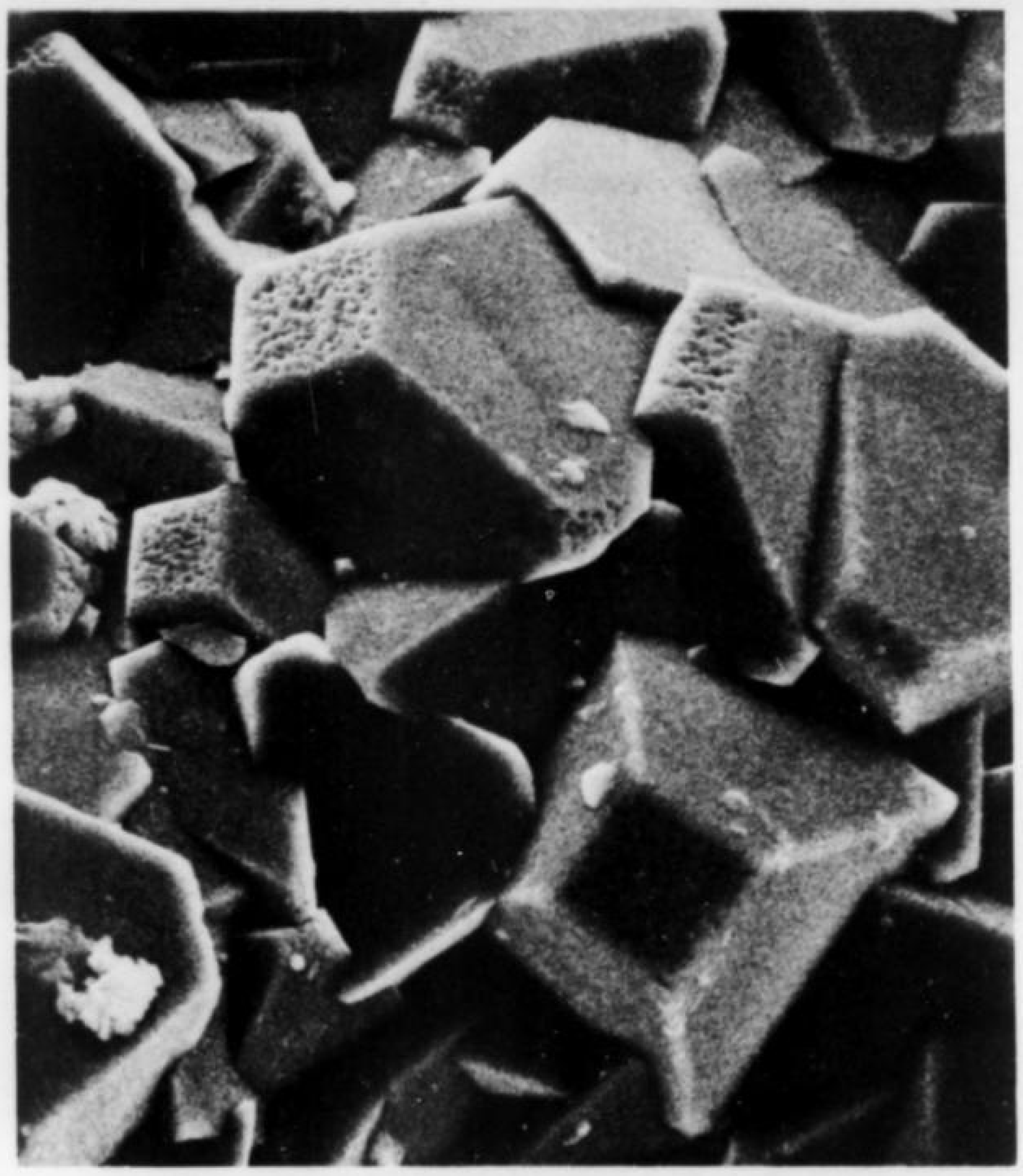

***Figure 12.* Ralstonite crystals from the surface; green, massive variety. The octahedron is dominant, in combination with cube faces showing pitted surfaces (see text). (SEM photo at 3060x).**

opal. *(2)* Microcrystalline coatings of ralstonite are very common on the other minerals, e.g. on pachnolite, quartz, anatase, brookite, aegirine (Fig. 13) and ramsayite (Figs. 14, 15). *(3)* In some parts of the ekerite, ralstonite occurs as relatively large white cubes (Fig. 16).

Ralstonite is one of the latest minerals to crystallize in the cavities, although the various forms mentioned above could be of different generations, and its precipitation might have spanned a certain temperature/time interval. Sellaite aggregates have been observed as a younger mineral, growing on white ralstonite cubes; on the other hand, microcrystalline ralstonite is found as a coating on sellaite. However, the detailed paragenetical sequence of all the cavity minerals has yet to be worked out, and the topic is reserved for a separate paper.

The crystal habit of ralstonite is varied. It may occur in the form of cubes, only slightly truncated by octahedral faces (Fig. 16), or as cubes with the octahedron more or less prominently developed (Figs. 14, 15). Sometimes the octahedron is dominant, with smaller cube faces (Fig. 12), or the crystal may be cuboctahedral (Fig. 13). The cuboctahedrons shown in Figure 13 are slightly modified by the dodecahedral form {110}. Cubic crystals of ralstonite modified by the dodecahedron are seen in Figure 9. To the authors' knowledge the form {110} has not previously been reported for ralstonite.

Normally, the crystal faces of ralstonite are well developed, but on some crystals the cube faces may be strongly pitted, whereas the octahedral faces are perfectly even (Figs. 12, 14). Whether this phenomenon is caused by growth or dissolution is hard to decide. For the crystals shown in Figure 12 we are more inclined to explain it as the result of a dissolution process, which is normally of vectorial character. The surface structure of the crystal shown in Figure 14 is, however, somewhat different, and in this case it could be explained as a growth phenomenon, the cube faces growing much more rapidly than the octahedral faces.

According to Pabst (1939), ralstonite has a pyrochlore structure with varying amounts of sodium and magnesium: $Na_xMg_xAl_{2-x}$

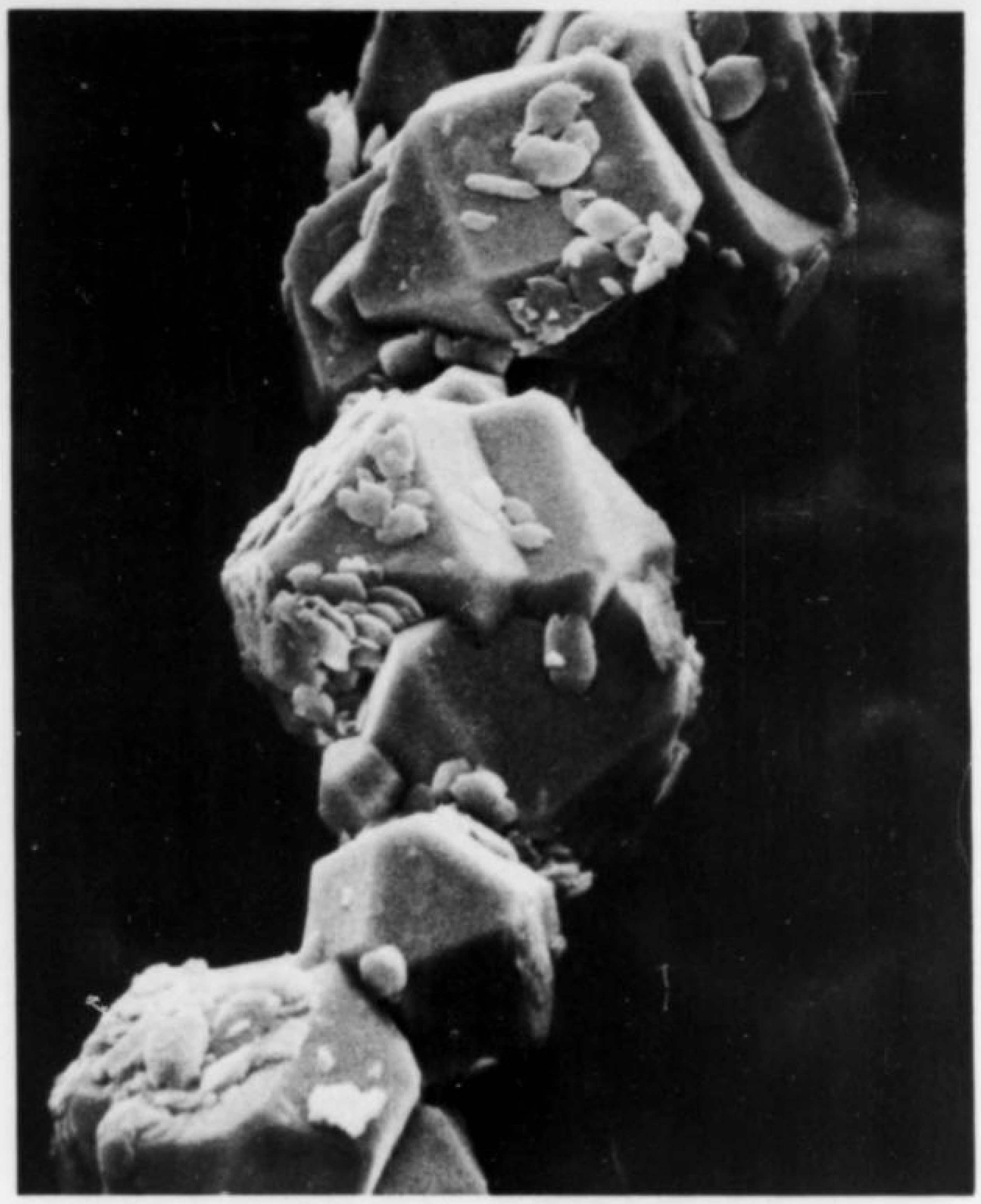

Figure 13. **Ralstonite crystals growing on an aegirine needle (unexposed). The cube and octahedron are equally developed; note also the small dodecahedral faces at the corners. The mineral on the surface is unknown. (SEM photo at 3060x).**

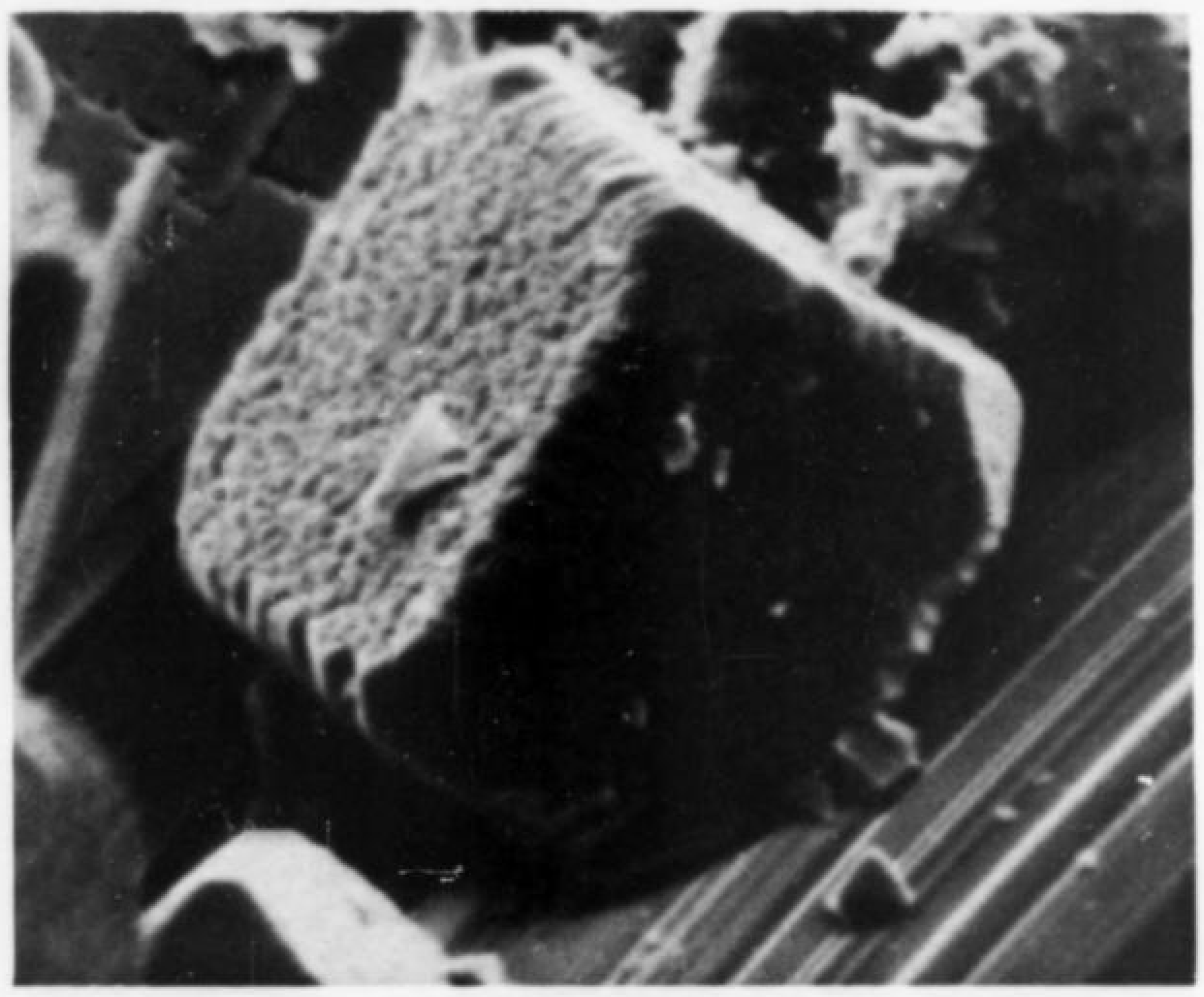

Figure 14. **A cubic ralstonite crystal modified by the octahedron, growing on ramsayite (striated mineral). Note the uneven cube faces, as opposed to the smooth octahedral faces, and repetition of octahedral faces along the edges (see text). (SEM photo at 5600x).**

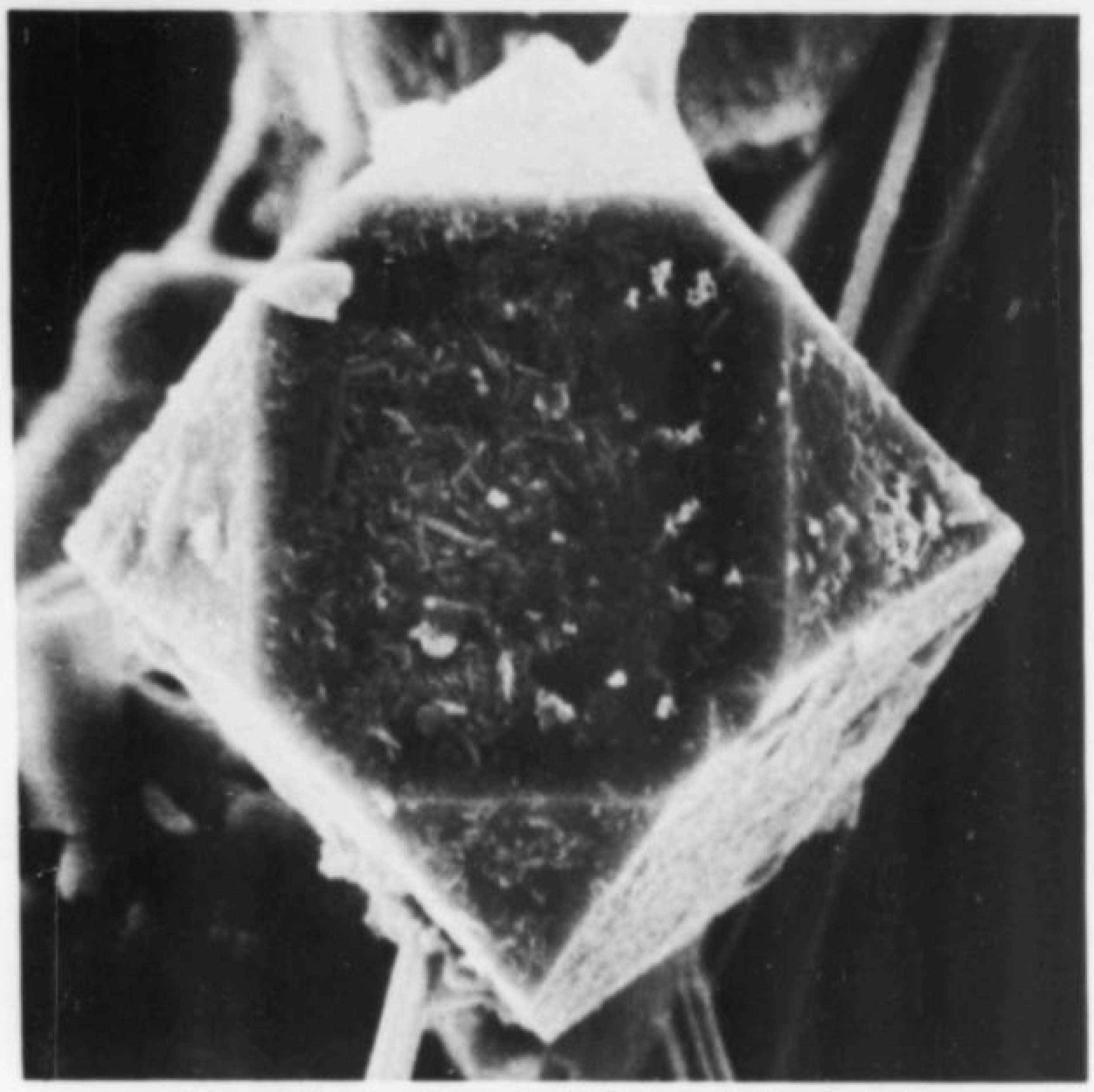

Figure 15. **A cuboctahedral crystal of ralstonite growing on ramsayite needles. Note the repeated formation of octahedral faces resulting in a re-entrant angle (upper right edge). (SEM photo at 6300x).**

Figure 16. **A white cube of ralstonite, only slightly truncated by the octahedron. (SEM photo at 306x).**

$(F,OH)_6 \cdot H_2O$, where magnesium substitutes for aluminum and sodium goes into interstitial positions. Pauly (1965) has established an interesting relation between the crystal habit of ralstonite and its chemical composition, the latter being reflected in variations of cell dimension and refractive index. Crystals showing the cube as the dominating form seem to contain more sodium and magnesium than the octahedral crystals. The very small size of most of the ralstonite crystals from Gjerdingen (the crystal habit is, in many cases, only visible with the electron microscope) makes it difficult to test Pauly's result. However, cell dimensions calculated from powder data for massive ralstonite gave a = 9.99(1) Å (white; two samples) and a = 10.01(2) Å (green), indicating high contents of sodium and magnesium.

Neighborite was described as a new mineral of authigenic origin from the Green River formation of Utah (Chao *et al.*, 1961). It was later reported from metasomatites in the Urals (Efimov *et al.*, 1967) and in eastern Siberia (Arkhangel'skaya, 1973). It must be regarded as a very rare mineral. In the Gjerdingen locality it occurs in a special variety of ekerite, which is somewhat finer grained than the common type, contains fewer and smaller cavities and has a darker color. Neighborite forms simple cube-like crystals, more or less elongated, which are colorless to weakly brownish (Fig. 17). Modifying faces were observed in one case only (Fig. 18). It should be noted that in the other known occurrences, neighborite is found as rounded grains or octahedral crystals. Multiple transformation twinning is observed on most of the Gjerdingen crystals, often as two sets of twinning striations at right angles, and serves to distinguish the mineral from others of similar form. The Gjerdingen neighborite is often associated with rhodochrosite of similar, brownish color, and a late generation of zircon in the form of yellow, flat bipyramids. Well formed crystals of rhodochrosite are easily distinguished from neighborite, but rhodochrosite cleaves with more difficulty.

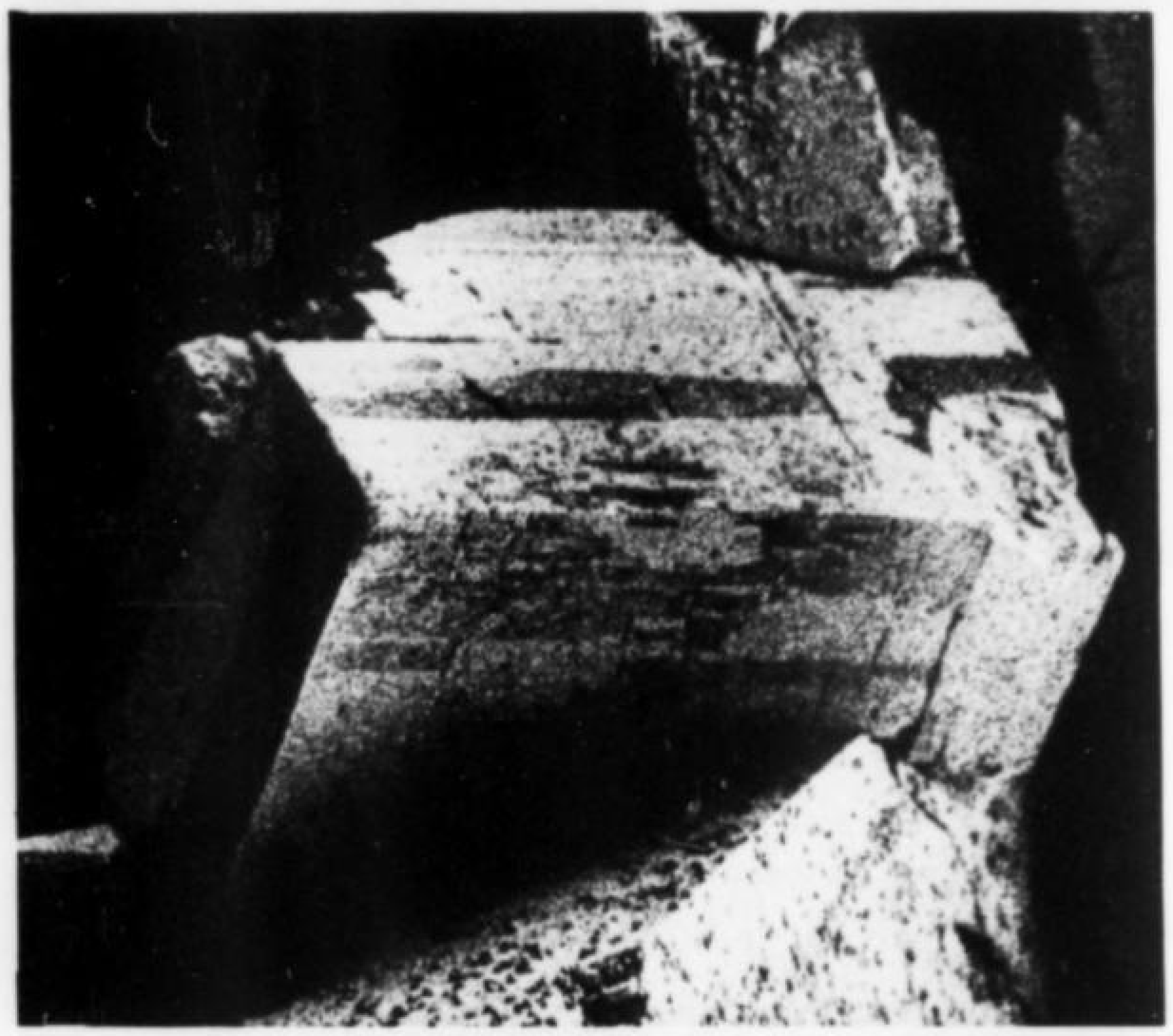

Figure 17. **A neighborite crystal showing multiple transformation twinning (tetragonal → orthorhombic). (SEM photo at 125x).**

Figure 18. **A neighborite crystal of definite orthorhombic symmetry *mmm*, with forms interpreted as prism {101} and two pinacoids (see text). (SEM photo at 112x).**

The neighborite crystals have inverted from a tetragonal (pseudocubic) form to a structure with orthorhombic symmetry, with resulting micro-twinning on $\{101\}_{\mathrm{orth}}$ (Lewis and Bright, 1971). Heating experiments indicate a transition temperature of 760°C (Chao *et al.*, 1961). This temperature will be considerably lowered under high water pressures, but the relation has not been determined experimentally.

The crystal shown in Figure 18 is puzzling, in that the symmetry is definitely orthorhombic *mmm*, yet twinning striations seem to be present. It could be that this crystal started to grow with a tetragonal structure and completed crystallization slightly below the inversion point, resulting in an orthorhombic shape and inversion of the tetragonal part of the crystal. However, what looks like twinning striations might in fact be growth striations resulting from a repetition of the form {101} on one of the pinacoids, which means that in this case the crystallization took place completely within the stability field of the orthorhombic, low-temperature form.

Neighborite does not belong to the normal aluminofluoride parageneses (Table 1), but the mineralogy of both the Green River formation and the eastern Siberia occurrence shows striking similarities with the mineralogy of the ekerite cavities. From the Green River formation enigmatic authigenic minerals like labuntsovite (related to nenadkevichite), elpidite, catapleiite and acmite have been reported, as well as the occurrence of cryolite (Milton, 1977). Associated minerals from eastern Siberia include fluorite, tysonite, cryolite, weberite, ralstonite, pachnolite and, interestingly, even gagarinite and monazite (Arkhangel'skaya, 1973).

Bastnaesite occurs in three principal ways at Gjerdingen. *(1)* It is present as yellow spherulites growing on other minerals; *(2)* it forms pseudomorphs after octahedral pyrochlore crystals; and *(3)* it occurs as pseudomorphs after zircon in flat, bipyramidal form.

Phlogopite (polytype $2M_1$) occurs as a rarity in the same variety of ekerite as neighborite. It forms platy aggregates (Fig. 19), the plates sometimes having distinct six-sided outlines. The mineral is colorless to white, strongly resembling muscovite, and can thus be regarded as practically iron-free. Obviously formed in fluorine-rich surroundings, it can be expected to be close to fluorphlogopite in composition, a phase which has been synthesized under hydrother-

Figure 19. **Sub-parallel plates of colorless phlogopite $2M_1$. (SEM photo at 100x).**

mal conditions at moderate HF fugacities (Munoz and Eugster, 1969).

COMPARISON WITH OTHER OCCURRENCES

In Table 1, the fluoride paragenesis of the Gjerdingen locality is compared with three "classical" occurrences of rare fluorides, namely Ivigtut (Greenland), Miask (the Urals) and St. Peter's Dome (Colorado). Salient similarities and differences are apparent from the table. Minerals common to all four occurrences are fluorite, gearksutite, thomsenolite, pachnolite and ralstonite. The magnesium-rich phases sellaite, neighborite and phlogopite are unique to the Gjerdingen occurrence, as is gagarinite. The strontium-rich phases jarlite, stenonite and bøggildite are characteristic for the Ivigtut paragenesis. Elpasolite, containing potassium, is only found at St. Peter's Dome. The Miask locality does not seem to contain any unusual fluorides.

The characteristic cations of the fluorides from these localities are tabulated below:

Gjerdingen	Al	Ca	Na	K	—	—	**Mg**	**Y**	Ce
Ivigtut	Al	Ca	Na	—	**Li**	**Sr**	Mg	—	—
Miask	Al	Ca	Na	—	**Li**	—	Mg	—	—
St. Peter's Dome	Al	Ca	Na	**K**	—	—	Mg	—	Ce

Four cations are common to all: Al^{3+}, Ca^{2+}, Na^+ and Mg^{2+} (in ralstonite), although the number of Mg^{2+}-bearing phases is largest at Gjerdingen. K^+ is characteristic for St. Peter's Dome, Li^+ for Ivigtut and Miask, Sr^{2+} for Ivigtut, and the yttrium earths for Gjerdingen.

In all these localities, the fluorides have formed at a late- or post-magmatic stage of granite evolution. It is typical that cryolite is a primary mineral, partly replaced by secondary aluminofluorides like ralstonite, pachnolite and thomsenolite. However, this is not the case for Gjerdingen; at least, no primary cryolite has been found so far. The possibility of initial cryolite formation with subsequent breakdown cannot be ruled out completely, but it is more probable that the various aluminofluorides crystallized as primary hydrothermal phases at Gjerdingen.

Although occurrences of cryolite and other aluminofluorides are commonly found in conjunction with post- or non-orogenic, sodic granite intrusions, often associated with regional faulting, it should be noted that some of these minerals are also known from other environments, e.g. in late hydrothermal formations associated with carbonatites (Golden, Colorado; and Francon, Quebec), in fumarole and thermal spring deposits, and of assumed authigenic origin (Green River formation, western U.S.A.). The reader is referred to the comprehensive review articles on fluorine in granitic rocks and melts and on the formation of cryolite and other aluminofluorides by Bailey (1977 and in press).

We should also like to mention some rare aluminofluorides described from the oxidation zone of various fluorite-rich ore deposits in the U.S.S.R. These are hitherto not known from the cryolite deposits of granitic origin, but at least some of them could be expected to be found in such deposits considering their chemical compositions:

Calcjarlite		
	$Na(Ca,Sr)_3Al_3(F,OH)_{16}$ (or perhaps $Na(Ca,Sr)_2Al_2F_{11} \cdot H_2O$, see footnote to Table 1)	monoclinic
Chukhrovite		
	$Ca_3(Y,Ce)Al_2(SO_4)F_{13} \cdot 10H_2O$	cubic
Tikhonenkovite		
	$SrAlF_4(OH) \cdot H_2O$	monoclinic
Usovite		
	$Ba_2MgAl_2F_{12}$	orthorhombic (?)
Yaroslavite		
	$Ca_3Al_2F_{10}(OH)_2 \cdot H_2O$	orthorhombic

The more wide-spread mineral creedite, $Ca_3Al_2(SO_4)(F,OH)_{10} \cdot$

Table 1. **Survey of rare fluorides from four world-wide occurrences.**

			1 Norway	2 Greenland	3 Urals	4 Colorado
Sellaite	MgF_2	tetragonal	X			
Fluorite	CaF_2	cubic	X	X	X	X
Gagarinite	$NaCaYF_6$	hexagonal	X			
Tysonite (Fluocerite)	$(Ce,La)F_3$	hexagonal				(X)
Prosopite	$CaAl_2(F,OH)_8$	monoclinic		X	X	X
Cryolithionite	$Na_3Li_3Al_2F_{12}$	cubic		X	X	
Cryolite	Na_3AlF_6	monoclinic		X	X	X
Elpasolite	K_2NaAlF_6	cubic				X
Jarlite	$NaSr_3Al_3(F,OH)_{16}$*	monoclinic		X		
Gearksutite	$CaAl(OH)F_4 \cdot H_2O$	monoclinic	X	X	X	X
Thomsenolite	$NaCaAlF_6 \cdot H_2O$	monoclinic	X	X	X	X
Pachnolite	$NaCaAlF_6 \cdot H_2O$	monoclinic	X	X	X	X
Chiolite	$Na_5Al_3F_{14}$	tetragonal		X	X	
Weberite	Na_2MgAlF_7	orthorhombic		X		X
Ralstonite	$Na_xMg_xAl_{2-x}(F,OH)_6 \cdot H_2O$	cubic	X	X	X	X
Neighborite	$NaMgF_3$	orthorhombic	X			
Stenonite	$Sr_2Al(CO_3)F_5$	monoclinic		X		
Bastnaesite	$(Ce,La)(CO_3)F$	hexagonal	X			(X)
Bøggildite	$Na_2Sr_2Al_2(PO_4)F_9$	monoclinic		X		
Phlogopite 2M$_1$	$KMg_3(AlSi_3)O_{10}(F,OH)_2$	monoclinic	X			

1. Gjerdingen, Nordmarka, N of Oslo, Norway (Dietrich *et al.*, 1965; Sæbø, 1966; Raade, 1972; this paper).
2. Ivigtut, Greenland (Bøggild, 1953; Pauly, 1956; Pauly, 1962).
3. Miask, Ilmen Mountains, the Urals, USSR (literature survey by Bailey, in press).
4. St. Peter's Dome, El Paso County, Colorado, USA (Cross and Hillebrand, 1885; Eckel, 1961).

*This original formula is not consistent with cell volume and density (*cf.* Ferguson, 1949). A calculated density which equals the measured density (3.87 g/cm^3 by Ferguson, 1949) is given by the formula $NaSr_2Al_2F_{11} \cdot H_2O$ with $Z = 6$ (*cf.* Strunz, 1970). Ramdohr and Strunz (1978) assign the composition $NaSr_2[AlF_6]_2$, but the charges of this formula are unbalanced.

$2H_2O$, monoclinic, also belongs to this group of minerals, with a similar mode of occurrence.

As mentioned above, a special geochemical feature of the Gjerdingen fluoride paragenesis is the occurrence of several Mg-rich phases (sellaite, ralstonite, neighborite, phlogopite). There are indications that this late-stage concentration of Mg is at least partly due to contamination of the ekerite by incorporation of xenolithic material. Especially neighborite and phlogopite occur in a relatively dark and dense variety of ekerite, which sometimes contains "ghostly remnants" of partly digested xenoliths, the nature of which has not been determined. The presence of phlogopite in this fluoride suite is particularly interesting. Its formation is thought to be controlled chiefly by the chemical environment, depending on the simultaneous availability of Si and K together with Mg and F at low temperatures. Here again, contamination processes may be a clue to this particular feature.

APPENDIX: *THE RELATION BETWEEN THE CRYSTAL STRUCTURES OF NEIGHBORITE AND CRYOLITE*

During this study, a remarkably close resemblance between the X-ray powder patterns of neighborite and cryolite was noted. The *d*-spacing values for cryolite are somewhat larger, indicating a larger unit cell, but the relative positions and intensities of the reflections are otherwise comparable. A structural similarity between these two minerals was rather unexpected, and the resemblance of their powder patterns might be fortuitous. However, the unit-cell dimensions are closely related (interchanging *b* and *c*):

Neighborite, $NaMgF_3$, *Pcmn,* $Z = 4$,
a 5.363, *b* 7.676, *c* 5.504 Å (Chao *et al.*, 1961).
Cryolite, Na_3AlF_6, $P2_1/n$, $Z = 2$, *a* 5.46, *b* 5.61,
c 7.80 Å, β 90°11' (von Naráy-Szabó and Sasvári, 1938).

Projections of the structures are shown in Figure 20. Neighborite has a perovskite structure, cubic above 900°C, tetragonal between 900° and 760°C, and orthorhombic below 760°C (Chao *et al.*, 1961). The Mg atoms are surrounded by six F atoms, and the Na atoms occur in 12-coordination in the ideal cubic structure, but this is reduced to eight- or six-coordination in the distorted low-temperature forms. The cryolite structure was worked out by von Naráy-Szabó and Sasvári (1938), who have chosen axes in such a way that the angle β is nearly 90°. Each Al atom is surrounded by a nearly regular octahedral configuration of six F atoms. Two Na atoms at symmetry centers are six-coordinated with Na-F distances from 2.23 to 2.32 Å, four Na atoms in general positions are surrounded by an irregular group of six F atoms at distances from 2.21 to 2.68 Å.

In Figure 20 the F atoms, which occupy the largest volumes of the unit cells, are omitted for clarity and only the metal atomic positions are shown. However, considering the metal-fluorine coordinations discussed above, an inspection of this figure clearly demonstrates the similarity between the two structures, that of cryolite showing a higher degree of distortion relative to the neighborite structure. Half of the Mg atoms in neighborite, $4[NaMgF_3]$, can be considered replaced by Al atoms in cryolite, $2[Na_3AlF_6]$, and the other half by Na atoms, situated at symmetry centers. The other Na atoms in general positions in the cryolite structure are equivalent to the Na atoms in neighborite. Since the "substitution" of $2Mg^{2+}$ (radius 0.65 Å) by $1Na^+$ (0.95 Å) and $1Al^{3+}$(0.50 Å) involves ions of rather different sizes, it is reasonable that the symmetry is lowered from orthorhombic to monoclinic. It should be noted that the sums of the radii are not very different ($\Sigma 2Mg^{2+}$ = 1.30 Å *versus* $\Sigma\ 1Na^+ + 1Al^{3+}$ = 1.45 Å or $\Sigma 3Mg^{2+}$ = 1.95 Å *versus* $\Sigma\ 2Al^{3+} + 1Na^+$ = 1.95 Å). The correct structural chemical formula for cryolite should be written Na_2NaAlF_6, pointing out the two different Na sites in the structure. Above 550°C the cryolite structure is cubic with *a* 7.95 Å and $Z = 4$.

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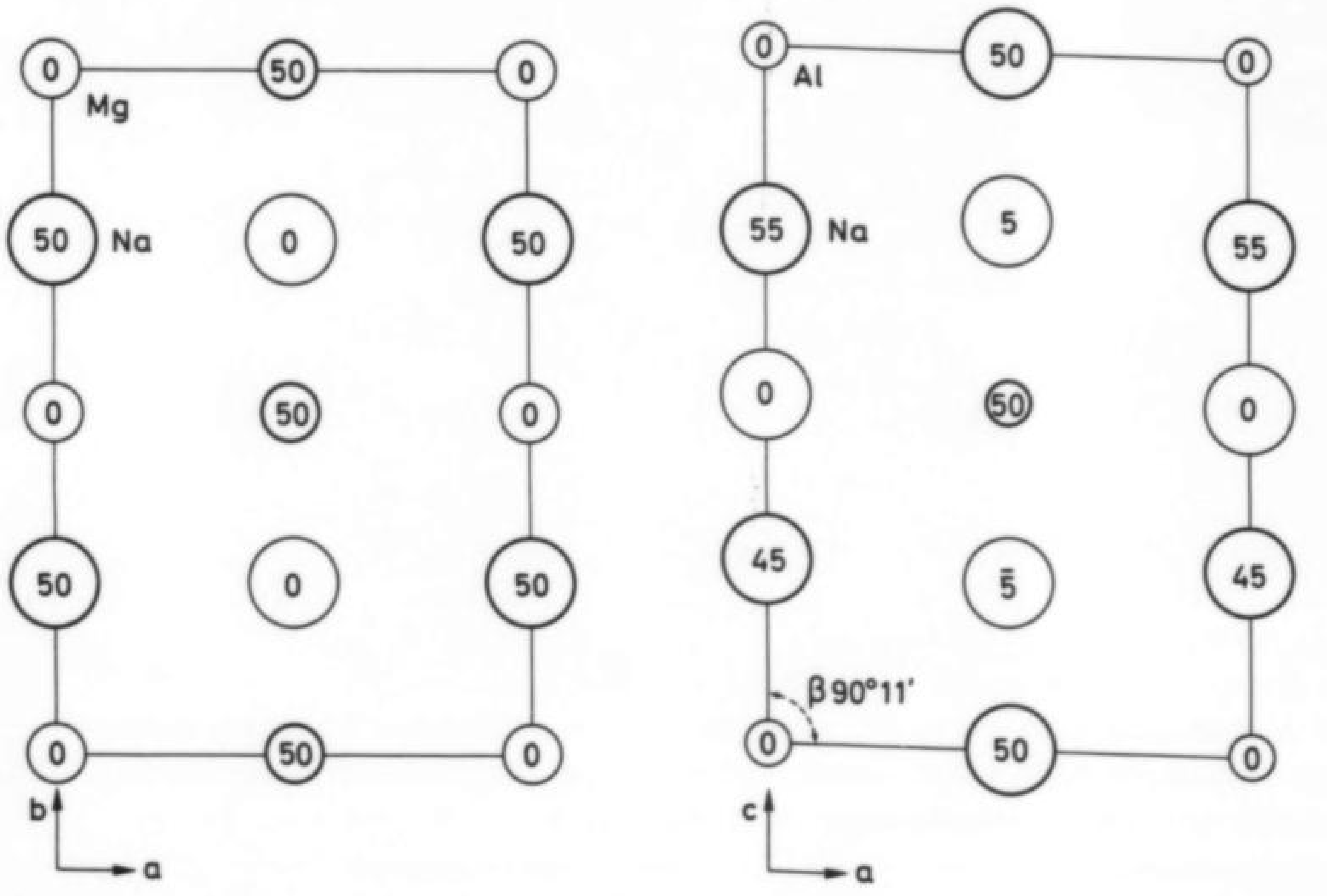

Figure 20. **A comparison of metal atom positions in the crystal structures of neighborite and cryolite. Fluorine atoms are omitted for clarity. *Left:* Structure of neighborite, $4[NaMgF_3]$, space group *Pcmn,* projected on (001), with atomic positions simplified as for a cubic structure (based on Fig. 1 in Lewis and Bright, 1971). *Right:* Structure of cryolite, $2[Na_2NaAlF_6]$, space group $P2_1/n$, projected on (010) (after von Naráy-Szabó and Sasvári, 1938). Numbers denote the relative heights of atoms above the projection plane. See text for further discussion.**

Note added in proof:

In a recent survey of the mineralogy of Ivigtut (Pauly, 1979), the presence of elpasolite is recorded, occurring in one single specimen. A crystal drawing of ralstonite showing dodecahedral habit appears in the same paper, but this form is not mentioned in the text.

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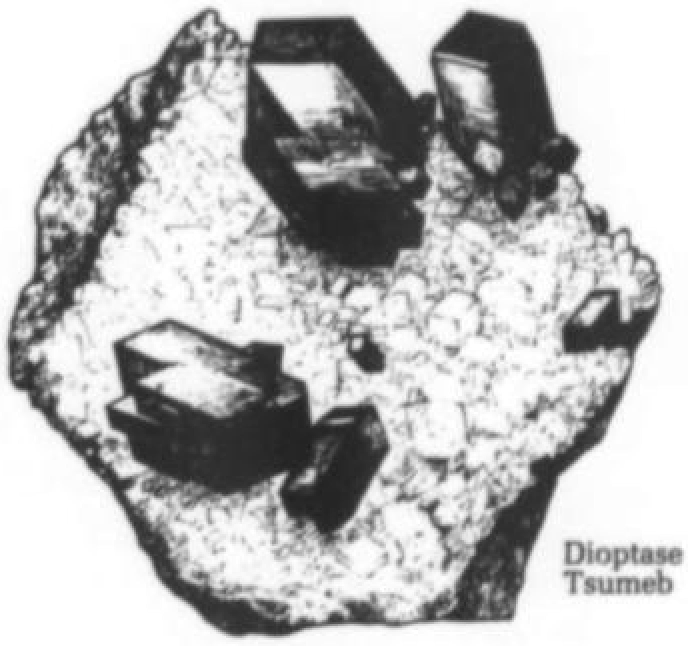

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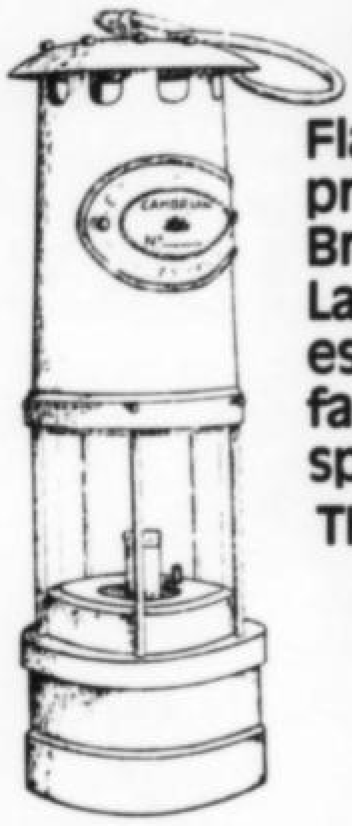

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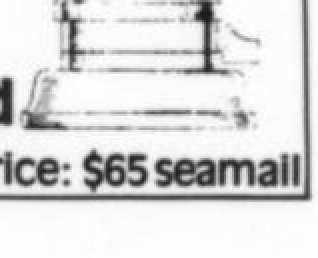

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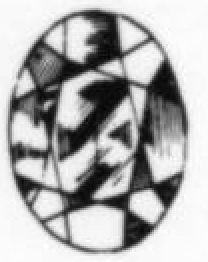

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Giant Crystals of KORNERUPINE

by **Ole V. Petersen** and **Ole Johnsen**
Geological Museum
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and **Aage Jensen**
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During the summer of 1975, one of the authors (OVP) had the opportunity of visiting the classic mineral areas near Fiskenæsset in southwest Greenland. Some of the more remarkable outcomes of this expedition — a couple of giant kornerupine crystals, up to 23 cm, and a number of specimens with considerable gem potential — deserve a few words.

INTRODUCTION

Fiskenæsset is a relatively small community with about 400 inhabitants, nearly 160 km south of Godthåb (Nûk) on the southwest coast of Greenland (Fig. 1). The ice-free coastal belt at Fiskenæsset is about 100 km wide; the area is characterized by deep fiords cutting far inland. The relief rises to about 1500 m and the degree of exposure, of the snow-free part, is close to 100%. The only vegetation consists of lichen, moss, grass and dwarf trees of birch and willow.

HISTORY

The mineral occurrences at Fiskenæsset were discovered in the spring of 1809 by Karl Ludwig Giesecke. His attention was taken by a blue mineral which he originally identified as kyanite, but later sent to F. Stromeyer under the name of sapphirine.

Kornerupine was first described by Lorenzen (1884). During his investigation of some samples from Fiskenæsset, collected by K. J. V. Steenstrup, he found some white radiating aggregates which most of all reminded him of sillimanite. A chemical analysis, however, showed that it was a new mineral, which he then named after the late A. N. Kornerup. It was Ussing (1889) who described in detail the crystallographic and optical properties of the kornerupine.

The Geological Museum, Copenhagen, has no material directly connected with the investigations of Lorenzen, but does possess four specimens, collected by Steenstrup in 1877 and registered in the museum in 1883 as kornerupine, possibly by Lorenzen. However, the material investigated by Ussing has been partly preserved; in the collection we found both the measured crystals as well as vials with powder used in the determination of the other physical properties of the kornerupine.

Since the first description, kornerupine has been found in various localities, several places on Madagascar, in Sri Lanka, several places in India, in Burma, several places in Africa (including Kenya), in France, and in the Soviet Union. In the most recent

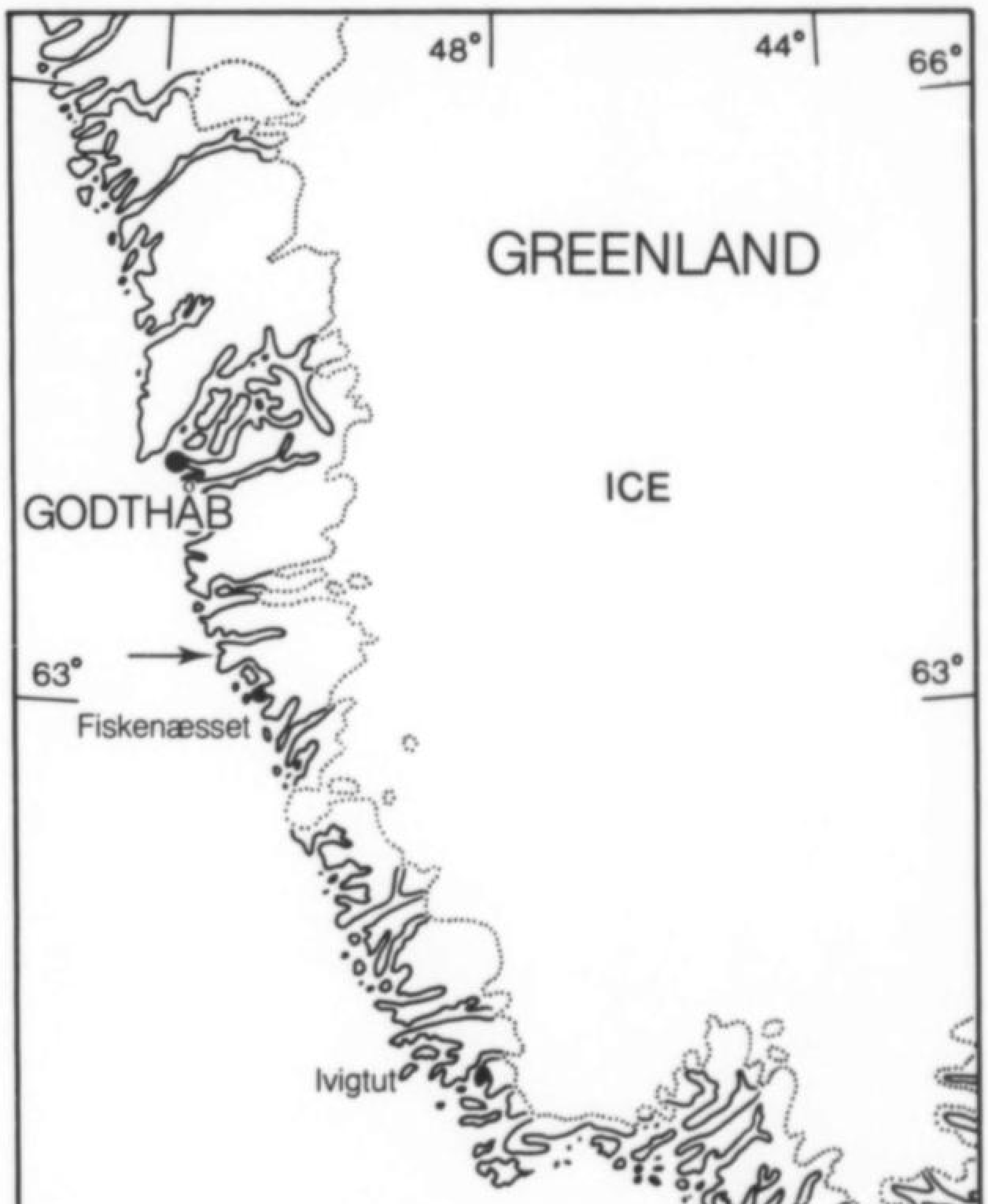

Figure 1. **Location map (arrow indicates locality).**

Figure 2. **Base camp, near the kornerupine locality, 20th of July, 1975.**

description of kornerupine, material from Strangeways Range, central Australia (Wilson, 1978), crystals of the same order of magnitude as the ones treated here are mentioned.

Since Giesecke, Fiskenæsset has been visited by a large number of geologists. Detailed mapping and investigation were started by the Geological Survey of Greenland in the mid-1960's and are still going on. Since 1969 the Canadian *Fiscanex Ltd.,* and its Danish subsidiary *Platinomino Aps,* have investigated the economic potentials of both the chromite and the various gemstones.

GEOLOGY

The occurrence of kornerupine at Fiskenæsset is very closely related to the occurrence of sapphirine. The West Greenland basement, which consists mainly of Precambrian gneisses, is characterized in several places by the presence of relict layering and inclusions of meta-anorthosites, often associated with mafic and ultramafic rocks. The Fiskenæs area is rich in such chromite bearing meta-anorthosites, alternating with pyribolites, amphibolites and ultramafic rocks. This complex—the Fiskenæs complex—represents the metamorphosed remnants of one large, stratified, intrusive complex of the Bushveld type. All the sapphirine localities are within the Fiskenæs complex, the majority occurring along the contact between the uppermost anorthositic part of the stratified complex and the overlying amphibolites.

Approximately 40 localities with sapphirine are known in the whole Fiskenæs area; of these only six are stated also to contain kornerupine. In the spring of 1975 one of the authors learned that in 1971 B. J. Walton had found a large sapphirine-kornerupine locality north of Agdlumersat (Bjǿrnesund). The reports mentioned sapphirine, corundum (variety ruby), red spinel and kornerupine in very large crystals.

As mentioned in the introduction, one of us had the opportunity of visiting the occurrence in the summer of 1975. Following is a short account of the chain of events during the four days spent at the locality.

On July 17, 1975, at a little past noon, my assistant and I, and all our equipment, were lifted by helicopter to our base camp. As the occurrence is situated in a valley at a relatively high level and even late in summer is often covered by snow, we had chosen to camp near a small brook, close to the snow-free bottom of the valley, at a height of about 900 m above sea level.

Thanks to two exceptionally skilful Swiss pilots, we were able to have most of our heavy equipment landed during the same afternoon: our drilling machine with wedges, various crowbars, hammers and chisels, and ("during an attack of monumental optimism") 20 large wooden boxes. Everything was placed on a steeply sloping but rather solid snow drift less than 50 m from the locality which, to our great pleasure, we found free of snow.

The next day, which was one of the best of the best Greenland days, with sunshine from a cloudless sky, calm and about 5°C, we started work at the locality. After a closer study of the occurrence it appeared that Walton had only exaggerated a little, and I think you will all understand when I tell you that we immediately started with great care to work the occurrence. In our anxiety to save better and better specimens we "forgot" to pack them; at the end of the working day we had covered all the surrounding, snow-free rocks with exciting specimens.

The next morning found us in the middle of a snow storm, which had already covered everything with about 25 cm of snow and which continued with undiminished violence all day and the following night, and which did not stop until late afternoon on the 20th of July. Any thought of work was out of the question. On the morning of the 21st we awoke to bright sunshine and spent the entire day finding our specimens, digging them out of the snow, packing them, and then collecting new specimens and packing these. When the day was over we had more than a ton of first-class mineral specimens securely packed in more than 20 boxes. The next morning we were flown from the locality to another kornerupine occurrence.

About the occurrence itself, only this: it is a lenticular body about 10 x 30 m, entirely surrounded by anorthosite. Besides kornerupine, sapphirine (although in small quantity), plagioclase, cordierite, mica, enstatite, pargasite, corundum (variety ruby), spinel and tourmaline were identified.

HABIT AND OPTICAL PROPERTIES

At this locality the kornerupine shows enormous variations in both habit and color. In the uppermost exposed part of the occurrence the kornerupine forms more or less radiating aggregates of white and almost colorless crystals, but downwards these are gradually replaced by aggregates of long prismatic blue and bluish crystals. Much lower, kornerupine forms groups of single crystals and single crystals with distinctly prismatic habit, in a matrix consisting mainly of cordierite and mica with a little plagioclase. The kornerupine of this zone is dark green and, in rare cases, translucent. The sensationally large single crystals of kornerupine occur below the lenticular body in the surrounding anorthosite. These crystals, which without any doubt are the most impressive kornerupine crystals ever found, are dark green and in general completely non-transparent, but some parts of some of the crystals might be considered translucent and very rarely transparent.

Figure 3 shows the largest of these crystals. Besides {110}, which dominates the crystal, and {100}, this specimen also shows one plane of the form {021}. Owing to the good {001} cleavage, this is rarely the case. Actually this crystal is the only one of the large number we brought home which shows something other than {110}, {010} and the cleavage plane {001}; both {110} and {010} are invariably strongly striated. Please note that the crystal is not shown in the correct crystallographic orientation.

Optically the kornerupine is biaxial negative, and $2V_\alpha$ varies from nearly zero to about 15°. α is parallel to the *c*-axis, β parallel to the *a*-axis, and γ parallel to the *b*-axis, i.e. the optic axial plane is the *bc* plane. The principal indices of refraction (determined by the $\lambda - T$ variation method with optical glass as internal standard

(Micheelsen, 1953), and calculated as suggested by Micheelsen (1978) using the dispersion formula of Louisnathan *et al.*, (1978) for $\lambda = 589$ nm, are: $\alpha = 1.667 \pm 0.001$, $\beta = 1.679 \pm 0.001$ and $\gamma = 1.682 \pm 0.001$. The principal indices of refraction are relatively small but well within the values reported for kornerupine from other localities; similar small refractive indices were reported by Schmetzer *et al.* (1974) for kornerupine and assigned a low iron content. Schmetzer *et al.* reported that different parts of some of the larger crystals of kornerupine from Kenya, in thin sections parallel to $\{001\}$ of large single crystals, show variation, not only in $2V_\alpha$ from 0° to 20° but also in the orientation of the optic axial plane. In some parts, the optic axial plane is in the *bc* plane but in other parts in the *ac* plane. A similar change in the position of the optic axial plane has not been observed in the kornerupine crystals from Fiskenæsset although $2V_\alpha$ varies both within the single crystals and from crystal to crystal. All the crystals examined had the optic axial plane in the *bc* plane. Schmetzer *et al.* also reported strong dispersion, $r < v$ for the optic axial plane in the *bc* plane and $r > v$ for the optic axial plane in the *ac* plane; the kornerupine from Fiskenæsset shows no observable dispersion at all.

CHEMISTRY AND X-RAY DATA

The chemistry of this kornerupine from Fiskenæsset has been investigated by means of electron microprobe analysis combined with emission spectrography and thermal gravimetric analysis to reveal the content of boron and water, respectively. These methods gave—when the microprobe data is processed by EMSKOR (J. G. Rønsbo), which is a modified version of the program of Springer (1967) in accordance with the scheme of Sweatman and Long (1969)—the following composition: SiO_2: 29.84%, Al_2O_3: 44.93%, Fe_2O_3: 2.61%, MgO: 18.81%, B_2O_3: ~ 1% and H_2O: 1.1%, total: 98.29%. In the correction procedure the Fe content is treated as ferric iron. The formula calculated on the basis of 22 oxygens is

$$Mg_{3.50}Fe^{3+}_{0.24}Al_{6.61}Si_{3.72}B_{0.22}O_{21.08}(OH)_{0.92}$$

In addition to the main elements, Na, K, Ca, Ti and Mn were searched for using the probe, but only traces of Mn were found. Emission spectrography showed the presence of 920 ppm Cr and 20 ppm V.

Figure 3. **The largest crystal found, 23 cm long, showing {110}, {100} and {021}. The crystal is not shown in the correct crystallographic orientation.**

The present analysis is very close to the one made by Lorenzen (1884), on the basis of which kornerupine was established as a new species. Compared to analyses from other localities (Schmetzer *et al.*, 1974) this analysis places the kornerupine from Fiskenæsset in the range characterized by high Al and Mg but low Fe contents.

An X-ray powder pattern of kornerupine was obtained with a Guinier-Hägg focussing camera, using Cu K_α radiation and quartz as internal standard. Least squares refinement of 44 d-values gave the following orthorhombic unit cell: a = 16.038(3) Å, b = 13.730(3) Å and c = 6.721(1) Å.

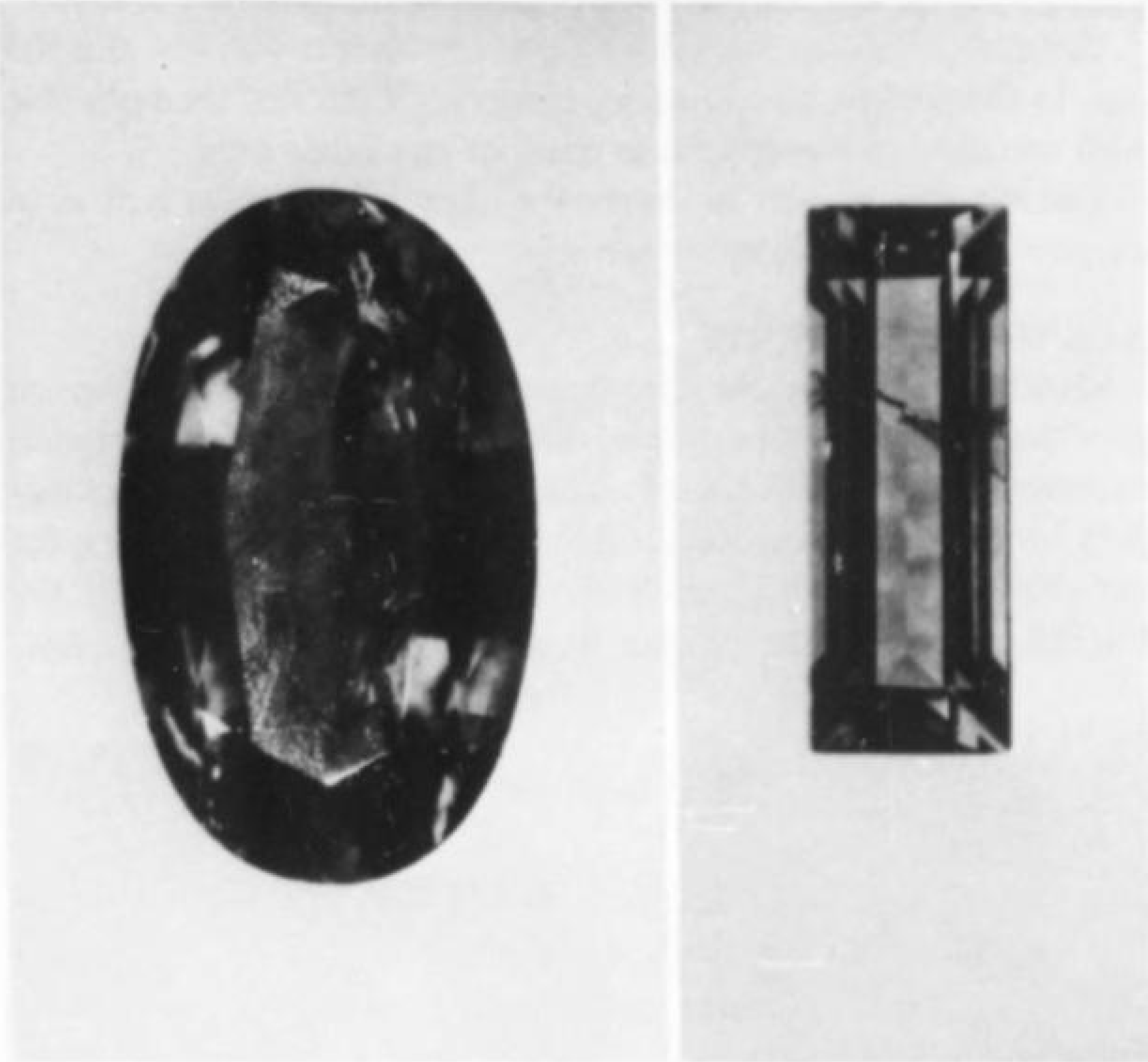

Figure 4. **(a.) A 1.72 ct cut kornerupine. (b.) A 0.68 ct cut kornerupine.**

GEMMOLOGICAL ASPECTS

The number of localities carrying kornerupine of gem-quality is very limited. Gem-quality kornerupine was first found in Madagascar, in a pegmatite containing several centimeter-long crystals of transparent kornerupine with a sea-green color (Lacroix, 1912).

The most important localities for gem-quality kornerupine are found in Sri Lanka. The occurrences there were first described by Anderson and Payne (1939, 1940), and Korevaar and Zwaan (1977) have described cat's-eye kornerupine from Sri Lanka.

Payne (1954) described kornerupine from the Mogok district, Burma, with a more attractive color than the Sri Lanka stones, but found only in very limited numbers.

Anderson (1971) mentioned rare, but attractive stones from Kenya.

Bank and Berdesinski (1974) described cut kornerupine from East Africa.

Schmetzer *et al.* (1974) described an occurrence of kornerupine in the Kwale district, Kenya, and these authors consider it most probable that the stones described by Anderson (1971) and Bank and Berdesinski (1974) also originated from this area.

The classical occurrence of kornerupine at Fiskenæsset, southwest Greenland, has so far been considered as being without gemmological interest. Thus Webster (1975) states that the material from Greenland is scarce and has no gem significance. After the visit to the Fiskenæs locality in 1975 by one of the present authors these statements cannot be maintained. The material can no longer be considered scarce, and at least part of the material can safely be said to be of gem quality. Gübelin (1979) has described some pieces of kornerupine from Fiskenæsset and, for the present investigation, 21 cut stones have been available (14 faceted and 7 cabochons, varying in size from 5.88 ct to 0.09 ct).

The stones are all transparent and have a beautiful dark green color without any brownish tint. They are strongly pleochroic: dark green, reddish blue, light blue. Larger inclusions seem to be absent but the stones have tension cracks.

The density is found to vary between 3.292 and 3.306, and thus is in the lower end of the range 3.28–3.35 for gem material given by Webster (1975); $d_{calc} = 3.31$.

The refractive indices as measured with the refractometer are: $n_\alpha = 1.662$ and $n_\gamma = 1.679$. These values correspond to those obtained by Gübelin (1979), but are somewhat lower than those determined with the double variation method in the present work.

Gübelin (1979) reports weak absorption lines at 446, 454 and 503 nm. In the present investigation, however, it has not been possible with certainty to identify these lines, or any other lines.

The material is inert in shortwave ultraviolet light as well as in longwave utraviolet light.

ACKNOWLEDGMENTS

Thanks are due to the Geological Survey of Greenland which provided, among other things, all the necessary transportation facilities during the field work. Thanks are also due to H. Bollingberg for the emission spectrographic analysis and to J. Knudsen for the thermal gravimetric analysis. J. Bailey kindly corrected the English of the manuscript, and A. Brantsen typed the manuscript.

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Mineralogical Notes

PYRITE CRYSTALS FROM DUFF'S QUARRY, HUNTSVILLE, OHIO, U.S.A.

by **Robert I. Gait**
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In the latter part of 1978 the Royal Ontario Museum acquired as gifts some interesting pyrite crystals from Duff's quarry, Huntsville, Logan County, Ohio. Crystals from this locality have been reported by Fisher (1976) and by Anderson (1979). Fisher (1976) describes the bedrock as being of the Tymochtee formation (Silurian) consisting of a slabby marine dolomite with numerous shale partings.

The pyrite crystals, lining small vugs in the dolomite, are particularly interesting because of the unusual forms they exhibit. At first glance they appear to be trapezohedra, which are scarce as a dominant form on pyrite, and therefore a detailed study was undertaken to identify them.

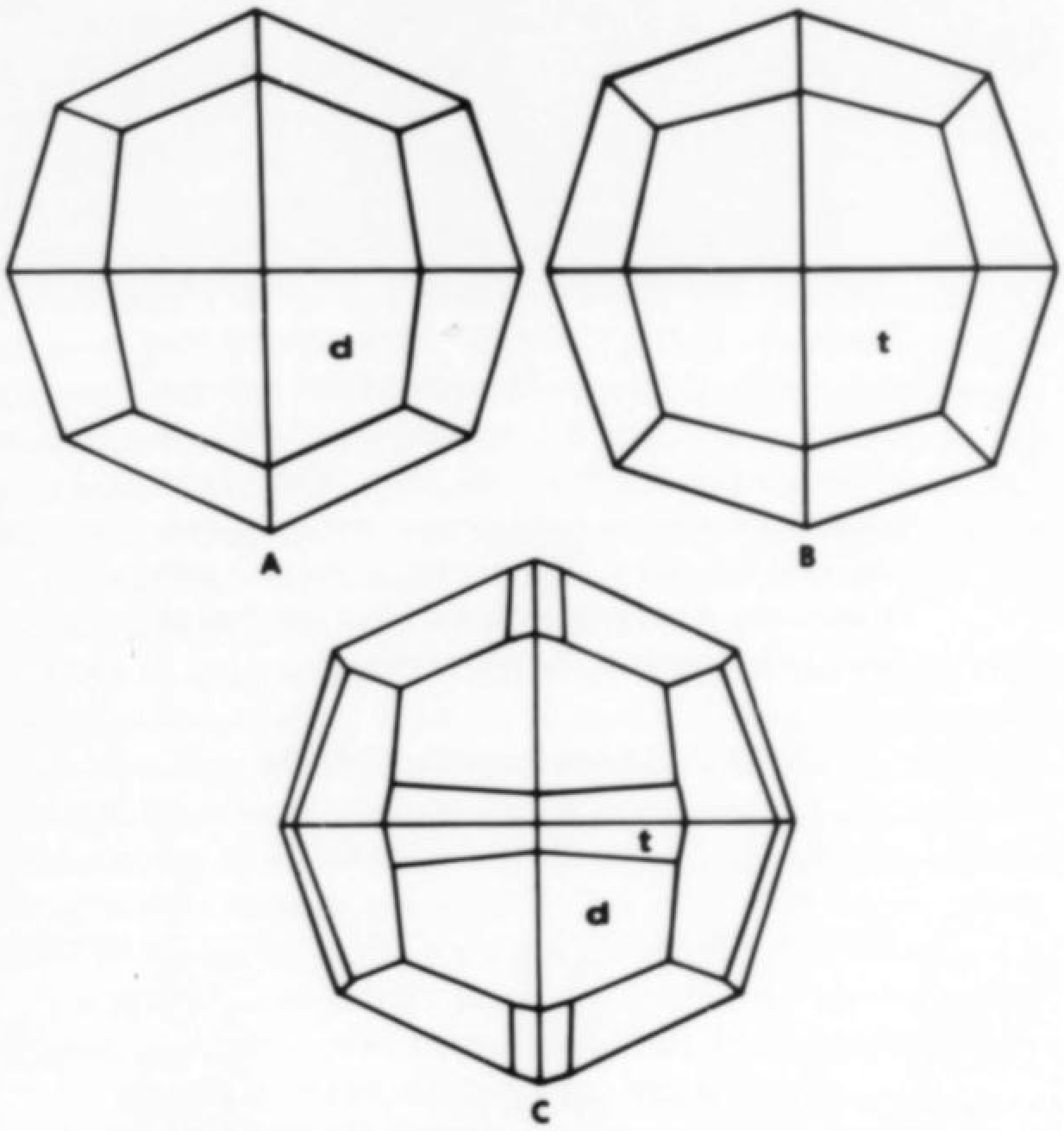

Figure 1. **Ideal crystal drawings projected along a two-fold axis. A. Diploid, Duff's quarry, Ohio. B. Trapezohedron {113}. C. Combination of A and B with the diploid dominant.**

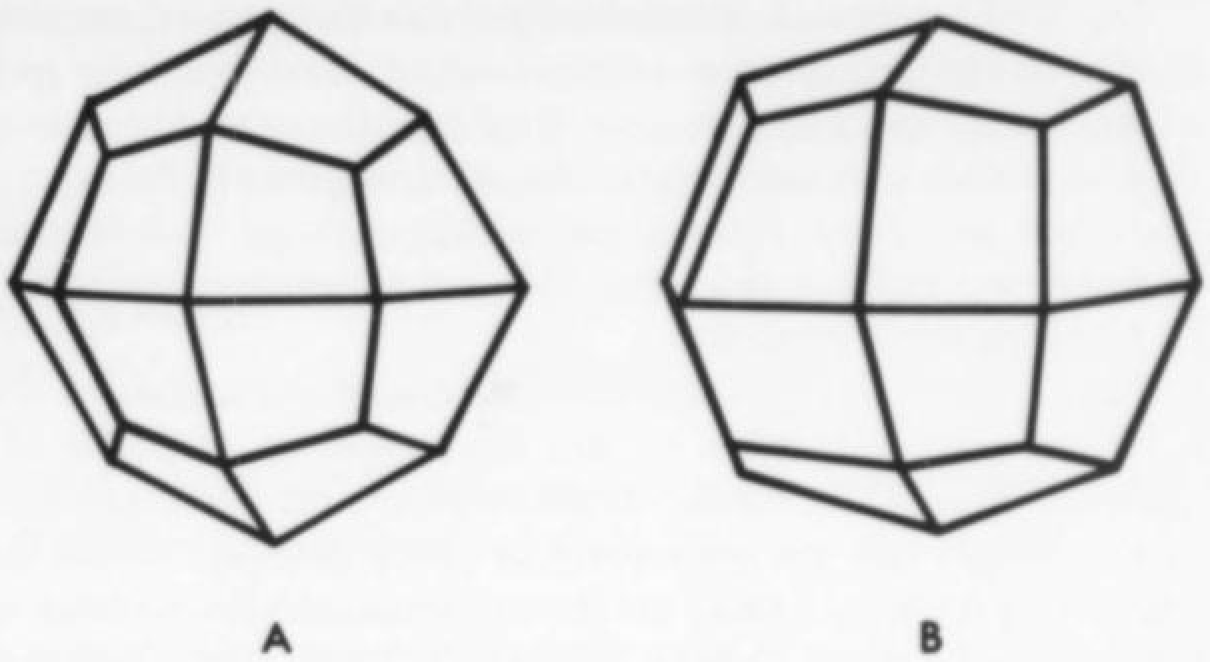

Figure 2. **A. Trapezohedron {112} and B. Trapezohedron {113}.**

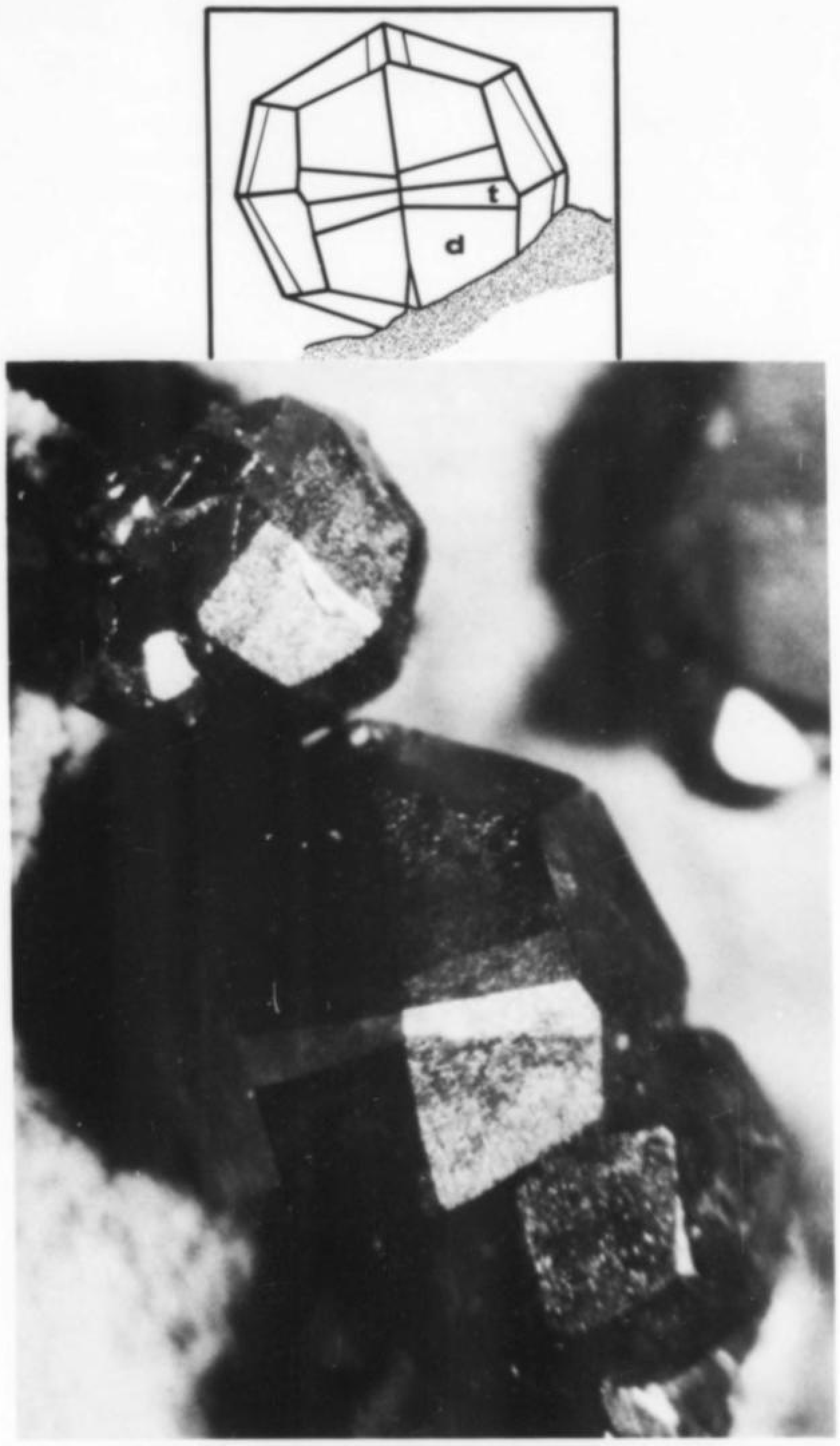

Figure 3. **ROM #M35607. Photomicrograph and sketch of the diploid modified by the trapezohedron {113}. The tiny triangle at the bottom centre of the picture is a pyritohedral face. The crystal is about 1.5 mm in diameter. Note: The edges shown by fine lines in the sketch are not visible in the photomicrograph but are present on the crystal.**

The study consisted of microscopic examinations of the four specimens available and the measurement of one crystal from each of three of the specimens on the reflecting goniometer to accurately determine their interfacial angles. On all the specimens the crystals are bright and shiny, more or less equidimensional, well-formed, and resemble textbook drawings. The crystals range in size from 1 to 6 millimeters in diameter.

The dominant form on crystals from three of the specimens was a diploid modified either by the trapezohedron {112} or the trapezohedron {113}. On the fourth specimen the dominant form of the crystals was the trapezohedron {112} modified by the octahedron. Figures 3, 4, and 5 are photomicrographs and sketches of some of these crystals, showing these forms. Other forms identified and measured, but only as minute faces are the cube, dodecahedron, pyritohedron {012} and trisoctahedron {122}.

It is impossible to assign Miller indices to the diploid with any degree of certainty as there are several sets whose calculated angles come close to those measured. Only a few of the calculated possibilities are listed in Table 1 and compared with the measured angles of the Duff's quarry diploid.

This diploid is quite similar in appearance to the trapezohedron {113} and Figures 1A and 1B are projections along a two-fold axis to help distinguish between them. Figure 1C is a similar projection of the combination of these two forms, with the diploid dominant. It may be worthwhile for the reader to make tracings of the diploid

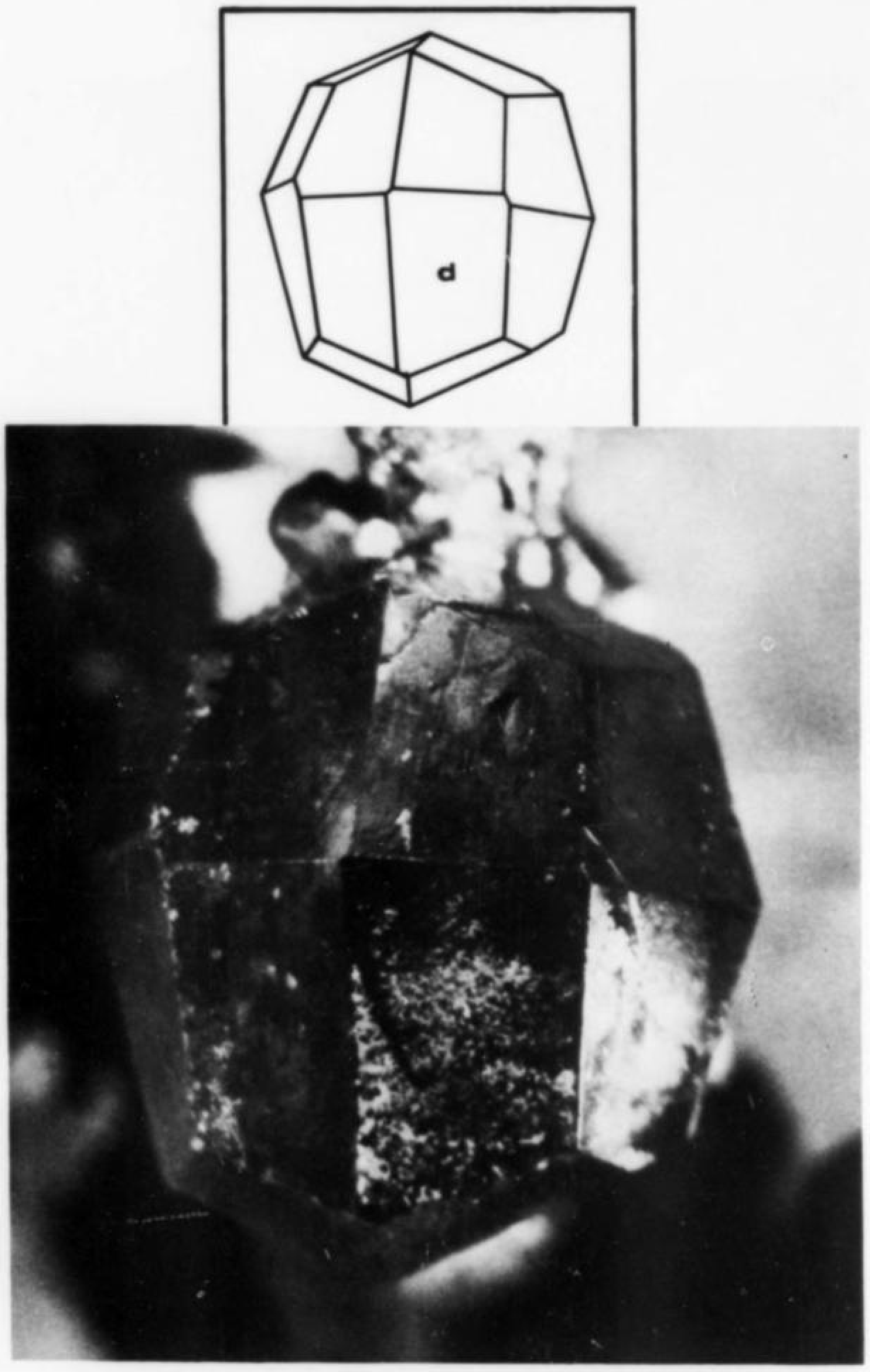

Figure 4. **ROM #M35586. Photomicrograph and sketch of the diploid. The other modifying forms are too small to be seen. The crystal is about 2.5 mm in diameter.**

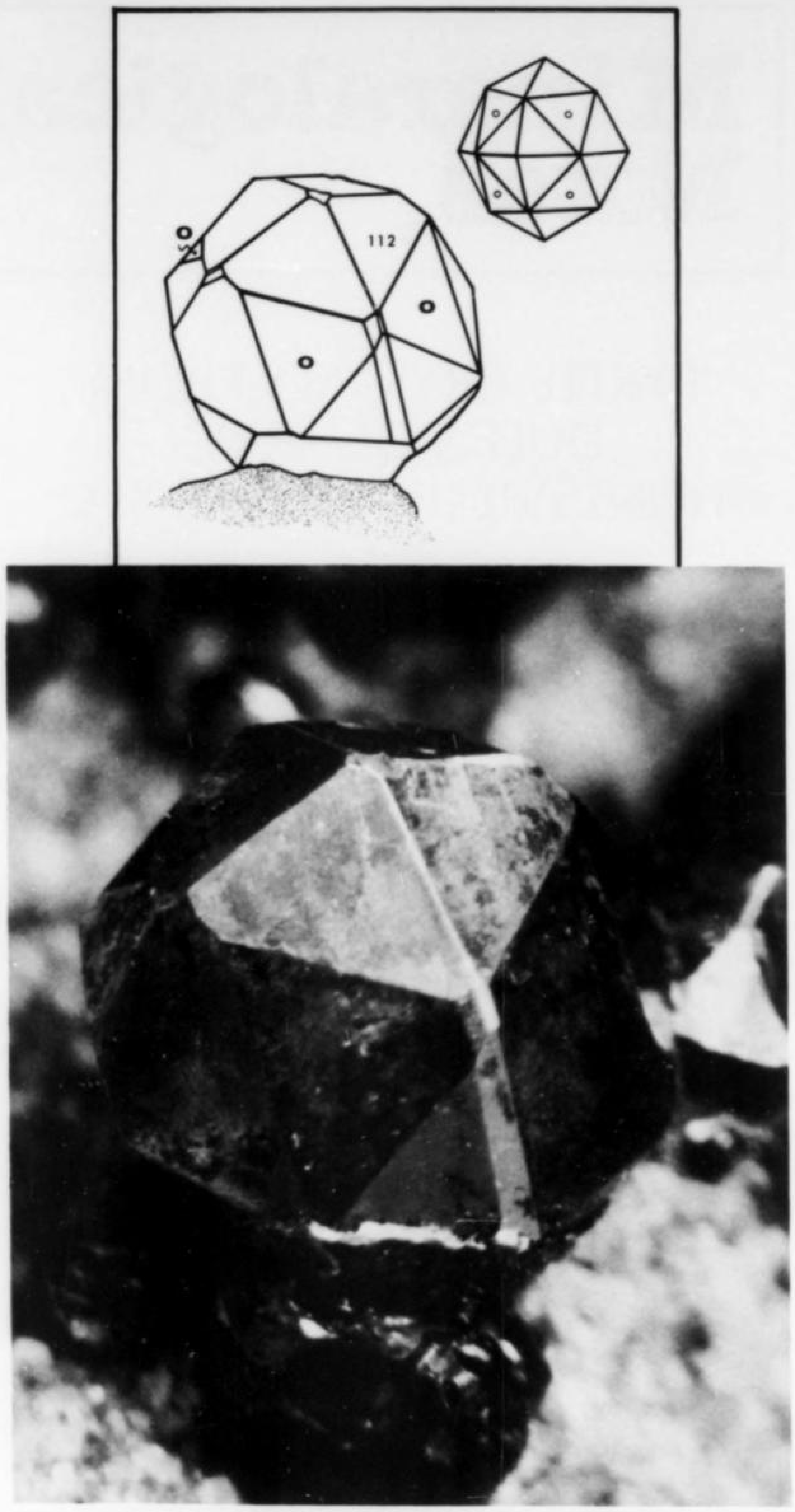

Figure 5. **ROM #M35608. Photomicrograph and sketch of the combination of the trapezohedron {112} and the octahedron *o*{111}, in almost equal development. The other faces shown are the dodecahedron, pyritohedron, and trisoctahedron. The crystal is about 3 mm in diameter. Compare with the ideal drawing of this combination to the upper right.**

Table 1. **Angles for some diploids.**

h k l	Calculated	
	φ	P
{5.7.16}	35°32'	28°16'
{9.13.29}	34°42'	28°36'
{7.10.22}	34°59½'	29°01½'
{11.16.36}	34°30½'	28°20½'
	Measured	
	φ	P
Ohio, U.S.A.	34°38' ±21'	28°45' ±07'

(Figure 1A) and the trapezohedron (Figure 1B) and overlap them, first on one another, and then in turn on the drawing of the combined forms (Figure 1C) to appreciate their differences and similarities. The differences between the trapezohedra {112} and {113} are shown in Figure 2.

ACKNOWLEDGEMENTS

The author would like to thank the following people at the ROM: Darko Sturman for his help with the goniometric measurements, Mrs. Violet Anderson for her care and talent in producing the photomicrographs, and Dr. J. A. Mandarino for kindly reading the manuscript and for his helpful suggestions.

On behalf of the ROM I would like to thank the donors of the four specimens: Violet Anderson, Toronto; Richard Boyer, Henry H. Fisher, and Sandy and Gloria Ludlum, all of Columbus, Ohio.

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SULFUR IN PYRITE CRYSTAL-SHAPED CAVITIES IN QUARTZ

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Inclusions of minerals in transparent crystals of another mineral have always excited the imagination of those who view them, and they have been very popular among mineral collectors. Widely known, of course, are those of rutile, goethite, tourmaline, actinolite and chlorite in quartz. Less common and correspondingly less well known are the following minerals reported (Frondel, 1962) as having been recognized as inclusions in quartz crystals: arsenopyrite, pyrrhotite, sphalerite, stephanite, pyrite, hematite, anatase, brookite, pyrochlore, zircon, anhydrite, copper, epidote, spodumene, ilmenite, magnetite, siderite, calcite, dolomite, topaz, sphene and mica. The list could be extended, no doubt.

However, the specimens of pyrite crystals within colorless optical-quality quartz crystals, looking as if they are suspended in glass, are probably the most visually exciting and highly prized of the inclusions. Only three localities for such specimens are represented in the collections of the U.S. National Museum of Natural History, two from Minas Gerais, Brazil; and one each from the Chivor mine, Colombia, and the Strickland quarry, Portland, Connecticut. In every specimen except the last one at least some of the pyrite is totally surrounded by flawless quartz so one can safely say that these pyrite crystals have been effectively insulated from any external influence that wouldn't also destroy the quartz. Therefore, the pyrite crystals have a very fresh appearance and one is tempted to assume that they haven't changed in any way since they first found themselves surrounded by quartz.

There is a considerable variance in habit of the pyrite from specimen to specimen. While all crystals are more or less equant, slight flattening or elongation is often seen. The dominant form is the pyritohedron, except for the Chivor specimen in which all eleven of the crystals have wildly distorted morphologies, defying identification without goniometry. The next most readily recognized forms on the others are the cube and the octahedron.

It is pyrite in quartz from Brazil that is of interest to the author. The two specimens in the museum collection are labeled as follows:

NMNH #105104	Diamantina, Minas Gerais
NMNH #140154	Minas Gerais

There is a color photograph of a specimen of pyrite in quartz in *Minerais do Brasil* (Franco *et al.,* 1972) and the locality is given as Serra do Cabral, Minas Gerais. Diamantina and Serra do Cabral are no more than 100 km apart, and it may be that the specimens are from occurrences that are at least genetically related if they are, in fact, from different occurrences at all. The two museum specimens and the one in the photograph appear quite similar. In addition, the author has seen others from Brazil which bear strong similarities to these three. One of the others is the subject of this article.


Figure 1. **The Hans Becker specimen, showing a pyrite crystal (center) imbedded in quartz.**

In October, 1978, in Idar-Oberstein, West Germany, the author was taken to the home of Hans Becker to see his collection. Mr. Becker had a specimen of pyrite in quartz from Brazil. The quartz crystal is 10 x 7.2 x 6.7 cm in size, weighs 517.1 grams, and is bounded by crystal faces over approximately 60 to 70 percent of its surface. Toward one side is a single, fresh, pyritohedral pyrite crystal, about 1.8 cm in diameter and 3 mm below the surface. It is completely surrounded by unflawed colorless quartz.

Toward the other side of the specimen, however, is one of the


Figure 2. **The Becker specimen, unaltered pyrite crystal at left, bright yellow pyrite-shaped inclusions at right.**

most extraordinary mineralogical sights that this author has ever seen. Near the surface are three cavities that are in mutual contact. All have the form of pyritohedrons. The largest is about 2.3 x 2 cm, and is within 1-2 mm of the surface. The other two are each 15 x 7 mm in size. There is no pyrite in the cavities. Instead, the cavities are approximately half filled with fine, crumbly material having the distinctive bright yellow color of elemental sulfur. When the specimen is turned, the yellow crumbs adjust by rolling as would loose sand or salt in a hollow glass container. None of the yellow material is attached to the walls of the cavities; it is all loose. If one carefully shakes the specimen the sulfur can be made to move from the large cavity into the smaller ones, and back again.

Since Mr. Becker would be unwilling to sacrifice the specimen, the identity of the yellow substance cannot be proven, but circumstances argue strongly for it being sulfur. The shapes of the cavities are clearly those of pyrite, and a pyrite crystal is still preserved elsewhere in the same specimen. Therefore, if we agree that pyrite was present in the cavities, we are admitting that sulfur was there as well. So, the presence of sulfur does not introduce any problem. The problem is, where did the iron go? The answer, obviously, is that the iron was carried away by solutions which also had the capacity to oxidize the sulfur to elemental form and leave it behind. It is also obvious that the solutions could not have diffused through the quartz. They didn't have to, as there is a very fine fracture connecting the cavity cluster to the outside surface of the quartz crystal. The fresh pyrite crystal is not similarly linked to the surface, thus it has been preserved.

We are forced to conclude that it is the presence of a hairline fracture which made possible the selective removal of the iron from former pyrite crystals. The chemical environment must have been unusual. We have come to expect oxidation of pyrite to occur when it is exposed to corrosive solutions. Traditionally it is sulfur that is carried off and the iron remains as goethite or hematite. One must marvel over the total removal of the iron; even the fracture which served as the conduit for the iron's removal is totally free of iron and is unstained.

The only reference to these inclusions in the literature that the author has found is that of Brech (1935), who described four optical-quality quartz specimens from Brazil containing pyrite crystals and another specimen, described as follows:

"A fifth specimen has also been found having a complete hole (approximately 10 x 4 x 8 mm), in which a crystal doubtless at one time existed, for the faces of the hole are striated corresponding to the structure of the pyrites crystal. Unfortunately, in the process of working the quartz the hole was cut into, so that its vapour content escaped before an examination could be made."

It is assumed that sulfur was not present in Brech's specimen or he would have mentioned it. Brech did make the observation that "the inclusions tend to lie in one particular plane through the quartz, and, further, the water inclusions in one of the specimens also lie in the same plane." This alignment of inclusions was not noted in any of the specimens examined by the author. This is also true of the Colombian specimen which has pyrite crystals in random positions throughout the crystal.

The Strickland quarry specimen can be disregarded because the two pyrite crystals in the quartz are exposed and could have been plucked from the matrix when the quartz crystal was detached.

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PYRRHOTITE NODULES FROM TEXAS GULF COAST SALT DOMES

by **Arthur E. Smith Jr.**
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Tiny pyrrhotite nodules were first reported in bit cuttings from shallow oil wells at Hoskins Mound, Brazoria County, and Sour Lake, Jefferson County, Texas, by Smith (1970). Both locations are shallow-piercement salt domes. The pyrrhotite occurs in super caprock and shallow flank shales at depths between 1000 and 1500 feet.

Damon Mound is a shallow-piercement salt dome located about 30 miles southwest of Houston in Brazoria County. In 1975 Dresser Minerals opened a quarry at Damon Mound to produce the limestone caprock for road metal and concrete aggregate. Eighty to 100 feet of Recent to Oligocene-age sediments are removed to reach the caprock. On the north side of the quarry at the base of the entrance ramp and just above the caprock is a small area of gray shale that contains pyrrhotite nodules. The shale has been disturbed and partly removed. The nodules seem to have a random distribution through it with some concentration of smaller nodules in local areas. An examination of the microfauna of this shale by F. L. Smith Jr. of Houston indicates it has an Eocene age. The normal depth for this age rock in the domal area would be below 15,000 feet. So this material is an isolated mass that has been carried up with the caprock during salt dome diapirism. A more complete description of the geology, mineralogy, and origin of Damon Mound is given in Etter (1979).

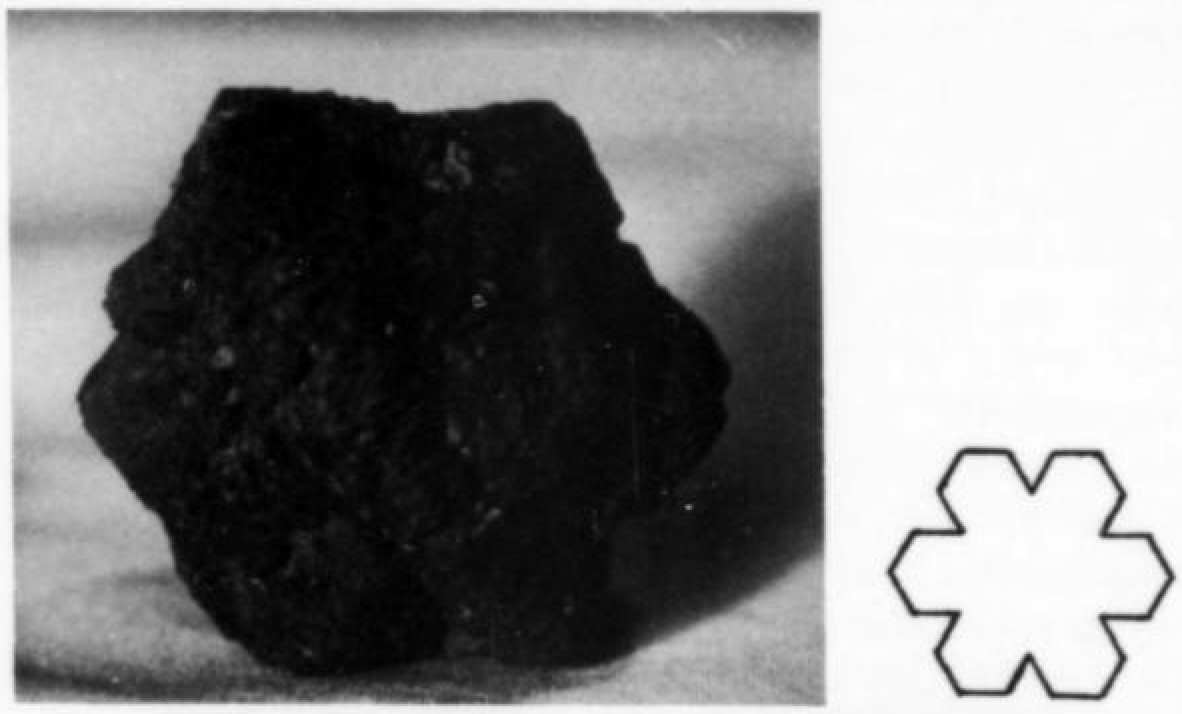

Figure 1. **A 2.5-cm pyrrhotite nodule sixling.**

The pyrrhotite nodules vary in size from 1 mm to slightly over 4 cm in diameter. The outer surface consists of platy hexagonal crystals arranged with pinacoid faces subparallel. The crystals range from less than 0.5 mm to over 5 cm in diameter and vary in color from metallic gray to bronze, but rapidly weather to a very rusty brown on exposure. Most of the nodules react weakly to a magnet. Some do not and may actually be pseudomorphs. Rarely, isolated small groups and single microcrystals occur on thin plates of massive pyrrhotite. The interior of the nodules has a somewhat foliated structure that radiates from the center. The centers of many nodules are hollow but others are filled with intergrown, clear, tabular barite crystals. Microcrystals of barite also occur in cracks. Both occurrences of barite are of secondary origin. Tiny crystals of pyrite may occur on the pyrrhotite crystals.

The smaller nodules (0.5 to 1 cm in diameter) are actually flattened rosettes that occur alone or in flat aggregates. Some of the rosettes have a crude but distinct hexagonal outline. The larger nodules (1 to 4 cm in diameter) always occur alone and are rounded. These nodules may also have a crude hexagonal outline, a circular outline, or a star-shaped outline (Fig. 1).

Other minerals in the quarry are pyrite in octahedral crystals and botryoidal coatings. Calcite occurs as scalenohedral crystals in small septarian nodules and geodes and as rhombohedral crystals in the Heterostegina limestone and caprock. Sulfur occurs as small crystals and masses in the limestone caprock. It also forms a yellow coating where black hydrocarbon-rich shales are exposed in small gullies. This shale contains layers and masses of marcasite that oxidize rapidly on exposure to a white to gray powdery sulfate. Clear gypsum forms 2 cm crystals that occur in small aggregates.

The Dresser quarry at Damon Mound presents an excellent opportunity to study some of the minerals associated with salt domes, a study that is normally limited to wellbit cuttings and cores. The quarry is currently inactive and collecting is allowed with advance permission from the watchman.

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OSARIZAWAITE-BEAVERITE INTERGROWTHS FROM SIERRA GORDA, CHILE*

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ABSTRACT

A specimen (8 x 5 x 2 cm) from Mina Herminia, Sierra Gorda, Chile, shows the interesting mineral assemblage atacamite, boleite, caracolite, osarizawaite/beaverite, paratacamite and anhydrite. The individual minerals occur mostly as crystals of comparatively larger size: atacamite (up to 16 μm), caracolite (up to 3 mm), osarizawaite (up to 20 mm) and paratacamite (up to 5 mm). Mineralogical descriptions of the various phases and microprobe analyses (+ SEM photographs) for osarizawaite are presented. This represents the first Chilean occurrence of osarizawaite and the fourth recorded discovery of that mineral worldwide.

INTRODUCTION

Some time ago a specimen measuring 8 x 5 x 2 cm, studded with very well developed atacamite crystals up to 16 mm in length, from Mina Herminia, Sierra Gorda, Chile, was obtained by one of the authors (W.P.). The specimen consists mainly of well developed crystals of hydrous Cu-Pb sulfate minerals and a matrix of heavily altered rock with relic rounded quartz grains. Atacamite, paratacamite and caracolite occur predominantly on one side of the specimen surface whereas caracolite, osarizawaite and beaverite dominate on the other side. Patches (0.5 cm) of anhydrite and small crystals (less than 1 mm) of boleite occur on both sides of the specimen.

Figure 1. **Atacamite crystals (bright green) from Sierra Gorda, Chile. Crystal size is approximately 1 cm. This and the following photographs are taken from the same specimen (W. Paar collection).**

Figure 2. **Caracolite crystals (colorless to greenish), type 1, on fine-grained osarizawaite. Crystal size is 3 mm.**

Figure 3. **Caracolite (type 2) and dark paratacamite tufts (greenish black). Crystal size is 0.1 mm.**

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*Dedicated to Prof. H. Meixner, Austrian mineralogist, in commemoration of his 70th birthday.

METHODS OF INVESTIGATION

The minerals were analyzed using a petrographic microscope, X-ray equipment, an electron microprobe and a scanning electron microscope. Microprobe analyses were performed using a MAC model 400 probe, using 20 kV and the following standards and emission lines: synthetic $PbSO_4$($PbL\alpha$,$SK\alpha$), antlerite ($CuK\alpha$), synthetic forsterite ($FeK\alpha$) and synthetic phlogopite ($AlK\alpha$). A computer program modified from EMPADR VII (Rucklidge and Gasparrini, 1969) was used for data correction. Morphological studies were performed using a two-circle goniometer.

THE MINERALS

Atacamite, $Cu_2(OH)_3Cl$, occurs as slender crystals prismatic along [001] with dominant faces *m*{110}, *s*{120}, *e*{011} and *r*{111}, and less developed *n*{121} (Fig. 1). The habit strongly resembles those from Chuquicamata, Chile (Palache *et al.*, 1951).

Caracolite, $Pb_2Na_3[Cl,(SO_4)_3]$, occurs as relatively large, well developed, beautiful crystals (Figs. 2, 3) of possibly two generations: Type 1 (crystallized first?) occurs as crystals up to 3 mm showing hexagonal dipyramids $\{10\bar{1}1\}$ (dominant) and $\{11\bar{2}1\}$ (minute), short prism $\{10\bar{1}0\}$, and base {0001} with dull surfaces (Fig. 3) rounding into the adjacent pyramids. The morphology is similar to that reported by Fletscher (1889) except for the dipyramid $\{11\bar{2}1\}$, which is probably new for caracolite. The crystals are colorless but usually masked by patches of various colored inclusions such as paratacamite (green) and osarizawaite-beaverite (greenish yellow to greenish). Type 2 (crystallized later?) occurs as well developed, water-clear crystals less than 0.5 mm in size (Fig. 3), and has morphology similar to Type 1 except without the dipyramid $\{11\bar{2}1\}$.

Optical properties and X-ray powder data are identical with those reported by Palache *et al.* (1951) and Schneider (1967), respectively.

Osarizawaite, $PbCuAl_2(SO_4)_2(OH)_6$, and ***Beaverite,*** $PbCu(Fe,Al)_2(SO_4)_2(OH)_6$, occur as powdery masses of microcrystals to 20 μm (Figs. 4–6). The minerals usually occur as oriented intergrowths forming bowl-shaped crystal aggregates. Osarizawaite, the major phase, occurs in the center whereas beaverite, the minor phase, occurs as the rim (2–4 μm in width). Osarizawaite also occurs as pure crystals not intergrown with beaverite (Fig. 5). Osarizawaite crystals are tabular on *c*{0001} and terminated with vicinal rhombohedra, probably $e\{10\bar{1}1\}$ (dominant) and $s\{01\bar{1}2\}$ (minor) (Fig. 6). In pure osarizawaite crystals, $\{01\bar{1}2\}$ faces are absent.

Optics. Osarizawaite crystals are hexagonal in shape and are colorless in immersion liquid. Beaverite shows distinct pleochroism with o dark yellow and ϵ yellowish white. Refractive indices (Na-light) for osarizawaite are $n_o = 1.732 \pm 0.002$, $n_\epsilon = 1.712 \pm 0.003$, and for beaverite are $n_o = 1.854 \pm 0.004$, n_ϵ not determined.

X-ray data. X-ray powder patterns of osarizawaite (with possibly minor contamination by beaverite) are identical to that reported by Morris (1962) for material from Marble Bar area, West Australia (JCPDF 15-178). Due to the intimate intergrowth, beaverite could not be isolated for X-ray study.

Chemistry. Microprobe analysis of osarizawaite was difficult because of the heterogeneity and fine-grained nature of the intergrowth. The analysis of osarizawaite is given in Table 1 in comparison with those reported by Taguchi (1961), Morris (1962) and Cortelezzi (1977) for other occurrences.

Cu, Fe and Al contents vary from spot to spot in the crystals, suggesting compositional zoning. They give ranges: CuO 8.80–9.53, Fe_2O_3 3.92–9.36 and Al_2O_3 10.5–14.61 weight percent. The analysis (Table 1) gives a formula $Pb_{1.01}(Cu_{0.76}Al_{1.81}Fe_{0.33})_{2.9}(SO_4)_2(OH)_6$. It is impossible to analyze the beaverite due to its small grain size. However, scanning traverse analyses across osarizawaite-beaverite grains showed a pronounced increase of Fe and decrease of Al for beaverite. Both Pb and S contents seem to be roughly similar in both phases.

Figure 4. **SEM photograph of osarizawaite-beaverite intergrowths. Length of the bar is 1.5 μm.**

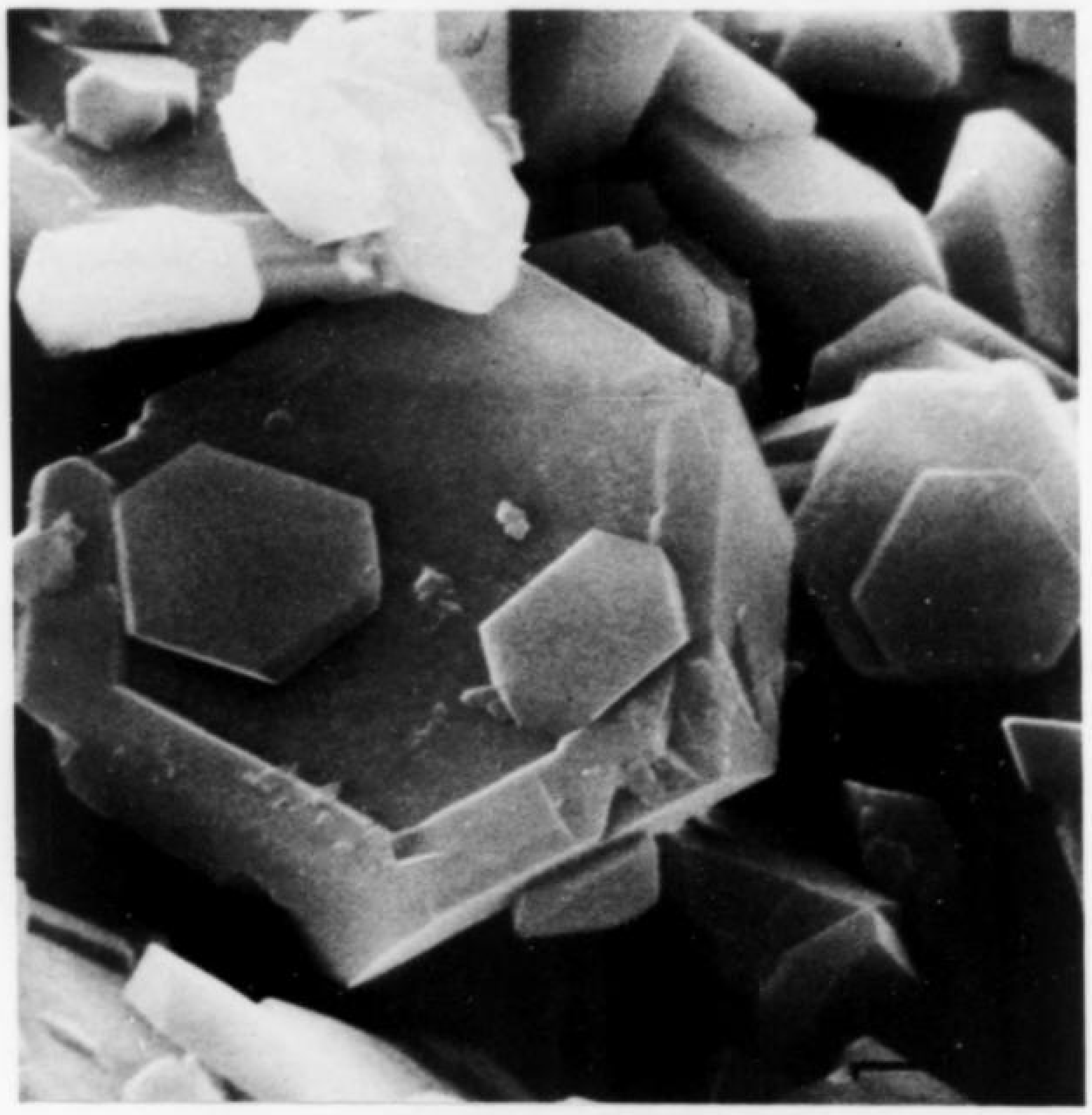

Figure 5. **SEM photograph of osarizawaite-beaverite intergrowth (large crystal) and pure osarizawaite crystals (most of the smaller). Length of the bar is 1.5 μm.**

Paratacamite, the rhombohedral dimorph of atacamite, is present as well developed crystals (Fig. 7, 8), mostly in the range of ± 1 mm. A few crystals in close association with atacamite range between 4 to 5 mm. They are twinned and resemble the crystals of the "prismatic type" reported by Smith (1906, p. 172, Fig. 2). Goniometric measurements indicate the presence of *c*{0001}, $e\{01\bar{1}2\}$,

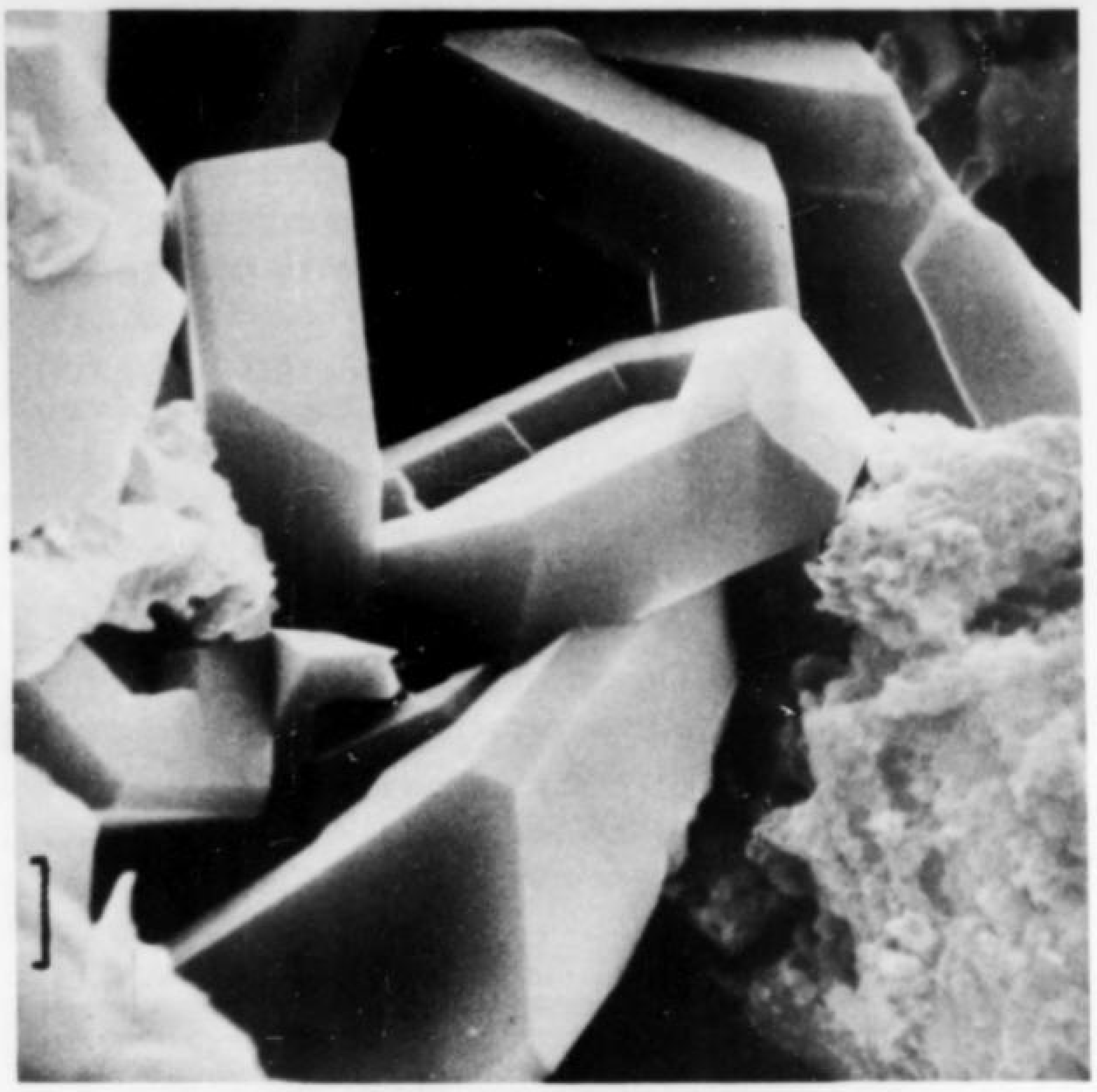

Figure 6. **SEM photograph of osarizawaite-beaverite intergrowths, showing the presence of rhombohedra *e* and *s*. Length of the bar is 0.5 μm.**

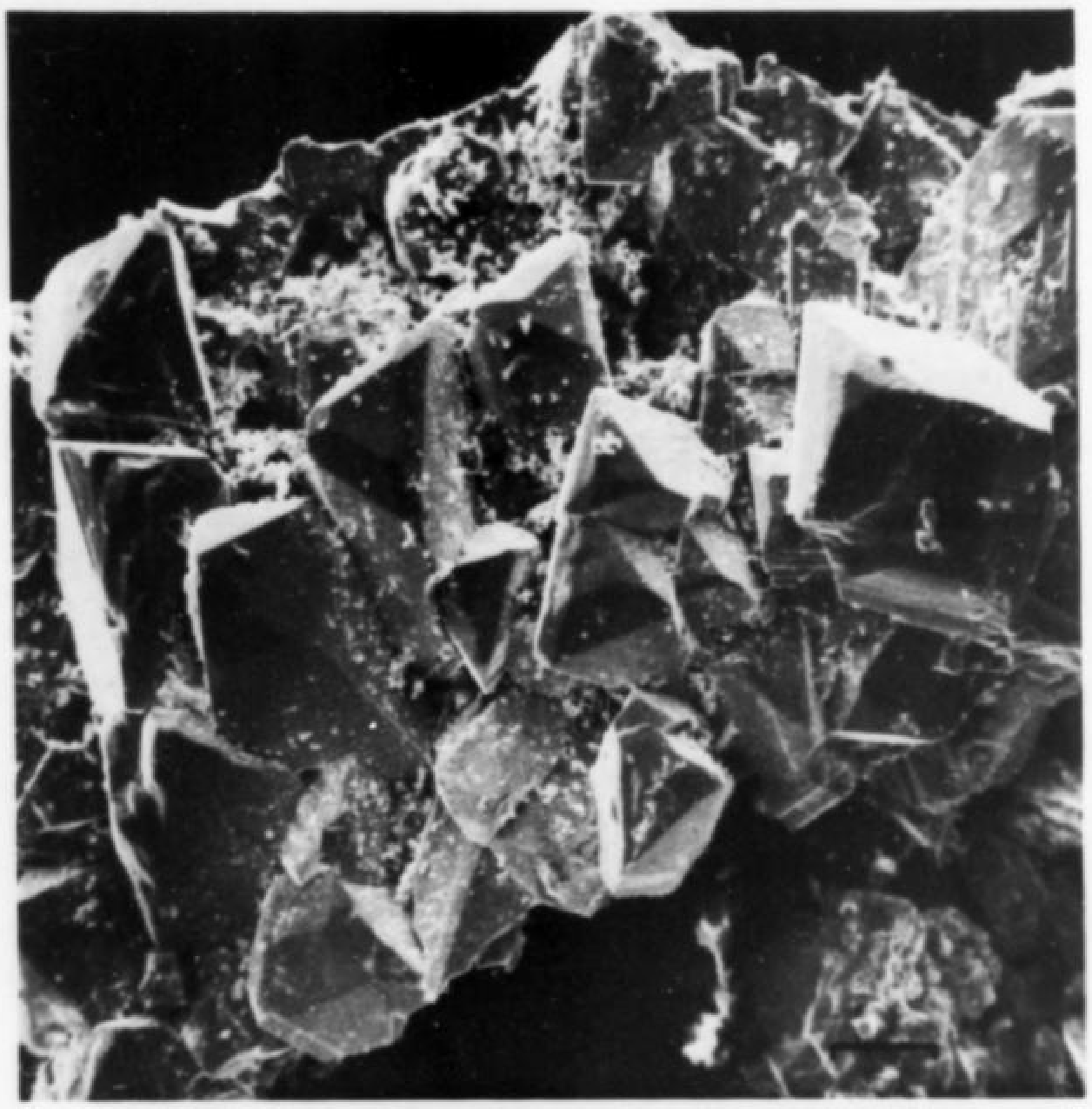

Figure 7. **SEM photograph of paratacamite crystals (greenish black) showing rhombohedral faces. Length of the bar is 3 mm.**

$q\{05\bar{5}7\}$, $f\{02\bar{2}1\}$, $w\{20\bar{2}5\}$ and $r\{10\bar{1}1\}$. The rhombohedron q is probably a new form for paratacamite (Frondel, 1950). X-ray powder pattern, chemical analyses and optical properties are identical to those reported by Frondel (1950).

A mineral originally labeled as "percylite" occurs in minor amounts as tiny blue crystals of pseudo-cubic habit. However, three good cleavages, optical properties, and X-ray analyses proved it to be boleite (Winchell and Rouse, 1974).

DISCUSSION

The mineral assemblage is typical for arid, saline conditions. The earliest secondary minerals might be osarizawaite-beaverite and anhydrite (?), followed by the precipitation of atacamite and paratacamite with the latter overgrown on the former. Caracolite probably crystallized through reaction of NaCl-bearing solutions

Table 1. **Analyses of osarizawaite from Sierra Gorda (Chile) and other localities.**

	(1)	(2)	(3)	(4)
PbO	35.74	33.15	32.72	15.8
CuO	9.53	11.83	11.27	8.5
Fe_2O_3	4.22	0.77	4.43	3.4
Al_2O_3	14.61	17.51	12.35	17.4
SO_3	25.36	26.02	22.92	33.5
H_2O^+	10.54*	10.42	8.50	10.9
H_2O^-		0.09	4.55	0.4
ZnO	—	—	0.22	0.7
Ins.	—	0.19	—	—
Total	100.00	99.98	99.09	99.9

*by difference

1. (1) Osarizawaite. Sierra Gorda, Chile (This study). Fe calculated as Fe_2O_3.
2. (2) Osarizawaite. Mt. Edgar Pastoral Station, Marble Bar, Australia (Morris, 1962).
3. (3) Osarizawaite. Osarizawa mine, Akite Prefecture, Japan (Taguchi, 1961). Total includes SiO_2 2.18, CO_2 0.45.
4. (4) Osarizawaite. Ortiz mine, Capillitas, Argentina (Cortelezzi, 1977). Total includes K_2O 6.0, Na_2O 0.7, SiO_2 2.6.

Figure 8. **SEM photograph of paratacamite crystal showing the rare form $\{05\bar{5}7\}$ and others. Length of the bar is 50 μm.**

with Pb-bearing secondary minerals (osarizawaite?). Copper, Pb and Fe might have been derived from decomposed sulfides such as pyrite, bournonite and galena, while Al might have originated from weathered feldspars or micas.

ACKNOWLEDGEMENTS

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(d) Specimen ***owner***

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Nepouite (Ni-rich Serpentine)
*These minerals are new to science and were initially discovered in this deposit.

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Figure 1. **Italian stamp issued to commemorate the 150th anniversary of the birth of Quintino Sella.**

Quintino Sella

Mineralogist and Statesman

by **Renato Pagano**
Via S. Anna, 1B
I-34074 Monfalcone, Italy

INTRODUCTION

A 16 cent "stamp" (actually the artwork of editor Wendell Wilson) bearing the portrait of A. E. Foote, mineral dealer, was shown for some time near the heading of the "Letters to the Editor" department in the *Mineralogical Record.* Stamps featuring minerals, gems and related subjects have become an interesting sideline to many mineral collections. Presumably, stamps showing mineralogical personalities, (such as the Foote stamp if it had really existed), would be welcome additions to such collections. A stamp of this kind (Fig. 1) has been issued recently by the Italian Post Administration to commemorate the 150th anniversary of the birth of Quintino Sella, one of the nineteenth century's outstanding mineralogists who, early in his scientific career, became a leading Italian statesman and left a lasting influence in the history of his country.

THE MINERALOGIST

Sella, the eighth of twenty children of a textile industrialist, was born on July 27, 1827, at Mosso near Biella in Piemonte, Italy. Graduated from the Turin engineering school in 1847, he enrolled in the Royal Corps of Mines and was sent to the *Ecole des Mines* of Paris to complete his education. Sella's stay in Paris lasted over three years, during which he attended the lectures of some of the best known savants of the time. A particularly close and fruitful relationship was established with Henry de Sénarmont, who initiated Sella to the practical aspects of mineralogy.

In 1852 Sella began teaching at the University of Turin, initially as professor of geometry and later, in 1859, as professor of mineralogy and director of the mineralogical museum. The University mineral collection, which included mainly the specimens assembled earlier in the century by Vincenzo Barelli to illustrate the mining resources of the Kingdom of Sardinia, had been neglected after Barelli's death in 1843. Sella devoted much care and work to the University museum, and added to it his own private collection of over 5,000 specimens.

The years between 1885 and 1861 were Sella's most productive in the field of science. During that period he published various works on theoretical crystallography and the crystal forms of chemical

Figure 2. **Commemorative bronze medal issued in 1885, the year after the death of Quintino Sella. Diameter: 6.2 cm. Photo by L. de Magistris.**

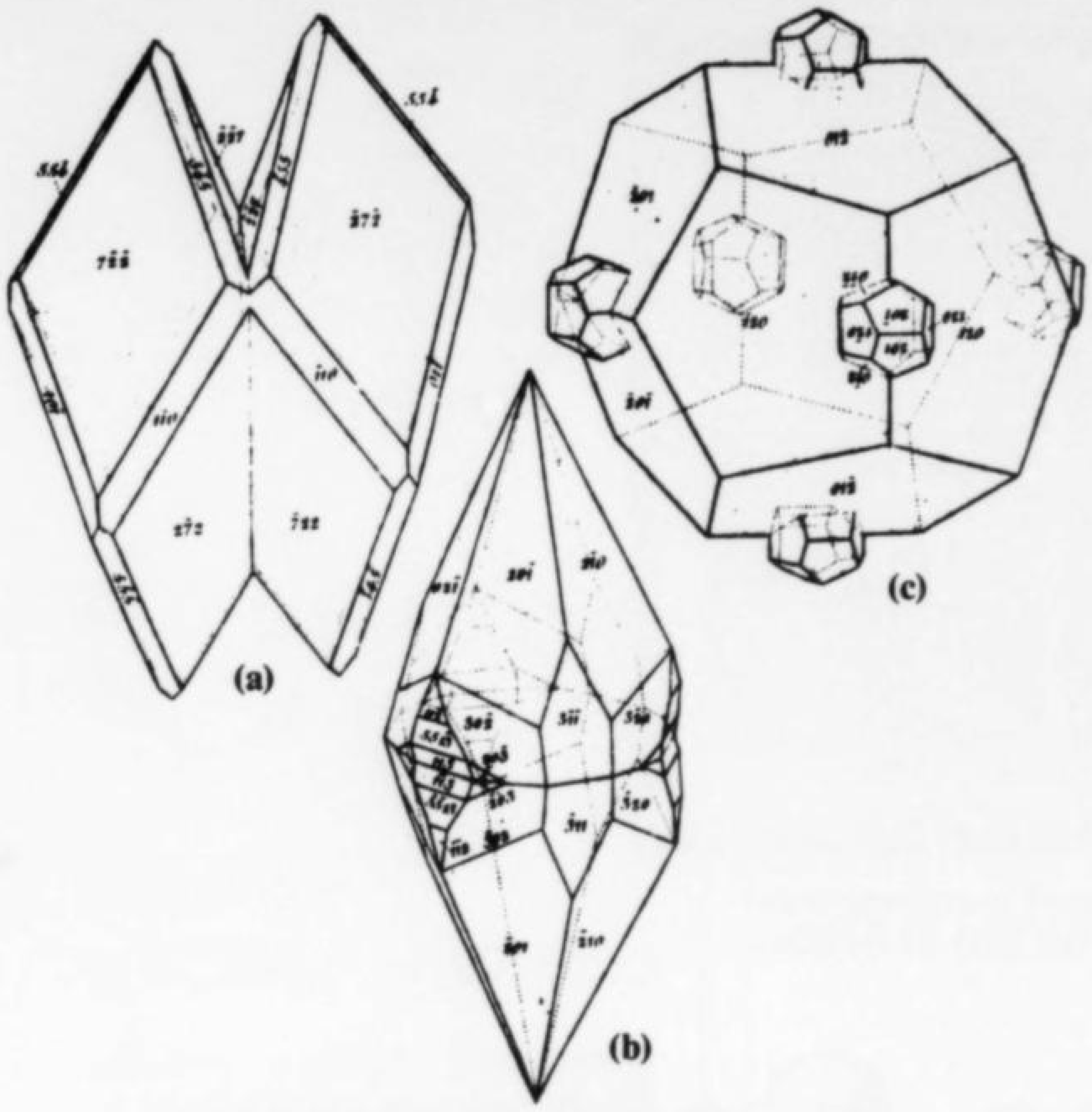

Figure 3. **Crystal twins from Traversella, Piedmont, Italy: (a) Dolomite, (b) Calcite, (c) Pyrite. Drawings from Q. Sella's 1856 work *Studii sulla mineralogia sarda,* based on specimens from his private collection, presented to the museum of the University of Turin.**

substances, remarkable at the time for the advanced mathematical approach and for the accuracy of the experimental analyses. Sella's first and most complete work on mineralogy was his *Studii sulla mineralogia sarda* (1855), covering minerals from localities in the Kingdom of Sardinia, which at the time also included Savoy, Piemonte and Liguria. In that work, which was meant to be the first in a series of studies on the mineralogy of Sardinia, Sella described a number of crystals of dolomite, calcite, pyrite and quartz, mainly from the classical locality of Traversella near Turin (Fig. 3). Most of the data pertains to twins and includes several new forms for these species.

The new mineral meneghinite, from the type locality of Miniera del Bottino, Seravezza, Tuscany, was described in 1852 by E. Bechi. Sella presented further data in 1862, particularly on the crystal forms of this mineral, which he assigned to the orthorhombic system. The symmetry of meneghinite was the cause of much argument at the time (vom Rath, in particular, considered this mineral to be monoclinic) but later studies proved Sella to be correct.

Sella spent considerable effort and time in the study of minerals from Sardinia, particularly the famous crystals of proustite, pyrargyrite and anglesite from the lead, silver and zinc mines of the Iglesiente and Sarrabus districts. Unfortunately only preliminary summaries of the studies were published (1856 and 1858), as other subjects of research first, and other tasks later, occupied Sella.

In 1876 Sella began a review of his previous work on Sardinian anglesite. In 1879 he presented the results at a session of the *Accademia dei Lincei:* to the 44 crystal forms known at the time, 38 new ones were added; notes on three additional new forms were found in Sella's papers after his death.

Other mineralogical works by Sella include studies on *savite,* a mineral from Tuscany described as a new species by Meneghini (which was subsequently shown to be natrolite), on babingtonite and datolite from Baveno, and discussions of the work of other authors such as Scacchi and Strüver.

THE STATESMAN

In 1861 Sella was elected to the Chamber of Representatives, and from then on the young and brilliant scientist spent most of his energies for the advancement of the newly unified State of Italy. Secretary-general of the ministry of public instruction, he was later minister of finance, gaining a reputation for tough and able administration, and held various other public offices as well as the presidency of the *Accademia dei Lincei.*

During the years from 1861 to his death on March 14, 1884 Sella's political and administrative activity brought him to work in other related fields of science and technology. In 1863, after visiting the most important European geological institutes of the time, Sella drafted a proposal to start the first geological survey of the new Italian state. Various of his works deal with mining technology, mining law and the mining industry, particularly in Sardinia, which he loved and toured extensively, and where he promoted the creation of the Iglesias School of Mines. A dedicated and able mountain climber, in 1863 Sella promoted the foundation of the Italian Alpine Club, still existing and very active today.

SELLAITE

It is fortunate that the name of Quintino Sella, better known in general as a statesman than as a mineralogist, is associated with that of a mineral species: sellaite, MgF_2. Sellaite was described as a new mineral by Giovanni Strüver, formerly one of Sella's assistants and then, for many years, professor of mineralogy at the University of Rome. The mineral was first discovered in the form of small prismatic crystals embedded in anhydrite from the Gebroulaz glacier in Savoy near Moutiers, north of Modane, with sulfur, fluorite, quartz and celestite. Sellaite was later found in the Carrara marble, in ejected blocks on Vesuvius (*belonesite*), in fumaroles on Etna (*zamboninite*), and in other European localities.

ACKNOWLEDGEMENTS

The author wishes to thank Leandro de Magistris of Genova and Vincenzo de Michele, Curator of Mineralogy, Museum of Natural History of Milano, for the helpful discussions and for providing reference material.

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NOTES for Collectors

A RUST REMOVAL METHOD FOR MINERAL SPECIMENS

by **R. Waller**
National Museums of Canada
National Museum of Natural Sciences
Mineral Sciences Division
Ottawa, Ontario K1A 0M8

Rust is a general term describing various hydrated ferric (Fe^{3+}) oxides and hydroxides. It is without doubt the most common disfiguring coating found on mineral specimens. The ubiquitous nature of rust is not surprising considering that iron is the fourth most common element by weight in the earth's crust and is readily dissolved as ferrous (Fe^{2+}) ions and precipitated as limonite, the natural form of rust.

Mechanical methods of rust removal such as picking, brushing, airbrasing and so on are probably the safest methods but usually do not result in completely cleaned specimens. Chemical methods, although potentially more hazardous to specimens, tend to be more effective and easier to apply.

The problem of removing rust is found in nearly every area of conservation, and in several fields of science and engineering. Consequently, numerous methods for removing rust have been proposed. The methods used by most mineral collectors are those employing acids, especially organic acids such as oxalic. The efficacy of these methods relies on the increased solubility of ferric hydroxide in low pH (acidic) solutions and the ability of the anion to sequester ferric ions. The anion is that part of an acid molecule that becomes a negative ion in solution. Sequester means that one ion combines with a different ion to prevent it from behaving normally. In the example of oxalic acid, the oxalate ions combine with ferric ions to prevent the precipitation of ferric hydroxide. Unfortunately the major reason for the success of acid, rust removal techniques, that is the low pH, is also a cause of destruction for a wide variety of minerals.

In order to avoid acid attack on minerals rust may be dissolved in neutral solutions containing sequestering anions. Examples of this type of solution include neutralized sodium oxalate and neutralized ethylenediaminetetraacetic acid sodium salt (Na_x-EDTA). Unfortunately, these solutions are too slow in action to be of much practical use in mineral specimen preparation.

Much faster and safer rust removal techniques are possible if advantage is taken of the fact that ferrous hydroxide is not only much more soluble than ferric hydroxide but is appreciably more soluble over a wider pH range. One method which utilizes this advantage is that described by Mehra and Jackson (1958) for the removal of free iron oxides from soils. An adaptation of their method is described below.

Three sodium salts are employed in this technique: sodium citrate (Na-Citrate), to sequester ferrous ions; sodium dithionite ($Na_2S_2O_4$), to reduce ferric to ferrous iron; and sodium bicarbonate ($NaHCO_3$), as a buffer to maintain pH near the optimal value of 7.3. Because $Na_2S_2O_4$ is oxidized in solution, the formulation cannot be entirely premixed and stored, but it is convenient to keep the Na-Citrate and $NaHCO_3$ as a stock solution. This is prepared by dissolving 71 g Na-Citrate and 8.5 g $NaHCO_3$ in 1 liter of water.

The specimen to be treated is placed in the smallest available beaker or jar into which it fits safely. A premeasured volume of the stock solution, enough to cover the specimen, is then poured into the beaker. Next, 1 g of $Na_2S_2O_4$ for each 50 ml of stock solution used is added. For example, if 300 ml of the stock solution is used, 6 g $Na_2S_2O_4$ should be added. 50 ml of stock solution is capable of dissolving about 0.5 g of ferric oxide (Jackson, 1956), consequently the volume of solution required to cover a specimen often exceeds that required to dissolve all rust present. It is then possible to dilute the solution by as much as 2 parts water to 1 part solution and still achieve satisfactory results. Solutions diluted more than 2:1 tend to lose their ability to buffer, therefore they should not be used to treat pH sensitive minerals.

If convenient, some automatic means of stirring may be provided but this is not strictly necessary as one minute of hand stirring every thirty minutes is usually sufficient. Using an ultrasonic cleaner to agitate the solution shortens treatment time somewhat but the bath water should be cooled regularly to prevent excessive heat build-up. Most specimens treated to date have been cleaned in 4–8 hours, although the solution will remain active for about 12 hours. After 12 hours the $Na_2S_2O_4$ will be completely oxidized and, if rust remains, the treatment must be repeated with fresh solution.

Following treatment the specimen should be set in distilled water to rinse. The amount of rinsing necessary varies considerably from one specimen to another. For most specimens, which do not contain numerous micro-fractures and are not highly porous, changing the distilled water 3 times at 12-hour intervals is usually sufficient.

When this method was first developed it was employed as a twenty-minute treatment at 80°C. Sheldrick and McKeague (1975) have since shown that the 12-hour treatment at room temperature is equally effective for soil samples. For mineral specimens the room temperature treatment is not only as effective as the 80°C treatment but also has several advantages. The most significant of these are the reduced risk of thermal shock and the reduced extent to which soluble salts are drawn into microfractures. As well, temperatures slightly above 80°C can lead to precipitation of sulfur and ferrous sulfide on the specimen (Jackson, 1956).

In addition to removing rust stains and coatings this method is useful for macerating rust-cemented matrix and dispersing many clays and soils adhering to specimens. Some of the mineral species, from which rust has previously been difficult to remove, that can be successfully treated with this method include whiteite, siderite, rhodochrosite and apatite. Species that cannot be treated with this method include all appreciably soluble minerals and calcium minerals which are slightly soluble, such as calcite and messelite. The reason for the solution of many calcium minerals is that citrate sequesters calcium as well as ferrous ions. The search for a useful sequestering agent for iron which does not affect calcium minerals is still going on in this and other laboratories (Lewin and Rock, 1976).

As with any chemical treatment there are several general rules to be followed: 1) whenever possible quality specimens should *not* be treated until trials have been made on inferior specimens from the same locality. If inferior specimens are not available, a trial can often be made with small representative fragments picked from inconspicuous places on the specimens; 2) careful examinations of treated specimens should be made one week, one month, six months and one year following treatment to ensure that specimens are stable; 3) it is most important that details of treatments be recorded and kept with other specimen information.

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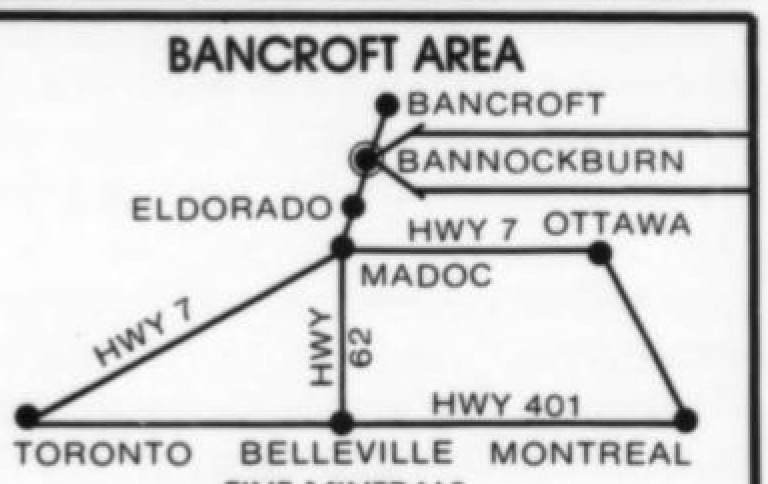

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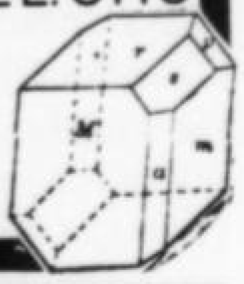

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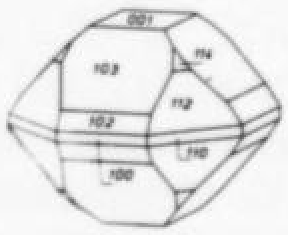


Abstracts of New Mineral Descriptions

by Wendell E. Wilson

We continue here to present abstracts of descriptions of new mineral species recently published, which have not previously been included in Fleischer's *Glossary of Mineral Species 1975* or subsequent updates thereto (*Mineralogical Record*, **7**, 91–95; **8**, 398–399; **9**, 371–374).

Ellisite

Tl_3AsS_3 Hexagonal

From the Carlin gold deposit, Eureka County, Nevada; color dark gray; luster metallic; Mohs hardness about 2; cleavage excellent to good rhombohedral; hacky fracture; opaque; streak light brown with a tinge of orange; density (meas.) = 7.10 g/cm^3, density (calc.) = 7.18 g/cxm^3; crystal size 0.4 to 1.3 mm; as anhedral to irregular crystals in dispersed grains and patches in mineralized, laminated, carbonaceous dolomite beds; named in honor of Dr. A. J. Ellis, Chemistry Division, D.S.I.R., New Zealand.

DICKSON, F. W., RADTKE, A. S., and PETERSON, J. A. (1979) Ellisite, Tl_3AsS_3, a new mineral from the Carlin gold deposit, Nevada, and associated sulfide and sulfosalt minerals. *American Mineralogist*, **64**, 701–707.

Ferridravite

$NaMg_3Fe_6^{3+}B_3Si_6(O,OH)_{30}(OH,F)$ Hexagonal

From the San Francisco mine, near Villa Tunari, Cochabamba, Bolivia; color black; luster resinous to splendent; Mohs hardness about 7; no cleavage; fracture uneven; streak brown; density (meas.) = 3.26 g/cm^3, density (calc.) = 3.33 g/cm^3; maximum crystal size "several mm"; as equant, euhedral crystals coating rock and intergrown in part to form sub-parallel aggregates; forms include $\{11\bar{2}0\}$, $\{10\bar{1}1\}$ and $\{\bar{2}02\bar{1}\}$; in fractures in schist; associations include crocidolite and schorl; ferridravite is a new mineral of the tourmaline group which is easily identified by X-ray; named for the compositional relationship to dravite.

WALENTA, K., and DUNN, P. J. (1979) Ferridravite, a new mineral of the tourmaline group from Bolivia. *American Mineralogist*, **64**, 945–948.

Keithconnite

$Pd_{3-x}Te$ Hexagonal

From the Stillwater complex, Montana; cream to brownish colored grains in reflected light; grains 38 to 220 microns; associated with kotulskite, telluropalladinite, and magnetite; four grains known; named in honor of H. Keith Conn of the Johns-Manville Corporation, who was largely responsible for the discovery of platinum-group metals in the Stillwater complex.

CABRI, J. H. G., and STEWART, J. M. (1979) Keithconnite, telluropalladinite and other Pd-Pt tellurides from the Stillwater complex, Montana. *Canadian Mineralogist*, **17**, 589–594.

Kingsmountite

$Ca_4FeAl_4(PO_4)_6(OH)_4 \cdot 12H_2O$ Monoclinic

From the Foote Mineral Company spodumene mine near the town of Kings Mountain, Cleveland County, North Carolina; color white to very light brown; luster pearly to fibrous; Mohs hardness 2½; streak white; density (meas.) = 2.51, density (calc.) = 2.58 g/cm^3; not fluorescent; as radiating bundles of sub-parallel, lath-like crystals in spherules to 2 mm, coating irregular fracture surfaces in a partly decomposed pegmatite; associations include mitridatite and birnessite; kingsmountite is the ferroan analog of montgomeryite; named after the town near the type locality.

DUNN, P. J., PEACOR, D. R., WHITE, J. S., and RAMIK, R. A. (1979) Kingsmountite, a new mineral isostructural with montgomeryite. *Canadian Mineralogist*, **17**, 579–582.

Kolicite

$Mn_7Zn_4(AsO_4)_2(SiO_4)_2(OH)_8$ Orthorhombic

From the Sterling Hill mine and the Franklin mine, Ogdensburg, Sussex County, New Jersey; color bright yellowish orange; luster vitreous; Mohs hardness about 4½; no cleavage; streak light orange; density (meas.) = 4.17 g/cm^3, density (calc.) = 4.20 g/cm^3; maximum crystal size 0.5 mm; as fractured grains and minute (0.05 mm) crystals of tabular pinacoidal habit with dipyramids and irregular faces; found in a shear zone with abundant slickensides; associations include willemite, franklinite, sonolite, holdenite, friedelite and calcite; 15 specimens known; named in honor of John Kolic who first found the mineral and recognized it as new; pronunciation KO′-LIK-AIT.

DUNN, P. J., PEACOR, D. R., and STURMAN, B. D. (1979) Kolicite, a new manganese zinc silicate from Sterling Hill, Ogdensburg, New Jersey. *American Mineralogist*, **64**, 708–712.

Lawsonbauerite

$(Mn,Mg)_5Zn_2(SO_4)(OH)_{12} \cdot 4H_2O$ Monoclinic

From the Sterling Hill mine (1570E stope), Ogdensburg, Sussex County, New Jersey; colorless to white; luster dull to slightly vitreous; Mohs hardness about 4½; no cleavage; transparent; density (meas.) = 2.87 g/cm^3, density (calc.) = 2.92 g/cm^3; not fluorescent; crystals less than 0.5 mm in size; crystals prismatic and bladed, elongated along *b*, flattened on {001}; common in parallel growth; forms include {001} and {100}; associations include pyrochroite, zincite, sussexite, calcite, franklinite; commonly with a coating of an amorphous black material; lawsonbauerite is the manganese analog of torreyite; named in honor of Lawson H. Bauer (1889–1954), chief chemist for the New Jersey Zinc Company and describer of torreyite.

DUNN, P. J., PEACOR, D. R., and STURMAN, B. D. (1979) Lawsonbauerite, a new mineral from the Sterling Hill mine, New Jersey, and new data for torreyite. *American Mineralogist*, **64**, 949–952.

MacFallite

$Ca_2(Mn^{3+},Al)_3(OH)_3[SiO_4][Si_2O_7]$ Monoclinic

From near Manganese Lake, Copper Harbor, Keeweenaw County, Michigan; rich reddish brown to maroon, brown, and dull pink in color; luster silky to subadamantine; Mohs hardness 5+; perfect cleavage on {001}; streak brown with reddish tint; density (meas.) = 3.43; crystals to 0.2 by 10 mm; thin prismatic on [010]; single crystals lining open cavities are rare, usually as solid compact masses and thick fibrous aggregates; twinning by reflection on {100} is universal; formed on basalt as a result of fumarolic action; associations include manganite, braunite, orientite, and pyrolusite; structurally related to pumpellyite; named in honor of Russel P. MacFall.

MOORE, P. B., ITO, J., and STEELE, I. M. (1979) MacFallite and orientite; calcium manganese (III) silicates from upper Michigan. *Mineralogical Magazine*, **43**, 325–331.

Nukundamite

$Cu_{3.37}Fe_{0.66}S_{3.97}$ Hexagonal

From the Undu mine, Nukundamu, Fiji; copper-colored; metallic luster; perfect cleavage on {0001}; streak dark gray to black; density (meas.) = 4.30 g/cm^3, density (calc.) = 4.53 g/cm^3; as irregular masses to 4 cm, and as tabular, hexagonal crystals to 2 mm in groups to 2 mm; occurs as a primary mineral in a kuroko-type deposit; associations include sphalerite, pyrite, chalcopyrite, and covelline; named for the locality.

RICE, C. M., ATKIN, D., BOWLES, J. F. W., and CRIDDLE, A. J. (1979) Nukundamite, a new mineral, and idaite. *Mineralogical Magazine,* **43**, 193–200.

Ranunculite

$AlH(UO_2)(PO_4)(OH)_3 \cdot 4H_2O$ Monoclinic

From Kobokobo, Kivu, Zaïre; gold-yellow in color; Mohs hardness 3; density (meas.) = 3.4, density (calc.) = 3.39 g/cm^3; not fluorescent; crystal size averages 0.3 mm with a maximum of 1 mm; as thin, rounded plates which compose nodules in uranium-rich portions of a pegmatite; associations include meta-autunite, phosphuranylite, phuralumite, upalite and threadgoldite; 15 samples known; named for the characteristic color ("ranunculus" = buttercup in Latin).

DELIENS, M., and PIRET, P. (1979) Ranunculite, $AlH(UO_2)(PO_4)(OH)_3 \cdot 4H_2O$, a new mineral. *Mineralogical Magazine,* **43**, 321–323.

Stibiobetafite

$(Ca,Sb,Sn,Fe,Mn,Na)_2(Ti,Nb,Ta,Al)_2O_6[O,(OH),F]$
Isometric

From south of Věžná, western Moravia, Czechoslovakia; brownish black in color; luster vitreous; Mohs hardness about 5; brittle; streak creamy white to pale brownish; density (meas.) = 5.30 g/cm^3, density (calc.) = 5.19 g/cm^3; as octahedral crystals and granular aggregates; occurs veining and replacing partly disordered columbite and niobian rutile in a pegmatite cross-cutting serpentine; associations include columbite, niobian rutile, cassiterite, zircon, stokesite, albite, native antimony; a member of the pyrochlore group; named for its relation to betafite.

CERNY, P., HAWTHORNE, F. C., LAFLAMME, J. H. G., and HINTHORNE, J. R. (1979) Stibiobetafite, a new member of the pyrochlore group from Věžná, Czechoslovakia. *Canadian Mineralogist,* **17**, 583–588.

Stoiberite

$Cu_5V_2O_{10}$ Monoclinic

From the summit crater of the Izalco volcano, El Salvador, Central America; color black; luster metallic; streak reddish brown; density (calc.) = 4.96 g/cm^3; crystal size less than 100 microns; habit platy on {100}, as an encrustation of polycrystalline aggregates; formed in the oxide zone of a volcanic fumarole; associations include chalcocyanite, chalcanthite, shcherbinaite; only a few milligrams known; named in honor of Dr. Richard Stoiber, professor emeritus at Dartmouth College; pronunciation: stoi′-bər-it.

BIRNIE, R. W., and HUGHES, J. M. (1979) Stoiberite, $Cu_5V_2O_{10}$, a new copper vanadate from Izalco volcano, El Salvador, Central America. *American Mineralogist,* **64**, 941–944.

Telluropalladinite

Pd_9Te_4 Monoclinic

From the Stillwater complex, Montana; cream-colored under reflected light; density (meas.) = 10.25 g/cm^3, density (calc.) = 10.68 g/cm^3; crystal grains 27 to 100 microns in size; associated with keithconnite and magnetite; only eight grains known; named for the composition.

CABRI, J. H. G., and STEWART, J. M. (1979) Keithconnite, telluropalladinite and other Pd-Pt tellurides from the Stillwater complex, Montana. *Canadian Mineralogist,* **17**, 589–594.

BOB SULLIVAN'S

LETTER from EUROPE

"Big Events" in the mineral world seldom take place, but when they do it is amazing to me how quickly the word flashes around the world. The pulses of all mineral collectors immediately quicken and the entire mineral fraternity, dealers included, are instilled with a new enthusiasm for all minerals. The last such memorable occurrence was the opening of a huge pocket of superb red tourmaline, subsequently baptized "cranberry tourmaline," at the Jonas mine, Itatiaia, Minas Gerais, Brazil, now nearly 1½ years ago. The *Record* and other publications progressively reported the series of events that followed the strike and, to me, the story was as interesting as was the superb color of the specimens that subsequently were offered by the few dealers who were able to acquire a collection of them.

Finally, after too long a wait, another such event has occurred, this time in Europe, in the form of a superb collection of azurite brought from a relatively unknown mine in Morocco by several French and Swiss dealers who really had their ears to the ground late this past summer. Once again, the story in back of this find is indeed fascinating. Let me tell you about it.

First showing of the specimens occurred at the Swiss Altdorf bourse September 8–9 by a pair of Swiss dealers who had joined hands in this venture; the impact of the find was sensational. Three weeks later, collections of these specimens were offered at the Munich bourse. A week later at the Geneva bourse on October 6–7, the bulk of the two Swiss dealers' collections, now cleaned and properly prepared for sale, was shown with the same sensational results. A few American dealers who were at Munich did bring back small collections of these expensive specimens but unfortunately, for American collectors at least, the bulk of the specimens were quickly snapped up by European collectors and museums. Specimens brought to the October Detroit show were amply illustrated by Wendell Wilson in the last issue of the *Record.*

Initially it was thought that the specimens were from Kerroucher, Morocco, which has been sporadically producing fair to good azurite specimens for over a decade. When the "secret" was finally let out the source was surprising. The azurite was from a virtually unknown mine on the edge of the village of Toussit (pronounced Two-seat) about 40 km south of the town of Oujda in Morocco. Oujda lies close to the Middle Atlas Mountains in the northeast corner of Morocco and about 60 km from the coast of the Mediterranean Sea. Toussit is only about 1 km from the Algerian border, has a population of some 2000–3000 people, whereas Oujda is the major center in the area with a population of over 50,000. Some specimens were incorrectly labeled "Oúgea" by the way, but I am assured Oujda is correct.

Azurite is normally found in copper mines and one normally associates a "new" find with a new mine. In this case neither is correct. The Toussit mine has been operating as an active lead and zinc mine for nearly 35 years and to date has never produced any of the copper minerals. Its specimens have never been anything special and to my knowledge they have never been offered for sale on the European market. The mine is presently owned and operated by the Moroccan government but in earlier days it was owned by the Belgians and later the English. Mining operations were started in 1945 and production continues to this day.

The azurite pocket was a huge one, some 5 meters by 5 meters, and was hit late this past summer when miners crossed a small vein of copper ore at the 200-foot level, reportedly the first copper ever encountered. The ore consisted of mostly massive cuprite and malachite and, while a few specimens containing malachite needles on the cuprite were recovered, they were nothing special.

The azurite, however, was a different story! The crystals generally are large, ranging up to 12 cm in length for the super ones with quite a few in the 5–10 cm range. One of the longest crystals found is a 12-cm beauty about 1½ cm thick and nearly 1 cm wide, and yet it had been broken off by a miner considerably above its point of attachment to the matrix. Many types of crystallizations were found, and most of the crystals are deeply striated parallel to the *c*-axis. The most beautiful of the specimens are those with long, thin, very transparent, rich blue azurite crystals reminiscent of those from Zacatecas, Mexico, some years back, but considerably larger. Some of these are over 1 cm wide and up to nearly 4 cm in length—truly magnificent, particularly in clusters. However, most of the crystals are a deep blue to a very dark black-blue. A fair number of matrix specimens were recovered but on many of them, the crystals are not really free-standing, but laid rather flatly on the reddish-brown matrix in parallel growth. Many of the azurite specimens show a partial pseudomorphing to malachite and a few are completely pseudomorphed, some in attractive clusters of crystals 4–5 cm in length. Of over a thousand pieces examined by one Swiss dealer, only one showed an azurite crystal with the so-called "Bailey azurite" flat termination. It was quickly popped into his collection. The term "Bailey azurite," incidentally, came into use in Europe back in the spring of 1973 when a miner by the name of Bailey recovered a small quantity of flat-terminated azurite crystals from a single pocket in the Tsumeb mine. They had occurred only once some 17 years before at this mine and were deeply and attractively striated on the end terminations as well as the sides—truly collector items.

It is difficult to say how many specimens were recovered from the huge pocket at the Toussit mine but best estimates indicate between 3000 and 4000 specimens, mostly single crystals. Unfortunately many of the crystals are badly etched and many others were severely damaged during their removal and subsequent transport by the miners in their first encounter with a pocket of super minerals.

One Swiss dealer who personally examined nearly 2000 of the specimens stated that only 5% were really very good and possibly an additional 10% in the acceptable class. This low yield showed up in the pricing of these minerals, which initially was not all that bad; at Altdorf one could buy a pretty good single crystal about 3 cm long by 1 cm wide for about 75 SF (about $45). As the impact of the find became known and many of the specimens recirculated through the hands of one or more dealers, prices rose quickly and sharply with some of the better groups reaching the multi-thousand-dollar range. The best of the specimens, those close to dinner-plate-size superb matrix pieces, were sold at between $12,000 and $13,000 each.

During show time at the above 3 bourses, European collectors were really buzzing about the news and typically the air was full of wild stories about this rather remote locality. There were stories of Europeans being caught in the mine, some being thrown in jail, wild escapes from the town and you name it. Now that the dust has settled, however, it appears that none of the four or five European dealers involved in the coup were actually jailed, but several were picked up and questioned and also told to get out and stay out of Toussit. Moroccan minerals are protected by an antiquities type of law but the authorities were more concerned with the thievery from the mine aspect and at least a couple of the miners reportedly ended up in jail.

I have a feeling there is more to come from this mine, however. And one of the reasons is that, in the excitement over the azurite, some of the other specimen material that was also brought out was somewhat overlooked. Certainly there is also a distinct possibility of another azurite hit. There were some other minerals found in the azurite pocket, most notably good crystals of anglesite and cerrusite as well as the previously mentioned needle malachite. Anglesite and cerrusite have been found in other lead/zinc mines in Morocco, notably at Mibladen in association with vanadinite, more often with pink bladed barite. The Toussit anglesite is especially good, and gemmy crystals up to 2 or 3 cm were recovered in both light yellow and clear colors. The quality of the cerrusite is average but crystals to 5 or 6 cm were reported in the same color range, and both the anglesite and cerrusite were taken out on a matrix of massive galena, truly a bonus. A few of the azurite specimens also have scattered anglesite and cerrusite crystals on them. Most of the anglesite crystals are striated on the *c*-axis with sharply formed wedge-shaped terminations but one specimen with a very gemmy, yellow, 1-cm, book-shaped crystal perched neatly on galena is a winner, and for sure there does appear to be promise here.

Another shaft of the Toussit mine did produce some fairly good wulfenite specimens. The crystals are thin and opaque yellow in color, reminiscent of the Mies, Yugoslavia, specimens and range to 1 or 1½ cm in size. The matrix is a rather gemmy pink curved bladed dolomite, some with scattered small pyrite/chalcopyrite crystals and similar to the well-known dolomite specimens from Arkansas. Damage on most all of the Toussit specimens is fairly extensive, detracting much from their appeal and value, but only time will tell if this new name to the mineral world can establish more than a one shot reputation. But it was *quite* a shot!

Generally speaking, the rest of the European scene was rather quiet throughout the fall and, as I write this, Basel and Paris in December are the only two remaining bourses. Attendance was mostly down, nearly 3000 at Munich for example, but unlike in the U.S.A., there was a definite uptrend in the buying. Traditionally in times of economic uncertainty the Europeans turn to gold, gemstones, stamps and, yes, minerals as a haven for their savings. Having been raised in the European mineral climate I feel the same way and when I purchase a good mineral I definitely classify it as a good investment, although my main interest lies in the beauty and sometimes the uniqueness of a fine specimen. Obviously the quality, condition, and the cost of the specimen are important considerations when investing.

Yet, there were some other interesting minerals to be had, mostly in the category of exceptionally fine material from some of the currently producing localities. Two of these were at Munich and strangely enough they were both aragonite. Minglanilla in the province of Cuenca, Spain, has long been a source of finely crystallized aragonite crystals and over the years thousands of them have been exported both to the rest of Europe and the U.S.A. Minglanilla lies in a beautiful mountainous region only a few kilometers from the large lake of Contreras and one can still collect good aragonite specimens at the locality. Minglanilla lies on a good road roughly 70 miles west of the east coast port of Valencia (which has an airport) in case the urge to collect does hit you. Their sharply formed pseudohexagonal prism shape, interesting way of twinning and relatively low cost have made these aragonite crystals popular with collectors. Normally they have ranged from 2–6 cm in length and 1–2 cm in diameter. At Munich, however, one Spanish dealer showed a small collection of them which was truly superb. The crystals are doubly terminated slender prism from 10–25 cm long, rather gemmy for aragonite and a rich purple in color. The sides of the hex are sharp and brilliant and (quite unusual) they were damage-free. The dealer sold out almost immediately and at rather moderate prices. Hopefully there could be more of these as the Minglanilla area continues to produce them, although in somewhat decreasing quantities.

The numerous mines of Sicily, Italy, have long produced a wide array of collector favorites including sulfur, celestine, and, of course, aragonite in many forms and colors. Occasionally the sulfur mine at Agrigento has yielded groups of small pseudohexagonal prisms of aragonite in whitish to very pale green colors. They have seldom commanded much respect from collectors, as damage has almost always been extensive and they lacked that "clean look" or strong color attendant with many other aragonite localities. Not so recently there appeared at Munich a fine but small collection of green pseudohexagonal aragonite specimens from Agrigento which were most attractive. The semi-translucent prisms range to nearly 4 cm in length on these and up to 2 cm in diameter, and are neatly clustered on ball-shaped groups of a dozen or more crystals. Color is a strong, pleasant apple-green with occasional creamy white mottling. Prices were moderate. The same dealer also offered some very fine gemmy, crystallized, rich yellow barite on a matrix of etched white fluorite. The barite crystals average 2–3 cm in length, are tabular in form and make for a very attractive contrast to the frosty appearing white fluorite. The specimens are from Santa Lucia, near Iglesias, Sardinia, Italy, an area which has been producing some rather fine minerals in recent years, but the news seldom travels much further than Italy as specimen availability has been rather limited.

There was much to see at Munich and there were numerous fine offerings by the nearly 300 dealers, including about 30 from overseas, who exhibited their wares. Munich, like most European bourses, is primarily a mineral bourse but there was something for everybody including fossils, lapidary material and machinery, gemstones, jewelry, and tables for traders and experts to identify questionable specimens. Over a dozen European museums exhibited selected specimens from their collections including those from London, Rome, Madrid, Copenhagen and Germany. Paris' Sorbonne display was especially notable and Dave Wilbur's world's largest (and most beautiful) phosphophyllite really raised some European eyebrows. Dave was a guest of honor at the bourse, by the way, and learned very quickly that phosphophyllite is phosphophyll*eet* when pronounced in German. The consensus of opinion was that it was a good show in every language but unfortunately for visiting American collectors and dealers, present in record numbers this year, next year's bourse falls on the same date as the famous Detroit show. Maybe 1981?

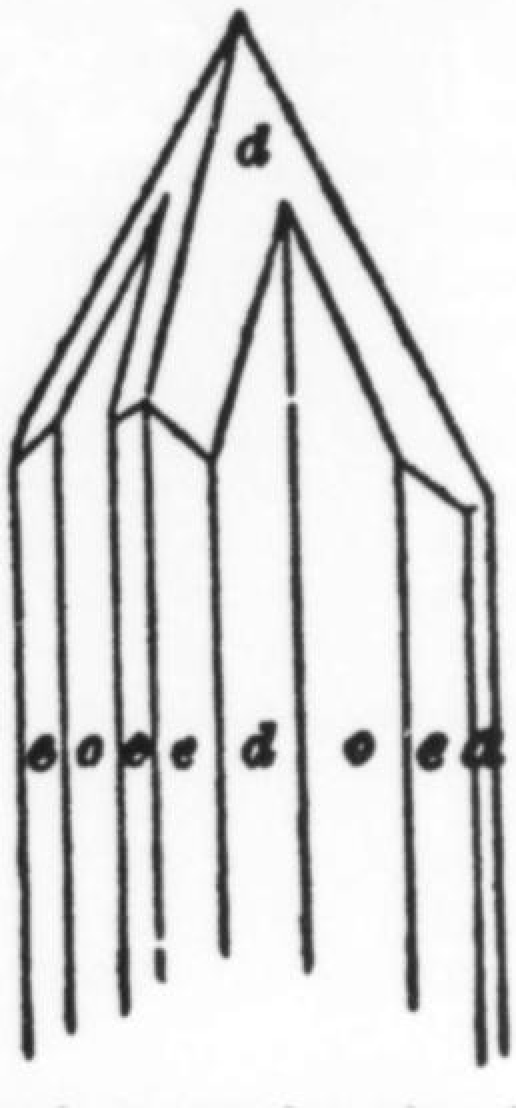
Last but not least is Zurich, whose bourse took a couple of unusual twists this year. I remember a few years back when a severe ice storm hit Zurich and the bourse was a disaster for everybody, including those who couldn't get to the famous *Zuspahalle*. Not so this year, and November 10–11 were good days by Swiss standards, (they say Switzerland's best kept secret is the weather), and a record attendance resulted. German dealers were conspicuous by their absence as the Stuttgart bourse occurred on the same weekend. By Zurich time the now-famous Moroccan azurite had pretty much disappeared and no particularly new mineral surfaced as a hit.

The minerals of India pretty much stole the show and at least a half dozen dealers had really superb collections of Poona's famous green apophyllite. There seems to be no end to the flow of this very fine mineral from the world's only producing district. The best of these was a dramatic 50x50-cm plate nearly covered with light green, beautifully defined clusters of pyramidal apophyllite crystals ranging from 3 to 5 cm in length, all on a pure white background of heulandite: truly gorgeous. The price on the specimen ("one half million Italian lira") shook a few people up but some quick mental arithmetic revealed it was only a bit over 1000 Swiss Francs or about $650. Needless to say it was sold—to an Italian, I think! Also in evidence were a number of unusually fine, silvery-white, crystallized heulandite plates with 2 to 3-cm-long interdispersed white stilbite blades. They were labeled Panwell, India, which I suspect should be Panvel, about 50 km from Bombay in the state of Maharashtra. This is the same area that produced a few of those very rare blue pyramidal apophyllite crystals a few years back. In my last column I mentioned the blue apophyllite as being from an unnamed quarry area near Bombay, but Panvel is correct.

Perhaps the greatest surprise at Zurich was the appearance of a small quantity of Switzerland's elusive octahedral "pink fluorite" and, as a bonus, perched on an attractive matrix of crystallized smoky quartz. The Swiss call them *rosa fluorit,* meaning they think the fluorite is more of a rose rather than pink color. These were actually a very pale cranberry color (meaning more of a blue-red), "doubly terminated" and a number of them showed phantoms. The largest specimen was a 30x30-cm matrix beauty and it was steeply priced. Incidentally, an unusually large number of museum-size pieces were sold at the Zurich bourse this year, for not only do the Europeans like a good size mineral specimen, but they feel they are the best investment pieces. So much for the European bourses.

In my last column I told you about some unique gold-coated and spinel-twinned native copper from Coquimbo, Chile, a collection of which was found in 1968 and did not come to light until early 1979, some 11 years later. Quite a bit of interest has been generated by the find and several questions have also been raised. First let me say that I failed to give the name of the mine, since the location was somewhat hazy at the time. But I now have found that it is called the Andacollo mine and lies on the edge of the town of Andacollo, in the foothills of the Andes, in the province of Coquimbo. Andacollo lies some 50–60 km southeast of the twin coastal cities of Coquimbo and La Serena, and the mine, as of August 15 of this year, has been purchased by the Noranda Company of Canada. Correct labeling would therefore be Andacollo mine, Andacollo, Coquimbo Province, Chile. At present the Andacollo mine still exists as an underground operation, but apparently Noranda plans to incorporate it into a large open pit mine adjoining it.

One of the questions raised was with respect to the name "spinel twin" when referring to the elongated, multiple spear-like crystals found both at Andacollo mine in 1968 and at the Ray mine in Arizona in 1973. Here I again refer you to the *Record* (Vol. 5, no. 5 and Vol. 6, no. 1) and if you look at these issues again, as I recently did, you will note that the Ray specimens were referred to as "single crystals of copper" with no reference to twinning. A second check with Bill Panczner, who authored the second *Record* report on the Ray specimens and also examined some of the Andacollo ones, indicates that the crystals are indeed twinned and that the type of twinning is that which does occur in crystals of spinel. Spinel twin, or perhaps more correctly, spinel-type twinning, is therefore considered by Bill to be an appropriate description. Jean Kemp, curator of the A. E. Seaman Mineralogical Museum in Michigan, raised her eyebrows somewhat at the nomenclature, felt there was a historical precedent for the name of such twins and, in short order, mailed me a valuable reference for which I owe her thanks. It was page 303 from *Mineralogy of Great Britain and Ireland* by Greg and Lettsom, dating way back to 1858. The page shows a drawing of an idealized, spear-shaped twin copper crystal (shown here) like the Ray and Andacollo specimens, and page 304 mentions them as "spear-shaped macles." *Macle* is the French word for twin, but it has been somewhat universally adopted particularly by the diamond industry in referring to certain forms of twinned diamond crystals. Regardless of whether you call them spear-macles, Jean's preferred short form, or spinel-type twins, they are indeed unique as well as beautiful if you happen to be a copper lover like me. For the record, I would like to report that one of the several small pockets at the Andacollo mine also did produce a few specimens of chalcotrichtite in small vugs in the breccia fragment matrix. The crystals are small, hair-like fibers and a few are on small pieces of native copper. Also it was subsequently found that a few of the spinel-type copper twins *did* have a coating of gold on them as a bonus.



Thanks to Julie and Miriam Zweibel for saving my skin with respect to a report I picked up in Europe this past summer (and almost published) about a new rhodochrosite hit in South Africa. Actually the long drought still continues and there is no new rhodochrosite coming out. As a result I was able to have the report pulled from my last column just before publication. Apparently the beautiful collection of 40 odd pieces of this material I did see in Europe was a hold back from earlier finds. Several of those rhodochrosite specimens also had some 1–2-cm, well crystallized, clear pseudo-cubic apophyllite crystals on them, the first I had ever seen of this combination, and they were very attractive.

Julie was able also to answer a previously raised question about current ore production at the Tsumeb mine. It is up, not down as many have suspected. Yet the supply of Tsumeb minerals remains remarkably low and the reasons for this are not readily apparent. It is a fact that the Tsumeb Corporation did hold an auction of approximately 150 lots of dioptase on October 5 but from some of those who attended, I gathered that the specimens were not all that good. Still, in these lean dioptase days, perhaps something is better than nothing? I really got a kick out of the Tsumeb Corporation announcement which said, "Please remember to bring packing material." As any of you who have ever been to Tsumeb and Windhoek know, toilet paper is the standard packing material used there. I guess there is a shortage of more than just dioptase!

Speaking of dioptase, you will recall that in several previous columns I have listed a number of localities other than Tsumeb; also I told you a story about a young collector who climbed the fence at Renneville, etc. First let me make a correction, for I have been bawled out in several languages including French and German for giving you one dioptase locality as "Renneville, Zaïre." There has always been confusion in Europe on this locality ever since the political changes in that part of Africa took place, and French Equatorial Africa and the Belgian Congo were progressively broken up to form such countries as Gabon, Democratic Republic of the Congo, Zambia, etc. In subsequent reshuffling, Congo became the Peoples Republic of Congo with its capital being Brazzaville, and the Democratic Republic of the Congo became Zaïre with its capital at Kinshasa (formerly Leopoldville). Brazzaville and Kinshasa lie opposite each other on the Congo River, which forms the border between the two countries and, even though there is a bridge across the river connecting the two cities, it is impossible to cross the border due to the political differences of the two countries. Correctly, therefore, at least as of the moment, it appers that Renneville dioptase should be labeled "Renneville, the People's Republic of Congo." Theoretically the province or district should also be included but I have not been furnished it, nor does my *National Geographic Atlas* show it. *(My* Times Atlas *does: Pool Province. Ed.)*

Renneville, though long-famous in Europe for its exceptionally large crystals and beautiful groups of dioptase, has remained somewhat of an enigma to Europeans for over a decade. I have only met two people who have ever been there and one was the lad whose fence-climbing story I told you some time ago. A much appreciated letter received from Dr. F. Krantz of Bonn, Germany, sheds a little light on this "mystery town," from which I quote: "Renneville is located northwest of Brazzaville about 100 km as the bird flies. There is no road, only a very bad track, hard to find. There is no chance to arrive without a jeep or truck. Renneville is a small village of about a dozen houses located 700 meters from the old mine. Most of the dioptases are found on the old dumps (the mine closed in 1918 I was told by the village chief). It is possible that a fence now exists but it is impossible that a European guy arrives without it becoming known to the black people. Every car coming from the next town is known and you can hear the noise a long time beforehand." It seems to punch some holes in my story but since Dr. Krantz was last in the area in 1973 it is possible things have changed since, for the teller of the story was a good friend of mine.

Thanks to letters from several readers I can add to the list of dioptase-producing localities mentioned in previous columns. In addition to Renneville, Mindouli, M'Foati and Pimbi are three other dioptase areas in the Peoples Republc of the Congo. Rus Behnke of Connecticut passed along this information and stated that, according to his contact at the U.S. Bureau of Mines, these mines are still operating and probably should be considered as capable of producing some desirable specimens. Rus also reports that the Mavoyo locality in Angola has produced fine dioptase crystals up to nearly 3 cm in length and that the mines are presently active. I have never seen any Angolan dioptase offered in Europe and, with the present situation in Angola, availability of any specimens seems doubtful in the near future. Both Rus and A. Delvaux of the University of Burundi in Burundi also report that fine examples of dioptase have occurred at Tantara in the Katanga province (now Shaba) of Zaïre. I do think there is more to learn about these localities and their specimens and I hope to be able to report back later on them. With the supply of dioptase rapidly diminishing at Tsumeb, perhaps one or more of them can eventually step into the breach.

I seldom get the time to read a book, let alone recommend one these days, but there are two I would like to recommend to you now. One is Hellmuth Boegel's book, *A Collectors Guide to Minerals and Gemstones*, published by Thames and Hudson Ltd. of London. It is a translation of the original German book *Knaurs Mineralienbuch* by Eva Fejer and Patricia Walker, and was edited by John Sinkankas. I obtained a paperback copy of it in London several years ago for about $5. The book contains 154 color illustrations of minerals, all of which are fine paintings by Claus Caspari. I like this book not only for its illustrations, but for the very useful and accurate locality information it contains, plus the authors' use of the simple European exclamation point system for classifying the quality of similar minerals from different localities. It uses !, !! and !!! notations to indicate progressively better quality with !!! meaning the best.

The other is a 40-page booklet entitled *Bad Ems Bergbau und Mineralien,* 2000 copies of which were published by Rainer Bode coincident with his Bad Ems, Germany, mineral bourse this past April. The terrific color photos (done by Rainer and *Record* staff photographer Olaf Medenbach) of classical Bad Ems specimens, primarily pyromorphite, are worth the price alone. It also traces the history of the Bad Ems mines from the year 805 until their closing in 1963 and contains, among other things, many old mining photos. It is available from Rainer Bode, Hohe Eiche 26, 4630 Bochum 7, West Germany, for 7 DM plus postage.

That's it for now. Special thanks go to Linda Kubler and J. P. Cand of Switzerland, H. Brueckner of Germany and H. Obodda from you-know-where for helpful information on the European scene. Until next time...

Cheers,
Bob Sullivan

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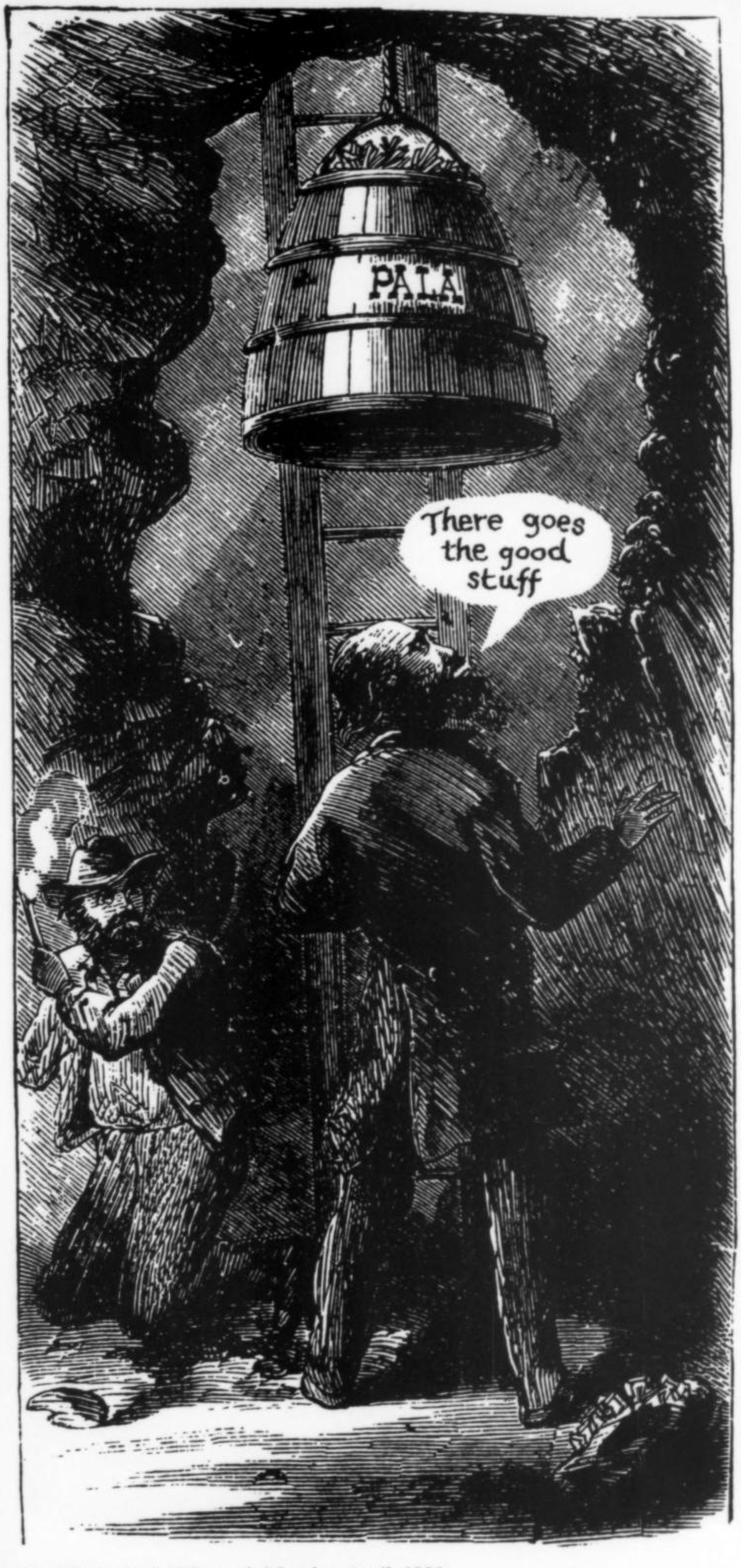

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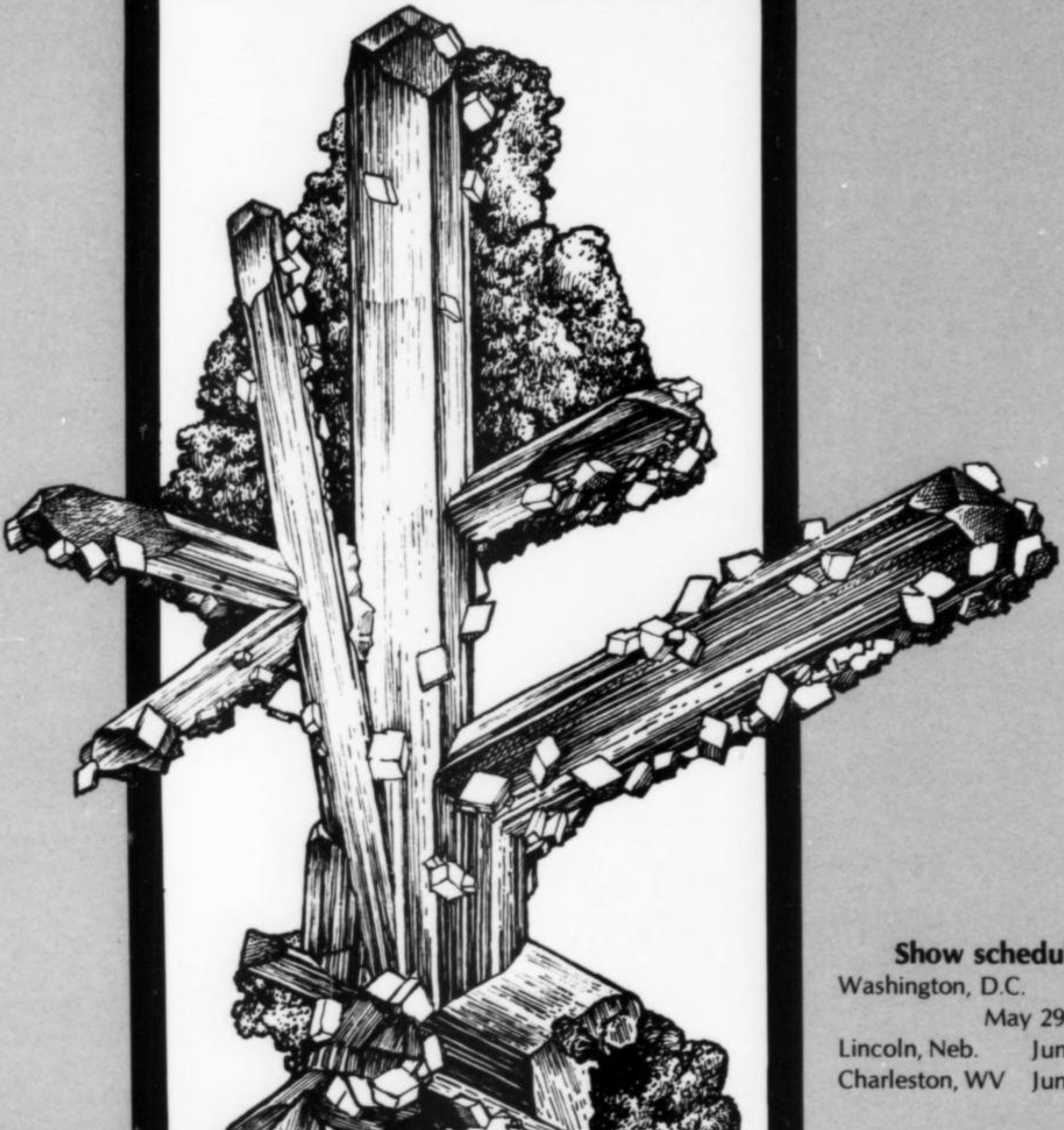


FM friends of mineralogy

A FAREWELL TO CORNWALL

The Pennsylvania Chapter of Friends of Mineralogy in conjunction with the Mineralogical Society of Pennsylvania sponsored a conference and field trip to the Cornwall magnetite mine at Cornwall, Pennsylvania, on April 21-22, 1979. The conference was held at the Grubb Mansion which was built in 1800 by Henry Bates Grubb, the grandson of the founder of the Cornwall ore bank.

The Cornwall iron mines are located in Lebanon County near U.S. Route 322 about ½ mile south of the village of Cornwall. Cornwall is 6 miles south of Lebanon and 30 miles east of Harrisburg. Ore was first mined at Cornwall in 1742. As of 1848, it was estimated that 776,000 tons of ore had been removed by the pick and shovel method. By 1910, 20 million tons of ore had been extracted. Ore production passed the 50 million ton mark by 1936; and in 1973, after 234 years of uninterrupted production, the total amount of ore mined was 106 million tons. The Cornwall ore bank mining operation ceased abruptly when hurricane Agnes and subsequent floods filled the mine and all shafts with water. The remaining ores could not justify the cost of dewatering the mine.

During 1858, Dr. Henry Rogers began the first geological and mineralogical study of the area, having been commissioned by the first geological survey in Pennsylvania. Subsequent efforts of the second survey began to show the relationship of the Cornwall ore to the diabase intrusives. By 1883, mineralogical interest in Cornwall continued to soar with the recovery of splendid specimens of numerous copper minerals, zeolites and complex pyrite crystal forms. The mines were visited by such notables as Dr. Frederick Genth and John Eyerman. An obscure Cornwall clergyman, Rev. George G. Rakestraw, collected tiny but perfect Cornwall specimens which he enjoyed viewing with a microscope. Rakestraw, along with George Fiss of Philadelphia, is credited with starting American interest in micromineralogy. In more recent years, the Cornwall open pit and the mine dump areas have been a favorite collecting area for professional mineralogists and serious amateur mineral collectors. Since 1972, however, permission to collect has not been easy to obtain, and some areas are off limits to all collectors. Nearly 60 mineral species have been identified as occurring at Cornwall. The latest addition to this list is the rare tochilinite.

The conference on Saturday opened with registration at the Grubb Mansion for the participants. Each registered participant was given a package including a map of the area, a history of the Grubb Mansion, a copy of the *Guide To The Geology Of Cornwall, Pennsylvania* by Carlyle Gray and Davis M. Lapham, and the book, *A Farewell to Cornwall,* authored and designed by Jay Lininger. *A Farewell to Cornwall* was a limited edition and all extra copies were destroyed. The first talk was given by Thomas Loose on the "History of the Cornwall Furnace." This historical talk was interesting in giving the participants both background and anecdotal information on the early mining days.

The second talk was given by Carlyle Gray on the "Geology of Cornwall" and covered the work done by him and Lapham in developing their book. The ore is spatially and genetically associated with a Triassic diabase sheet which is intrusive into folded and faulted lower Paleozoic limestones. Clastic Triassic sediments unconformably overlie the limestones. The ore replaces beds of the Buffalo Springs formation, the oldest of five Cambrian units mapped in the area. The magnetic ore is associated with chalcopyrite, pyrite, earlier amphiboles and pyroxenes, and later silicates such as mica, chlorite and zeolites. Both the structure and the mineralogy of the ore deposit indicate that it is genetically related to the diabase, although somewhat later in time than the crystallization of the diabase. Gray spoke in great detail of the geology and illustrated his talk with slides.

Following a prepared lunch, the participants were on their own to visit the Leighton Donley collection of Cornwall minerals and take a tour of the Cornwall furnace. The speaker for the banquet was Milton Leet who talked on "Cornwall, the Bethlehem Years." Milt presented an informative slide program dealing with the mining and production methods as well as many of the mineral specimens found there.

Through the efforts of Donald Hoff, arrangements were made for the participants to collect in the open pit and on the mine dumps at Big Hill, No. 3 and No. 4 mines, on Sunday.

Conference arrangements were handled by Jay Angelo, Ann and Martin Anné, Bryon Brookmyer, Harold and Martin Davis, Carlyle Gray, Donald Hoff, Milt Leet, Thomas Loose, Bethlehem Mines Corporation and Sheraton Slag Corporation. Credit for much of the leg work, research, preparation of the illustrated book and setup is given to Ann and Martin Anné, Bryon Brookmeyer, Karl Jones and Jay Lininger.

The Pennsylvania Chapter of the Friends of Mineralogy and the Mineralogical Society of Pennsylvania have established a precedent of cooperation in producing a very interesting and successful conference and field trip to commemorate this famous mineral locality.

J. Penrose Ambler
Pennsylvania Chapter - FM Bulletin Editor

Those wishing further information about the Friends of Mineralogy may write to the current FM president: Delbert Oswald, Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, Pennsylvania 15213.

What's New in Minerals?

PASADENA SHOW 1979

Visitors to the thirty-second annual Pasadena Gem and Mineral Show (hosted by the Mineralogical Society of Southern California) this November were treated to more fine displays and more quality mineral dealers than at last year's already excellent show. It seems obvious that the MSSC Show Committee is consciously and successfully attempting to close the gap between its own show and the nation's no. 2 show at Detroit (no. 1, of course, being at Tucson). The two shows invite comparison, and the differences could inspire lengthy debate, particularly where general philosophy is concerned. Detroit encourages competitive displays; Pasadena does not. Detroit runs for three days; Pasadena runs only Saturday and Sunday. Detroit crams every day with scheduled lectures; Pasadena opts for a relaxed schedule of only four lectures during its two days. Detroit's strong point is institutional displays; Pasadena's strong point is private collections. The numbers of mineral specimen display cases are comparable: 78 for Detroit in 1979 and 87 for Pasadena. Both shows are heavy with mineral dealers, the nation's best, and light on lapidary. Table space for each dealer is ample at both shows. Pasadena has a superior climate but the Detroit Show is shadowed by an unofficial satellite show at the nearby Holiday Inn (neither feature under the control of the respective show committees). Don't expect this editor to be drawn any further into the debate. Suffice it to say that three superb mineral shows per year are certainly preferable to two!

New discoveries in any quantity were again virtually nil, as has been the case at many recent shows. Very limited quantities of a few new items did show up. For example, the Colorado Quartz mine in California, famous for crystallized gold, produced some large groups of fine quartz crystals. Bideaux Minerals displayed some large (several inches) dull-lustered ilvaite crystals from a rediscovered locality on the island of Serifos, Greece, and also some fine, large hematite crystals from Wessel's mine in South Africa (shown here). Al Ordway and Bob Bartsch displayed some very large crystals of smoky quartz (to 6 inches or so) in groups with excellent, deep green microcline found in August, 1978, near Lake George, Colorado.

Because this show is so strong in private collections it seemed a shame not to let readers in on at least a little of this wealth of rarely seen beauty. Most of these collectors do not display outside of California. To help alleviate this limited exposure, a photo spread is presented here which might be entitled "Random Highlights of Pasadena Show Displays." "Random" is a key word. I was graciously loaned some table space during set-up evening, where I spread out my photo equipment. Then I circulated among the exhibitors as they set up their cases, borrowing a specimen here and there just long enough to photograph it. I ran out of time and energy long before running out of displays and specimens. A great

Figure 1. **Pasadena Center, site of the Pasadena Show, with Pasadena's 100-year old City Hall and the San Gabriel Mountains in the background.**

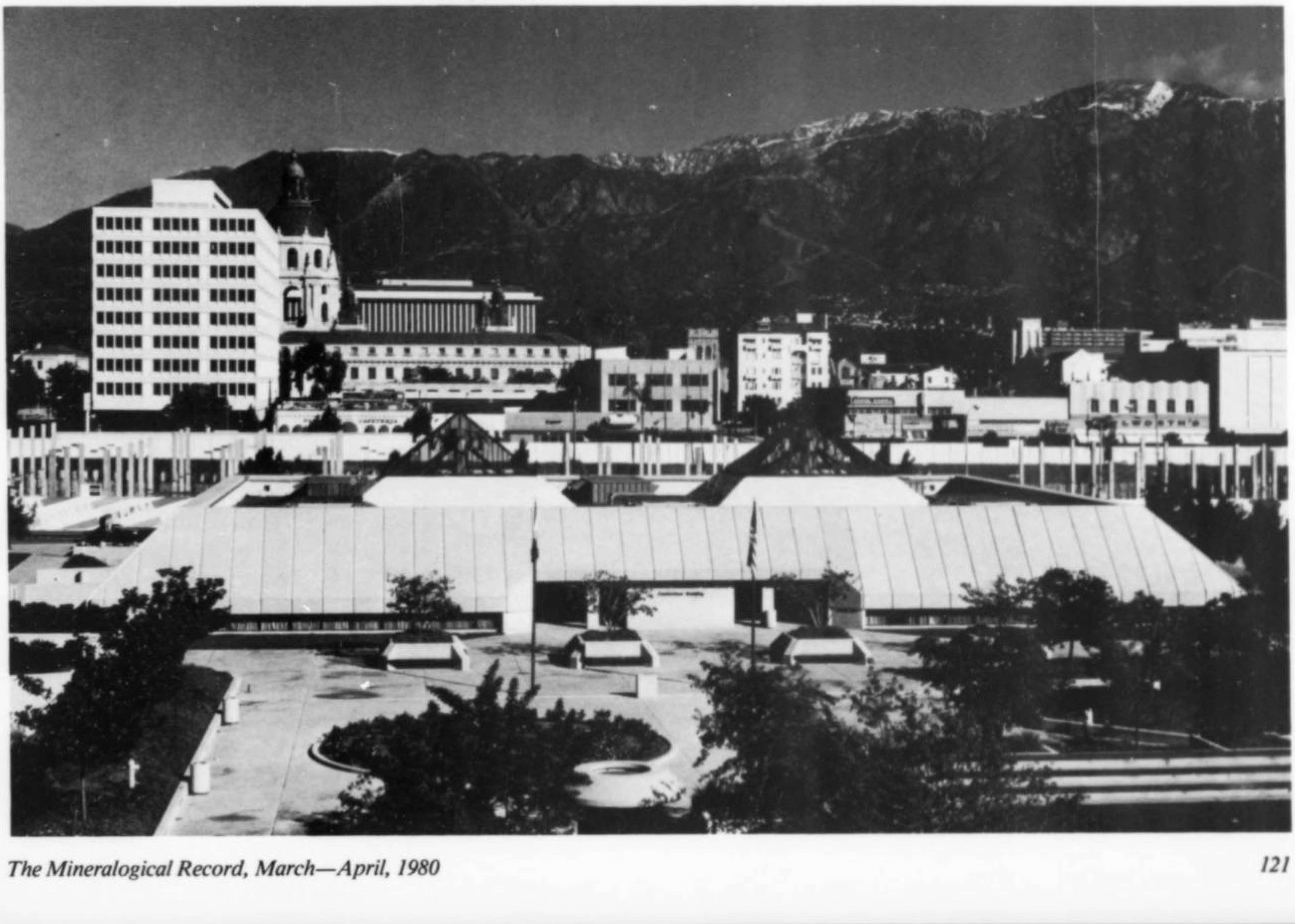


Figure 2. **A large (2⅛ inches), bright yellow sulfur crystal on matrix from Agrigento, Sicily. Los Angeles County Museum of Natural History specimen.**

Figure 3. **A crystal of ferberite nearly 2 inches tall, on matrix, from Cavnic, Romania. Frank Knechtel collection.**

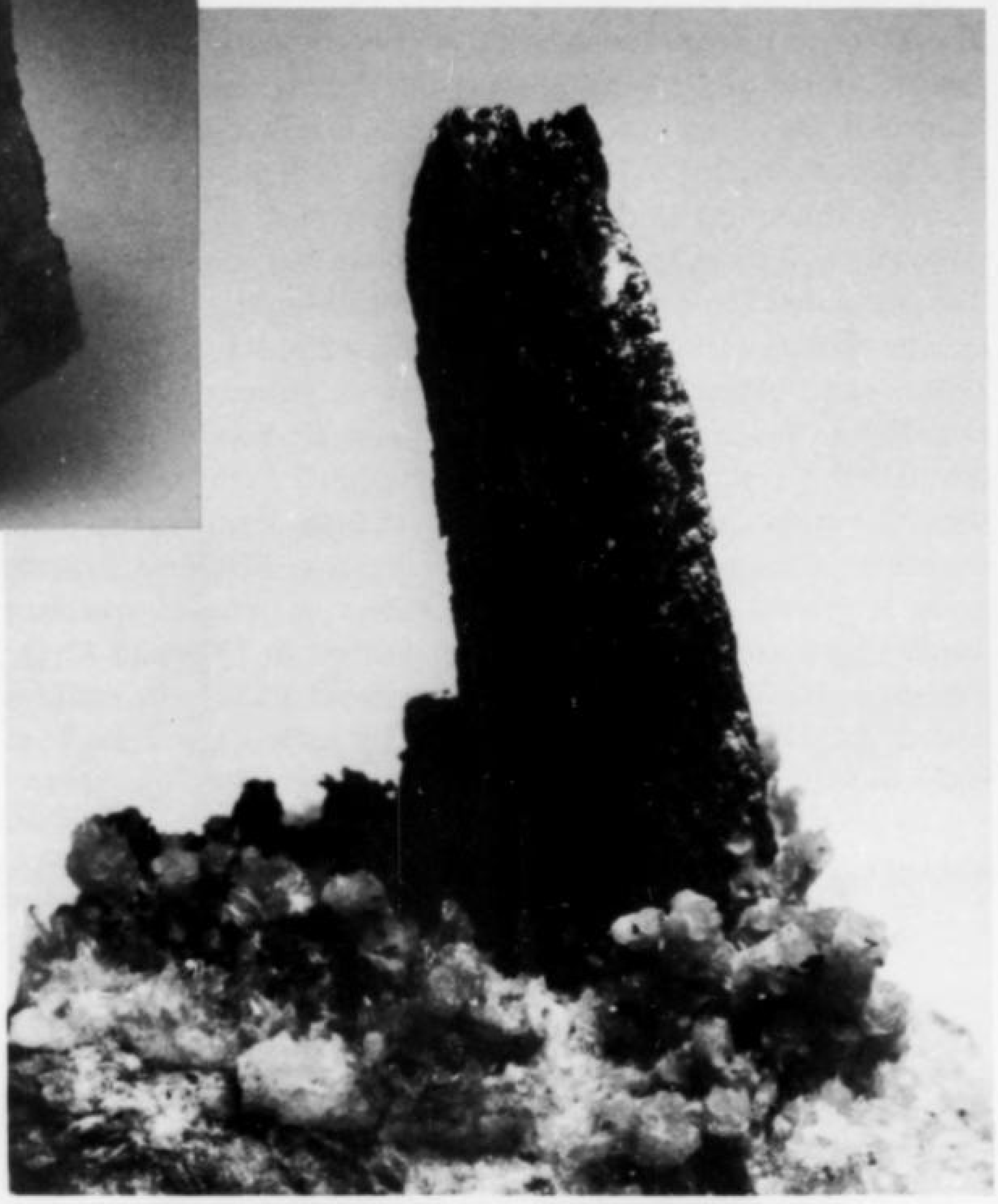


Figure 4. **Vibrant red cinnabar crystals, the largest over ½ inch, on matrix from Charcas, Mexico. Kerith Graeber collection.**

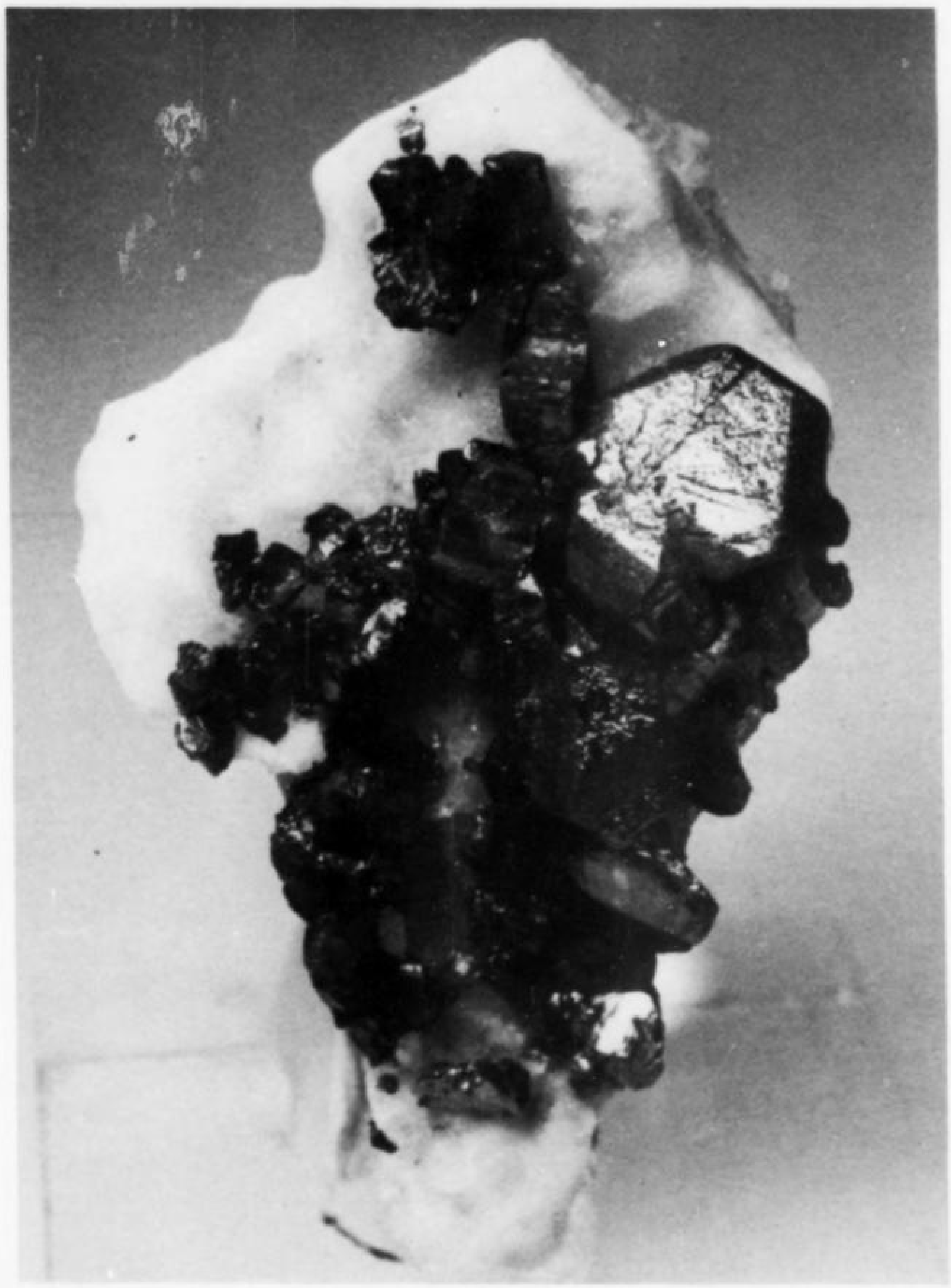


Figure 5. **Red wulfenite crystal 1⅙ inches across on matrix from the Red Cloud mine, Yuma County, Arizona. Louis and Marcia Schwartz collection.**

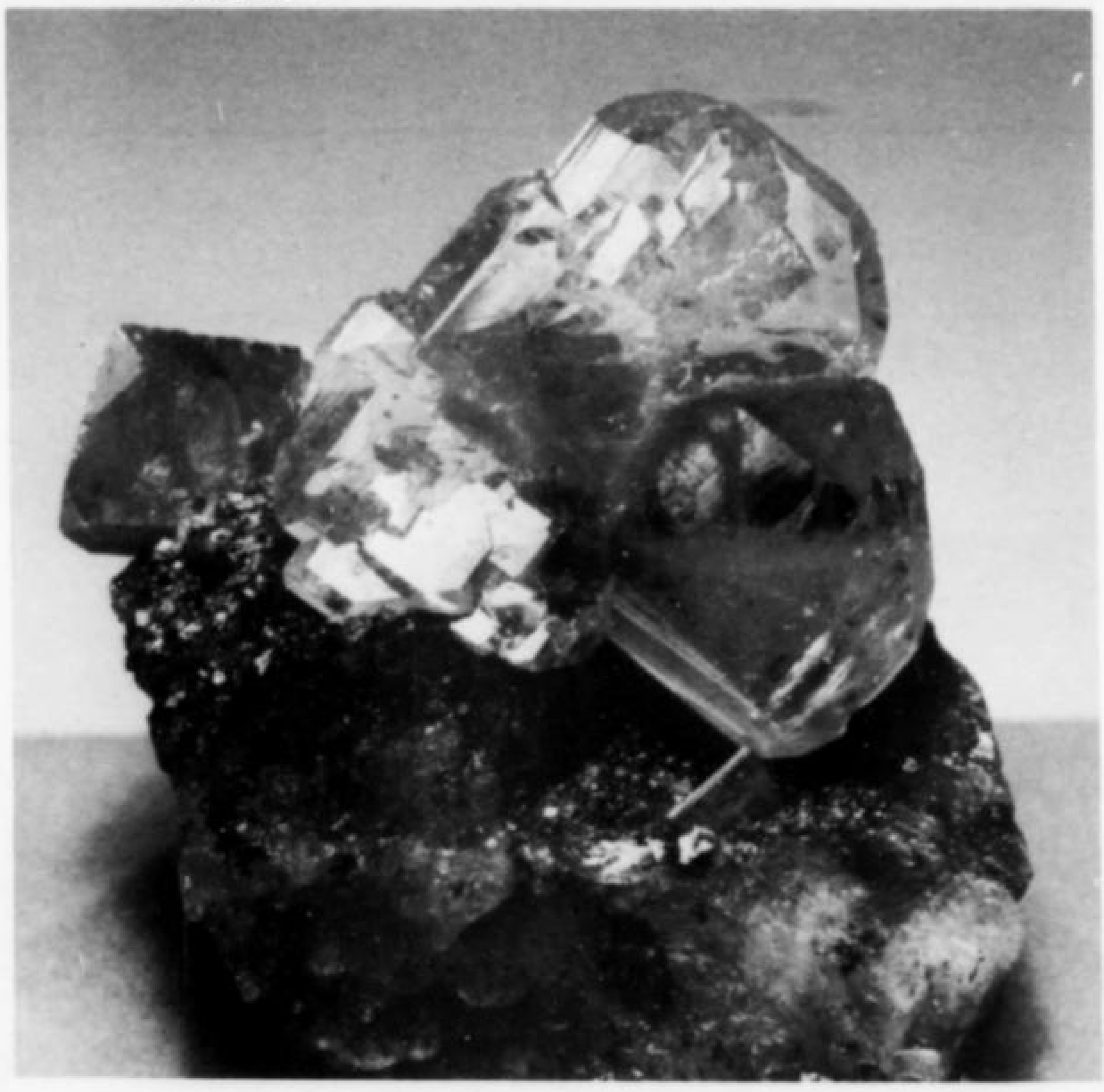


Figure 7. **A group of native silver crystals 1½ inches across on matrix from the Keeweenaw Peninsula, Michigan. Kent England specimen.**

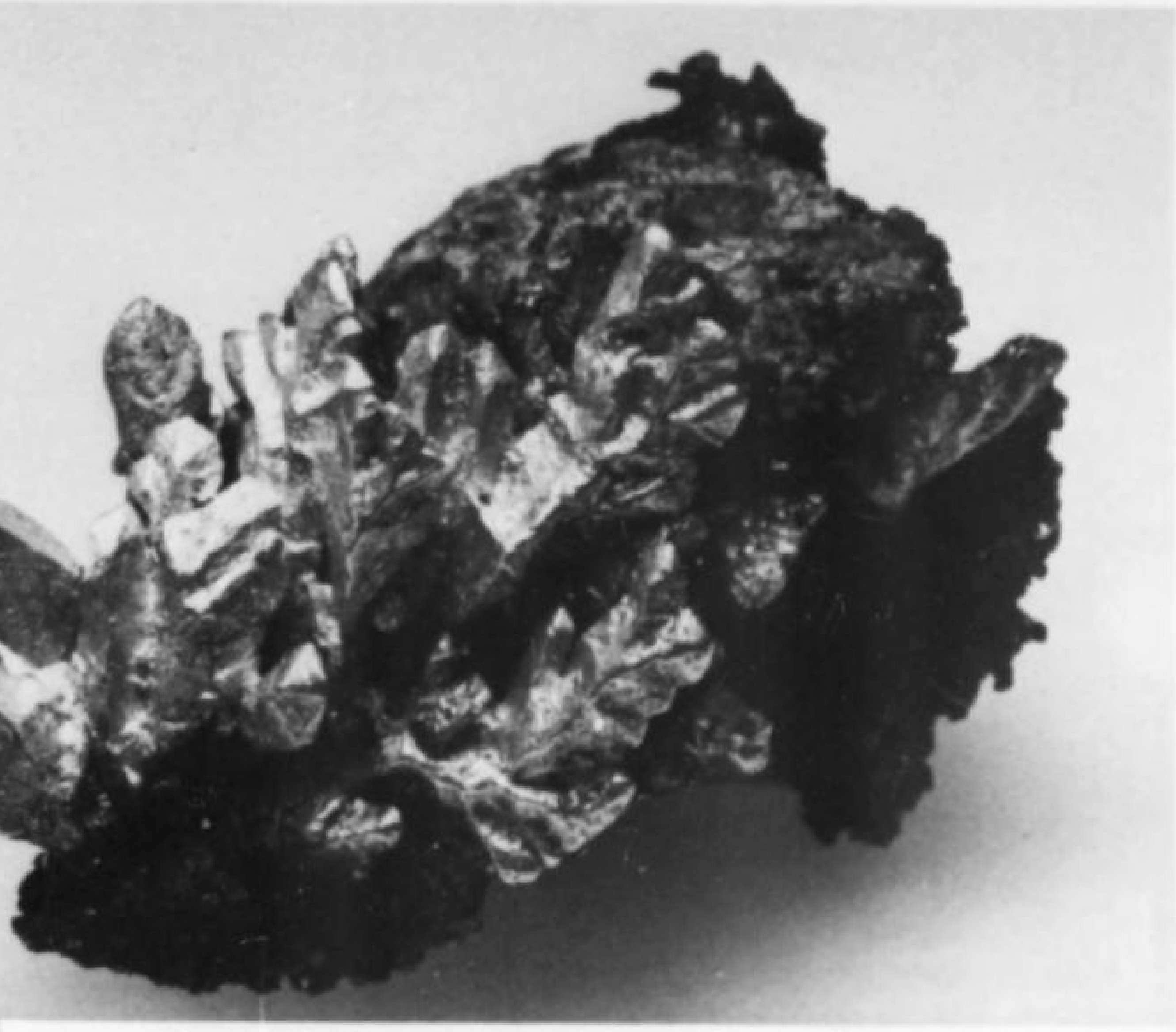
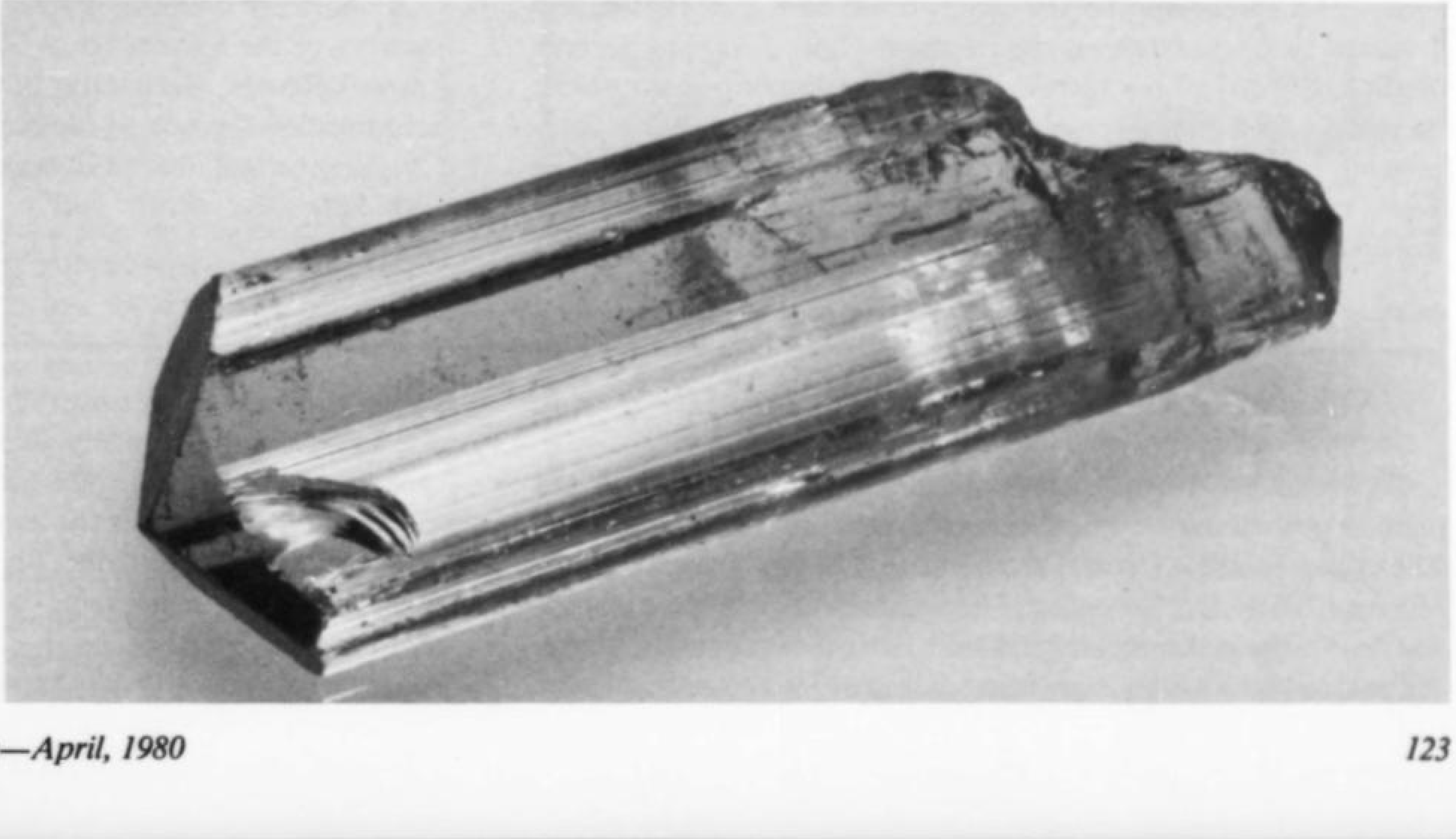


Figure 6. **A few miners' lamps from Ken and Betty Roberts' collection, including the very rare folding candlestick at bottom.**

Figure 8. **Malachite (green) after azurite crystals, just under 2 inches tall, from Bagdad, Arizona. William McCarty collection.**

Figure 9. **A pale yellow-orange crystal of scapolite 2⅜ inches long from Tanzania. Steven Smale collection.**



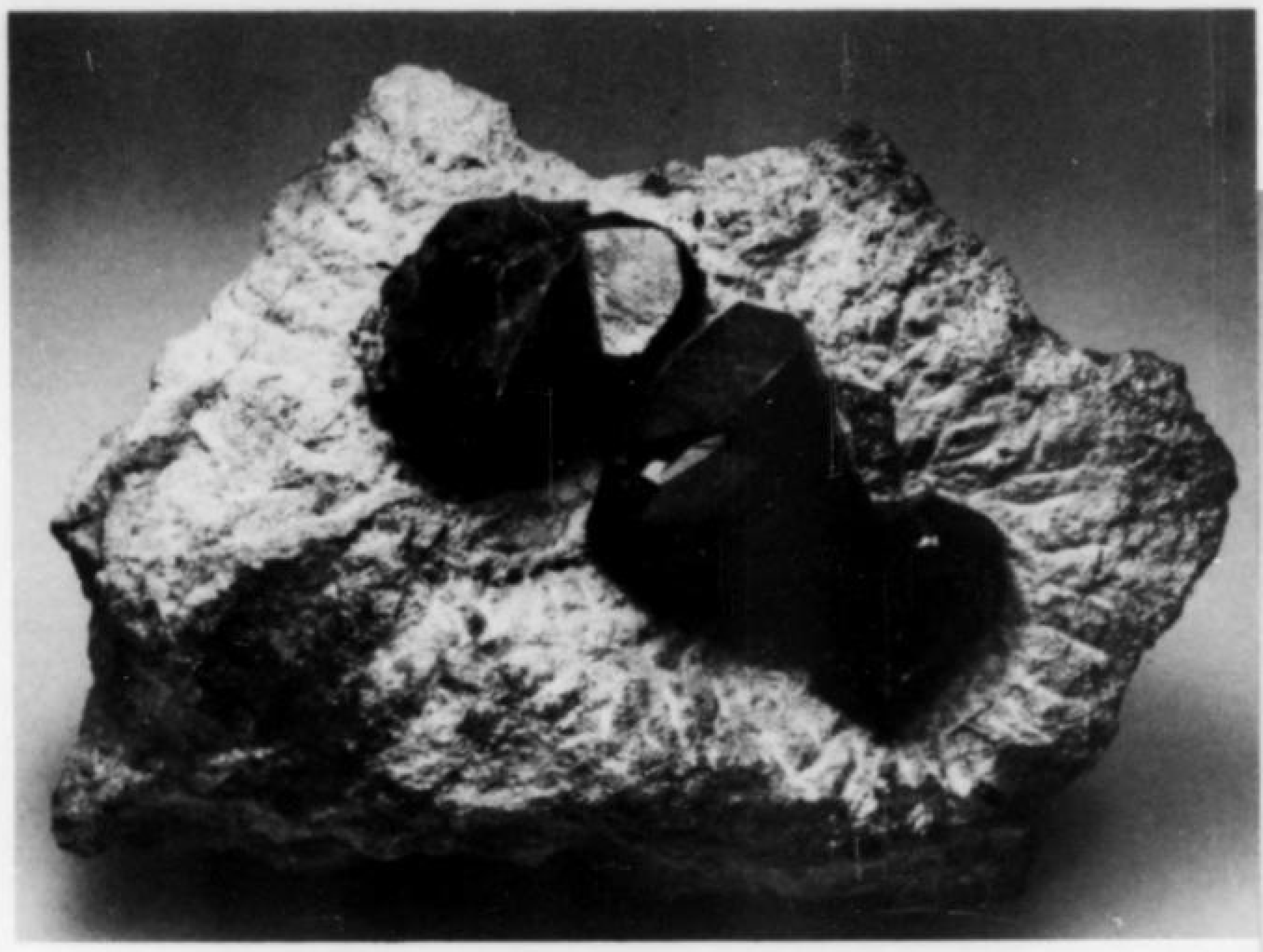


Figure 10. **A string of rutile crystals 3¼ inches long on pyrophyllite matrix from the White Mountains of California (see vol. 8, no. 6, p. 478). This specimen and others were recently collected there by Bill Hawes. The locality is open but difficult and dangerous to work.**

Figure 12. **Hematite, more than 1¼ inches across, from La Calamita mine, Elba, Italy. Kay Robertson collection.**

Figure 11. **Hematite crystals, the largest measuring 2¾ inches across, recently found at Wessel's mine, near the N'Chwaning mine in South Africa. Richard Bideaux collection.**

many other specimens of equal quality could have been chosen, and I missed getting to several top-notch displays (including George Holloway's, one of my favorites). So this selection should *not* be construed as a best-pieces-in-the-show award or as being comprehensive in any way; it's just a random selection from among the better pieces, with a slight (?) unavoidable bias in the direction of my own personal taste.

A showcase commemorating the late Jack Rodekohr, charter member of the Mineralogical Society of Southern California, well known collector, and curator of the Caltech collection in Pasadena, accompanied the sale of his collection by Mineralogical Research Co. (Eugene and Sharon Cisneros). Jack's collection, accumulated with taste over nearly half a century, contained some superb specimens.

W.E.W.

SMITHSONIAN'S NEW GOLD EXHIBIT

On December 19, the Smithsonian Institution opened to the public a new exhibit—"The Precious Metals: Gold and Platinum." The exhibit is in the Mineral and Gem Hall of the Natural History Museum. There are, altogether, 76 specimens of gold in the display and two large platinum nuggets—all from the museum's superb collection. Many of these specimens have been in the collection for a long time and were on exhibit previously. However, the older display was removed many years ago, and these pieces have not been on public display since then. Perhaps the most outstanding specimen of this group is the immense 82-Troy-ounce (2.5-kg) gold nugget from near Greenville, Plumas County, California (Roebling collection). This remarkable nugget was purchased in 1932 for $1398.58.

Augmenting the above in spectacular fashion are six recently acquired specimens of beautifully crystallized gold, all from California. Included are a 5.1-kg mass of gold from the Empire Star mines, Grass Valley, Nevada County (gift of Newmont Mining Corporation); a 258-gram leafy mass of gold from the Alaska mine, Sierra County (anonymous donor); and four extraordinary platy masses of brilliant gold from the Eureka mine, Tuolumne County. The weights of these specimens are 1612, 454.7 (cover of this issue), 200.8 and 137.2 grams.

The platinum nuggets are from Choco, Colombia (536.7 grams) (Roebling collection) and Nischne-Tagilsk, U.S.S.R. (444.4 grams).

The exhibit, in its vaultlike frame, sparkles against the lively blue fabric which covers the background. This is a permanent exhibit so one need not rush to see it, but the elegance of it will not disappoint those who do.

The J. E. Caldwell Company and its parent company, Dayton Hudson Corporation, gave financial support that helped make the exhibit possible.

J.S.W.

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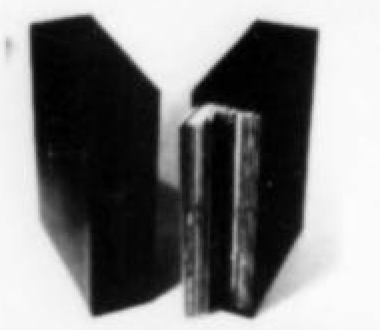

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Reflections upon perusing a 1942 bookseller's catalog

The title is *Catalogue of Books and Periodicals on Geology, Crystallography, Mineralogy, Metallurgy, Mining, Petroleum, Geologic Folios of the United States, Paleontology. . . . offered for sale by Henry George Fiedler, 31-33 East 10th St. (6th Floor), New York.*

Mr. Fiedler opens with a bang. Section heading "Early Geology and Mineralogy to the end of the XVIII Century," item number 1, Aldrovandus' *Museum Metallicum,* 1648. Frank Dawson Adams in his *The Birth and Development of the Geological Sciences* devotes almost two pages to the discussion of this work. He cites the hundreds of woodcuts, many of which are of minerals, and says in conclusion: "In reading Aldrovandus, however, one gathers the impression that he was writing at the opening of a new age, and that the authority of the past did not exert the same binding influence upon him that it had done upon the writers of the old lapidaries." Surely a classic for all time, listed as being in a contemporary parchment binding, nice clean copy for $30.00. A fair price for today would be around $1200.00.

Item 7, Cronstedt's *Essay towards a System of Mineralogy,* the second Magellan London edition of 1788 for $5.00; item 10, Gautier D'Agoty's *Histoire Naturelle . . .* with *80* color plates of minerals, folio size, Paris, 1781. I wouldn't even venture a guess as to how much this would bring today. In my book-collecting life I have never seen, nor heard of, a copy for sale, but in 1942 when I was 9 years old I could have had this copy for $50.00. (Incidentally, a large sum for those days.)

Both volumes of Rashleigh, 1797 and 1802, with 54 hand-colored plates were available for $20.00. Hugh A. Ford was to offer for sale such a set 14 years later for $50.00 and today one hears of sets being sold in London for $1000.00. Hugh Ford listed his Rashleighs in a full page of books for sale in the November-December 1956 issue of Peter Zodac's *Rocks and Minerals* magazine. About 5 years after this I was fortunate enough to be offered most of those books and the balance of Ford's private library and mineral collection. A few of the books are still with me, the majority I sold. One Ford book sold at that time, Schmidt's *Mineralienbuch,* Stuttgart, 1850, with 44 hand-colored plates, brought me $5.00. I have recently repurchased that very same copy for $400.00!

Getting back to Mr. Fiedler—item 27 is C. C. Schmiedel's *Erz stuffen und Berg Arten* with 30 hand-colored copperplates, published in 1753. This book, a collector's dream, has been on my want list for years, and still is. The book was issued with varying numbers of plates, and 30 is a very high number. The price today would have to be in excess of a thousand dollars; in 1942 it was $15.00.

This catalog came into my hands from the estate of Peter Zodac, whose minerals and library I purchased in 1967. Included in the catalog is a list of books in Zodac's hand, items he bought or tried to buy from Fiedler. It includes Dana's *Coral Islands* for $2.50, Eyerman's *Mineralogy of Pennsylvania* for 75¢ and Pogue's *The Turquoise* for $2.50. The most expensive item on the list is Pratt & Lewis' *Corundum of North Carolina* at $3.00.

The 18th century section closes with *two* editions of Xavier Wulfen's work on wulfenite, each with 21 hand colored plates, 1785 and 1791, $25.00 and $20.00 respectively at that time. Today, priceless. One could have purchased a first edition of Dana's *System,* New Haven, 1837, with a Dana letter for $3.00, or Johann Schoepf's *Beytrage zur mineralogischen Kentniss des Oestlichen Theils von Nord Amerika . . . Erlangen,* 1787, for $10.00. Anyone for a complete 6th edition of Dana's *System* for $5.00? or a *History of Mount Mica* by Hamlin, 1895, for the same price?

One interesting contrast emerges, #534, Carl Hintze's *Handbuch der Mineralogie,* complete to 1938 for $75.00! I know that this is one tough set, my copy only recently obtained after several years of looking, but was a work only possibly out of print for a few years in 1942 worth more than double an Aldrovandus, 50% more than a Gautier D'Agoty and triple the price of a Wulfen?? I wonder.

Others: Palache's *Minerals of Franklin,* #807, at 75¢; today perhaps $75.00. Certainly for the copy from Hugh Ford's library. It was a presentation to him from Palache. Gustav Rose's *Reise nach dem Ural . . .* in two volumes, Berlin, 1837 and 1842, is #882 and the price is $3.00. I should expect to pay $300.00 for a copy such as this, complete with maps and plates. Streeter's *Precious Stones and Gems,* 4th edition, seems fully priced at $10.00.

Number 1063 is a book that has eluded me for almost 20 years: Wada's *Minerals of Japan,* Tokyo, 1904. I once owned Hugh Ford's copy, but, alas, parted with it. Price in 1942—$3.00. The interesting books conclude with #1101, Gardner F. Williams' *The Diamond Mines of South Africa,* 2 volumes, 1905 for $10.00. One could also have bought at this time Volumes 1-25 of the *American Mineralogist* with index for $70.00.

Where does all this information take us? To the obvious conclusion that book prices have gone up dramatically, of course, but more than that. Most of the prices quoted were probably high for their day, but they *were* quoted and the items *were* available. Today, only the most vigorous and vigilant pursuits and pursuers are turning up any good old books on minerals and gems. The standard sources are drying up, and prices are going wild. One thing to remember is that the books *really* are rare. Very few older books were issued in editions of as much as 1000 copies. Information from my George F. Kunz archives tells that the modern classic *Ivory and the Elephant,* N.Y., 1916, was issued in an edition of only 750 copies. Try to find one today.

Lawrence H. Conklin
October 12, 1979

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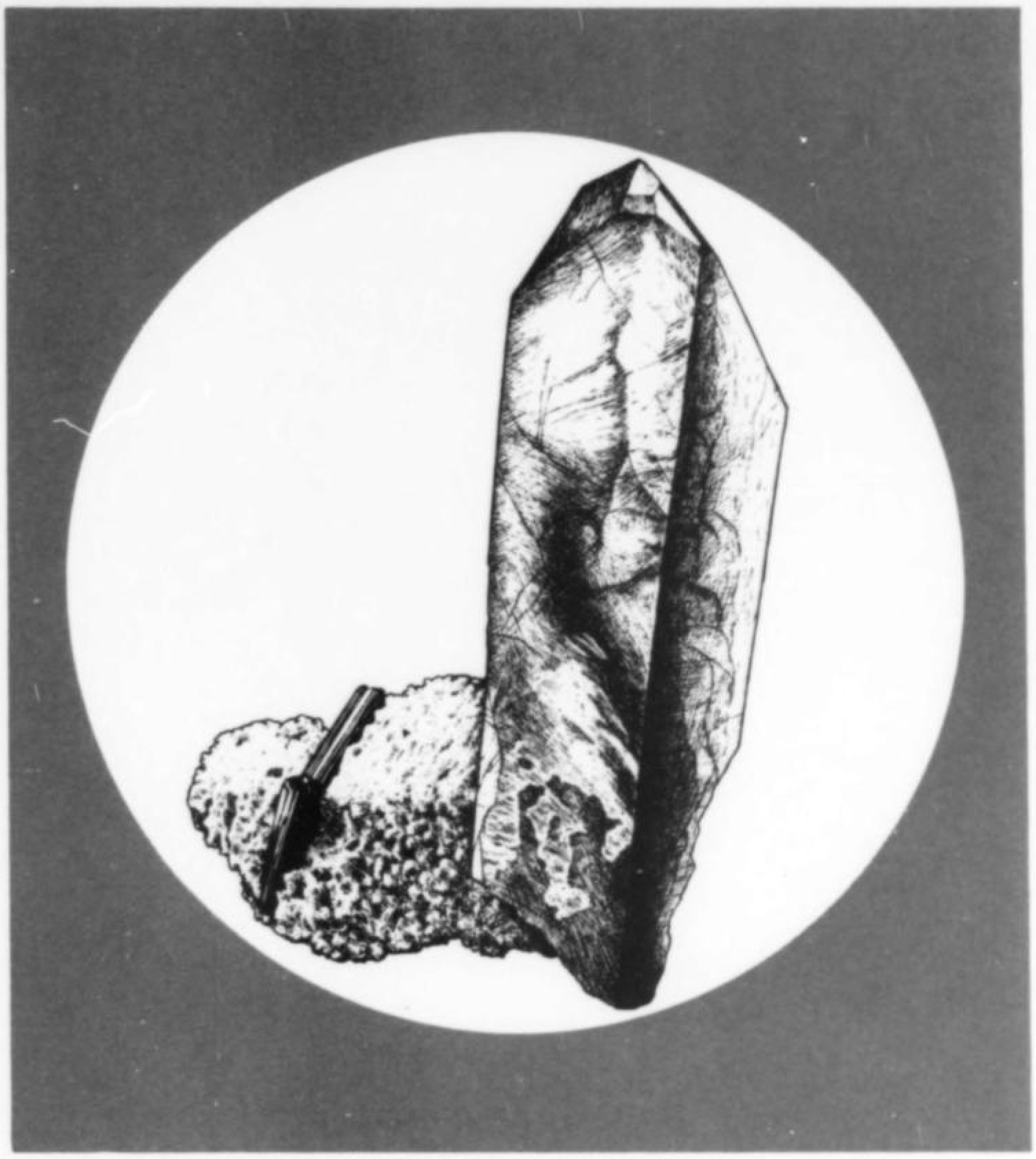

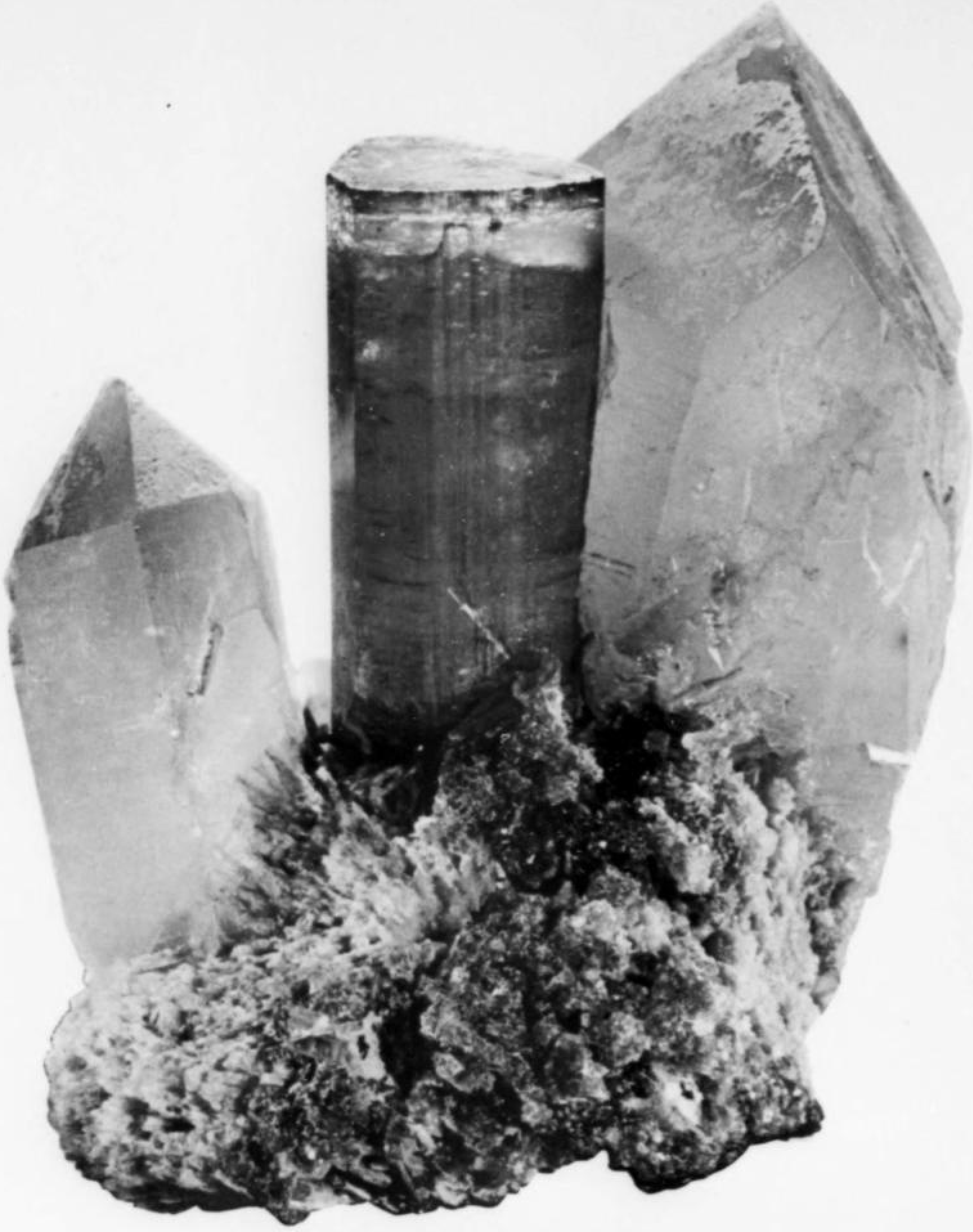

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