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Fibrous Tremolite.

Wavellite.

Columnar carbonate of Lead

CONVERSATIONS
ON
MINERALOGY.

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COVER: ROSE QUARTZ with elbaite from Lavra da Ilha, Minas Gerais Brazil. The specimen, 4 inches tall, is from the Jules Sauer Collection, Rio de Janerio. Photo by Harold and Erica Van Pelt, from a soon-to-be-published book, *Brazil—Paradise of Gems*, by Jules Sauer.

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the Bunker Hill mine
kellogg, shoshone county, idaho

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The Bunker Hill mine in the famous Coeur D'Alene district of Idaho has produced some of North America's finest cerussite, anglesite and pyromorphite specimens. Though many specimens were collected around the turn of the century, most were subsequently destroyed. Collecting in recent years has brought more fine specimens to light.

INTRODUCTION

The Bunker Hill mine is in the western part of the Coeur d'Alene mining district, Shoshone County, Idaho. The district is roughly 24 kilometers wide by 40 kilometers long, with the long axis oriented in an east-west direction. The Bunker Hill mine workings are adjacent to the towns of Kellogg and Wardner, Idaho, along the South Fork of the Coeur d'Alene River. The area is in mountainous, beautifully wooded country.

Gold production, for which the district was first important, has been superceded by the production of silver, lead and zinc. Metal production has exceeded $2.9 billion, making the district one of the ten most productive in the world.

The Bunker Hill mine is presently the leading lead-zinc producer in the district. The mine currently employs about 400 people underground and produces approximately 2,100 tons of ore per day. The mine area covers 6,200 acres, is over 1.6 km in depth, and has nearly 200 km of workings. Production from 1887 through 1979 totaled in excess of 34 million tons of ore containing 2.9 million tons of lead, 154 million troy ounces of silver and 1.3 million tons of zinc.

Minerals of particular interest to the collector come from the oxidized zones and include anglesite, cerussite, silver, pyromorphite and hydrocerussite.

HISTORY

The Coeur d'Alene district was established when placer gold was discovered northeast of Kellogg, near the present town of Murray, in 1883. Placer gold was dredged and sluiced near the communities of Prichard, Murray and Eagle. Much of the gold was coarse, with nuggets weighing up to 40 troy ounces reported. The discovery of lead-silver veins near the present town of Wallace attracted attention, and several claims had been established by 1885.

On August 1, 1885, Noah Kellogg was grubstaked by Origin O. Peck and Dr. John T. Cooper of Murray. If any good claims were found, Kellogg was to get one-half and his grubstakers to divide the other half. He returned on September 13, 1885, claiming no luck in his searches, and refunded the jackass and tools provided by Peck and Cooper. However, it soon became known that several lode claims were filed near Milo Gulch, on or shortly after September 10, 1885. The Bunker Hill, Richmond, and Sullivan claims were filed on behalf of a Phil O'Rourke and some of his friends. Noah Kellogg's name appeared as a witness on the Bunker Hill claim notice. Gossip circulated that Noah Kellogg had actually found the original lode while chasing a donkey that had strayed from camp into Milo Gulch. It did not take long for litigation to get started over the claims. Peck and Cooper filed suit on September 26 against Noah Kellogg, Phil O'Rourke and others for one-half interest in the claims. The ownership litigation trial was reconstructed for television by "Playhouse 90." A highlight of the trial was the admittance of the jackass as a witness. Peck and Cooper eventually received a one-quarter interest in the Bunker Hill claim as a result of their law suit.

The location in 1885 of the Bunker Hill mine and the adjacent Sullivan mine, as well as the discovery of rich lead-silver ores in several other mines in the region, caused a rush from the declining gold mines to the district's silver-lead mines. The Last Chance, Tyler and Sierra Nevada mines, all in close proximity to the Bunker Hill mine, were also located about this time.

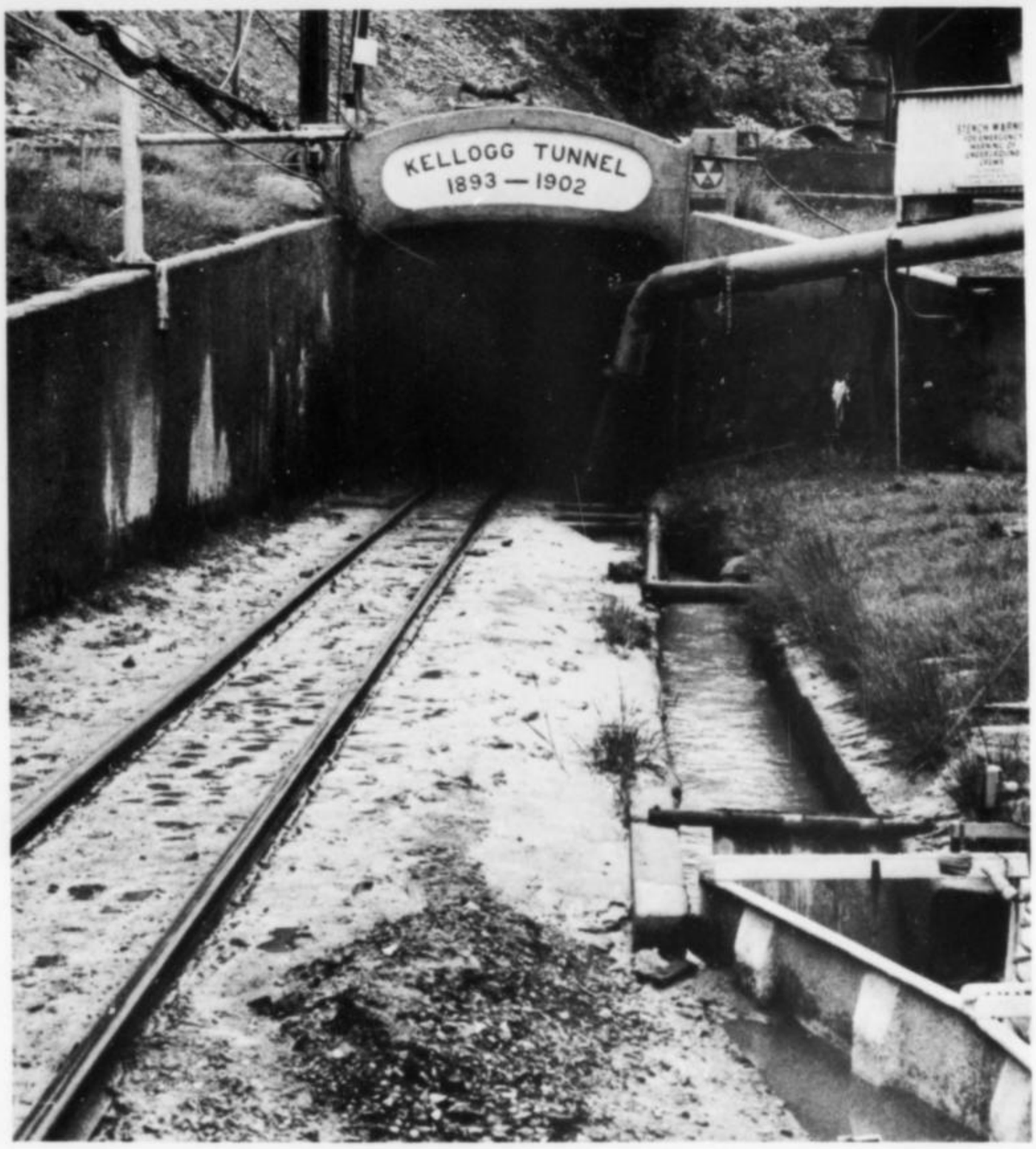


Figure 1. **The entrance to the Bunker Hill mine. Photo by Norm Radford.**

In 1887 the Bunker Hill mine and the Sullivan mine were sold and consolidated into the Bunker Hill and Sullivan Mining and Concentrating Company. By 1916 (Umpleby and Jones, 1923) the mines in existence near Wardner included the Bunker Hill and Sullivan Group, incorporating the Arizona, Blue Bird, Phil Sheridan, Stemwinder and Tyler mines. Other mines not yet part of the Bunker Hill were the Alhambra, Blackhawk, Caledonia, Crown Point, Idaho, Last Chance (Sweeney) and Wyoming mines. In addition to these mines there was a large number of adits, stopes and workings bearing a plethora of individual names. Eventually most of these came under the ownership of the Bunker Hill Company.

Mining has been carried out continuously since the Bunker Hill and Sullivan Mining and Concentrating Company was formed in 1887. The company is now known as The Bunker Hill Company, and is a subsidiary of Gulf Resource and Chemical Corporation of Houston, Texas.

The early-day mines being worked in the oxidized zones produced a variety of excellent mineral specimens. Shannon (1926) described cerussite from the district: "Certainly no other district in North America, and none in the world, has exceeded this region in the production of fine specimens of cerussite, both in quality and number, yet these are now practically unobtainable. They have all been lost or destroyed and practically none have found their way into the large collections or museums of the country, and their existence has not heretofore been mentioned in the literature. In the days when carbonate ores were being mined, almost every miner had a private cabinet filled with choice specimens in a corner of his home, and many gorgeous crystallizations were on view in cigar cases, in hotels, boarding houses, and barrooms; and these could, in most cases, be had for the asking. Of late years, however, they have largely been lost to sight."

The Bunker Hill mine had an exhibit similar to that of the Hercules mine. Shannon (1926) described the Hercules mine: "there was for several years, at the mouth of the No. 3 Hercules tunnel, a grotto walled up with logs and provided with shelves on all sides where specimens of cerussite, native silver, and pyromorphite weighing from 10 to 200 pounds each were placed and exhibited to visitors by candlelight. When this receptacle became crowded, and specimens were constantly being added, a quantity would be cleared out and thrown in powder boxes in the head house for anyone who wanted to carry them away." In the case of the Bunker Hill mine, the specimens were thrown in a mine car and milled when they became dirty! Few old specimens have survived.

GEOLOGY

The Bunker Hill ores are mined from the regionally metamorphosed St. Regis formation and Revett quartzite of the Precambrian Belt series. The regional metamorphism is of the greenschist facies.

The St. Regis formation is composed predominantly of impure quartzite and interlaminated argillite, with a lesser amount of pure quartzite. The Revett quartzite consists of light-colored, thick-bedded, fine to medium grained, pure quartzite. The contact between the St. Regis formation and the Revett quartzite is gradational through a zone of quartzites and impure quartzites several hundred feet thick.

The majority of the Bunker Hill mine workings are located south of the Osburn fault, a predominantly strike-slip fault with a slightly north of west trend. The structure in the Bunker Hill workings is very complex. The rocks of the Revett quartzite and the St. Regis formation have been severely deformed by faulting, and in many areas intensive bleaching of the rocks has further complicated the

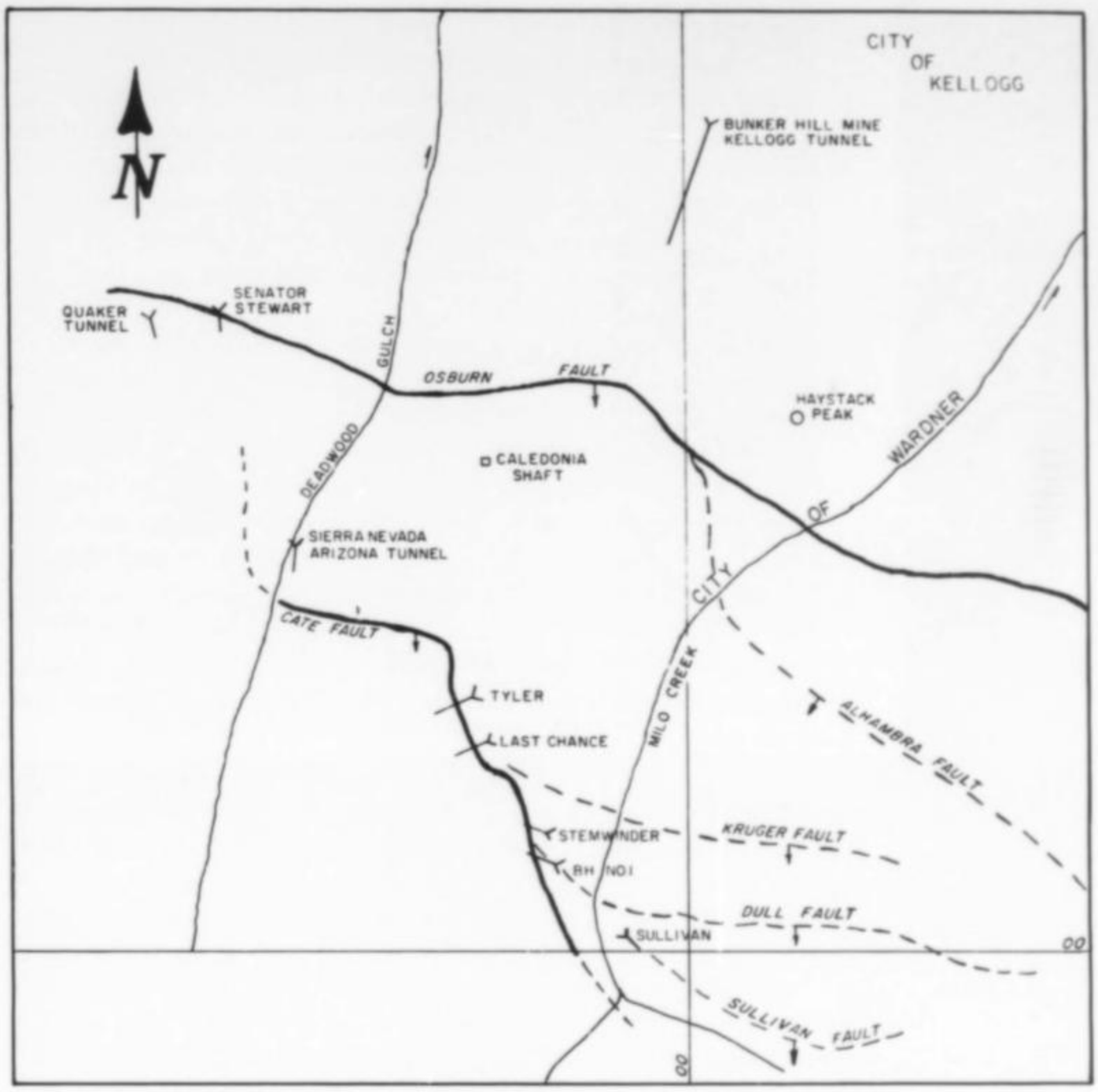


Figure 2. **Prominent old mines in the neighborhood of the Bunker Hill mine.**

picture to such an extent that it is difficult to identify the rock units. Within the main mine area the northwest-trending Cate fault is the dominant structural feature. The Cate fault may have formed prior to ore emplacement and had some subsequent movement. Mining continues both in the hanging wall and footwall of the fault. Ore is found along other faults in steeply dipping replacement veins or in breccia-stringer zones related to folding. Main stage metallization had been considered Cretaceous in age, but there is abundant controversy concerning this interpretation.

Several of the 30 orebodies presently being mined or explored may be called stratabound, but nearly every orebody is unique. The Bunker Hill orebodies are broken into three distinct types:
(a) *Bunker Hill type;* massive siderite partially replaced by sulfides, which are primarily galena with lesser sphalerite and pyrite.
(b) *Bluebird type;* predominantly sphalerite and pyrite with minor galena and some siderite.
(c) *Jersey type;* well defined quartz-galena veins with minor sphalerite and chalcopyrite.

MINERALOGY

The combined workings of the Bunker Hill mine have produced outstanding mineral specimens, the majority of these appearing prior to 1916, when a large part of the production was from the oxidized zone. Few of these fine old specimens of cerussite, anglesite, native silver, and pyromorphite have survived. Some specimens are trickling from the mine; these come from new workings in oxidized areas, from old workings that are broken into, or whenever someone has the daring to crawl into old stopes. After more than 90 years of production there is a possibility that more fine mineral specimens will be found.

Primary Minerals

The primary assemblage, from a mineral collector's viewpoint, is uninspiring. The minerals are usually massive and contain almost no crystals. Some of the more interesting occurrences are described below:

Boulangerite $Pb_5Sb_4S_{11}$

Boulangerite was common in the Tony sphalerite orebody below the 18 level. Most of the boulangerite was found as films and stringers, but occasional small vugs in quartz were found containing bright black needles of boulangerite.

Bournonite $PbCuSbS_3$

Bournonite was occasionally found in the galena-sphalerite ore above the 5 level in the West Reed area. It occurred as discrete blebs to 5 cm in diameter. In 1975 some minute "cogwheel" crystals were found.

Calcite $CaCO_3$

Calcite is common in the Newgard and Quill orebodies. Above the 9 level in the Newgard orebody some well formed milky scalenohedrons to 5 cm in length were collected from an open fissure.

Pyrargyrite Ag_3SbS_3

Films and minute crystals of pyrargyrite are relatively common in the J orebody. The films generally coat fractures in galena or fractures in quartz veinlets. Several euhedral crystals 2 mm in length were collected in 1979 from the 20 level.

Secondary Minerals

The oxidized ores are the ones of most interest to the mineral collector. Oxidation of the veins in the Bunker Hill complex of workings ranges from a depth of less than 100 meters in most orebodies to 579 m below the surface in the Orr orebody.

Acanthite Ag_2S

Minute, brilliant black, blade-shaped crystals of acanthite are rarely found on cerussite blades or in tiny vugs in earthy limonite. An X-ray powder pattern run on samples from the Orr stopes gave a fair pattern approximately matching that of synthetic acanthite.

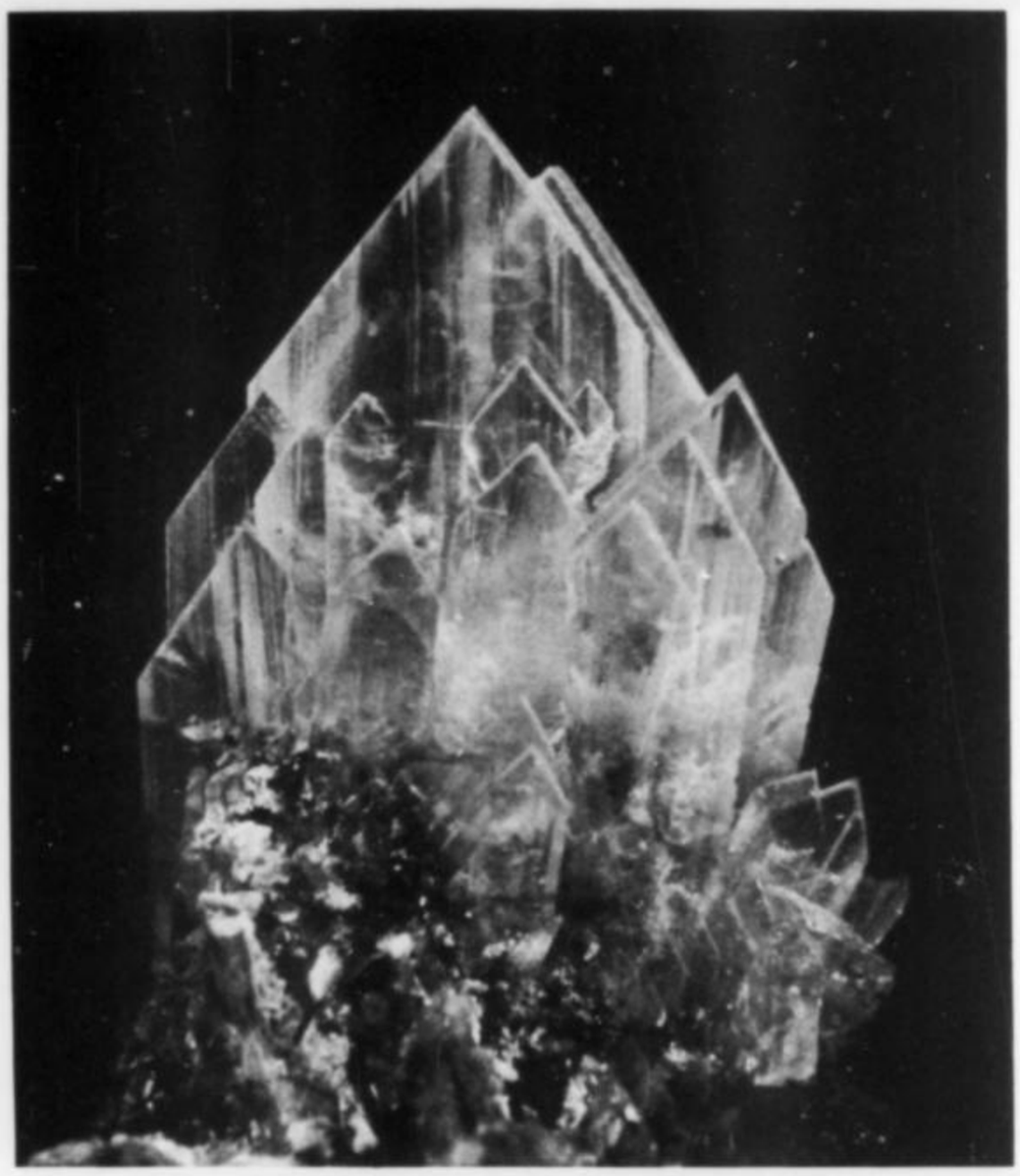


Figure 3. **Transparent and colorless anglesite crystals 5 cm tall from the 11 level, Orr orebody, Bunker Hill mine. John Davis collection; photo by the author.**

Figure 4. **Translucent white anglesite in crystals in a 5 by 5-cm group from the 11 level, Orr orebody, Bunker Hill mine. Author's specimen and photo.**

Anglesite $PbSO_4$

It is interesting to note that Ransome and Calkins (1908) had not recorded anglesite as occurring anywhere in the Coeur d'Alene district. Umpleby and Jones (1923) reported that, as of 1916, anglesite had been reported in only one specimen, from the Hypotheek mine a few miles west of the Bunker Hill mine. Numerous specimens from many mines must have been mistaken for cerussite. By 1926, Shannon (1926) had recorded nice anglesite specimens from five mines in the district, including the Last Chance workings of the Bunker Hill. At the Last Chance anglesite occurred as prismatic, flattened crystals elongated on the *b* axis and reaching "an extreme length of 5 cm. These were commonly smoky gray to black from included unoxidized galena." Crystals were reported to 1 cm with perfect form and complete transparency. Although an uncommon mineral, museum-quality anglesite specimens of this type have been recently found in the Bunker Hill mine. Groups of two to three crystals up to 7.5 cm in length have been found, primarily as prisms with a basal pinacoid. Crystals of this type are normally milky to translucent and occasionally contain grains of unaltered galena. Other crystal habits have been recognized, generally in slightly corroded or etched galena.

In 1979 outstanding anglesites were recovered from the Orr orebody. Several simple prism and pinacoid crystals have been collected reaching more than 5 cm in length. One of these consists of a hand-sized group of crystals with individuals ranging up to 5 cm in length, rather blocky, subtranslucent to transparent and colorless. Specimens with bladed crystals similar to those described from the Last Chance workings have also been obtained. Much of the Bunker Hill anglesite is fluorescent a pale yellow color. These anglesite specimens, although of somewhat different habit, equal in quality the crystals from the classic locality at Monte Poni, Sardinia.

Brochantite $Cu_4(SO_4)(OH)_6$

A beautiful spray of brochantite has been preserved in the Wallace Mining Museum (loaned by a local mineral group called SCAMPS, Inc.) from the Sierra Nevada workings. The 7.5 cm long by 2 cm by 1 cm green crystalline mass was collected by Tom McBride and Art Cooper in 1939, from the Smiley lease.

Cerussite $PbCO_3$

Cerussite specimens from the Bunker Hill complex come in a seemingly infinite variety of habits, shapes and forms: untwinned, pencil-shaped crystals in jackstraw aggregates, masses of V-twinned and butterfly twinned crystals and "bridge girder" reticulated twins, have all been recovered.

Figure 5. **Pale gray to white jackstraw cerussite in a 24-cm matrix from the 4 level, Small Hopes orebody, Bunker Hill mine. SCAMPS Gem and Mineral Club collection; photo by Norm Radford.**

Figure 6. **White cerussite crystals in an 8-cm group from the 11 level, Orr orebody, Bunker Hill mine. Author's specimen and photo.**

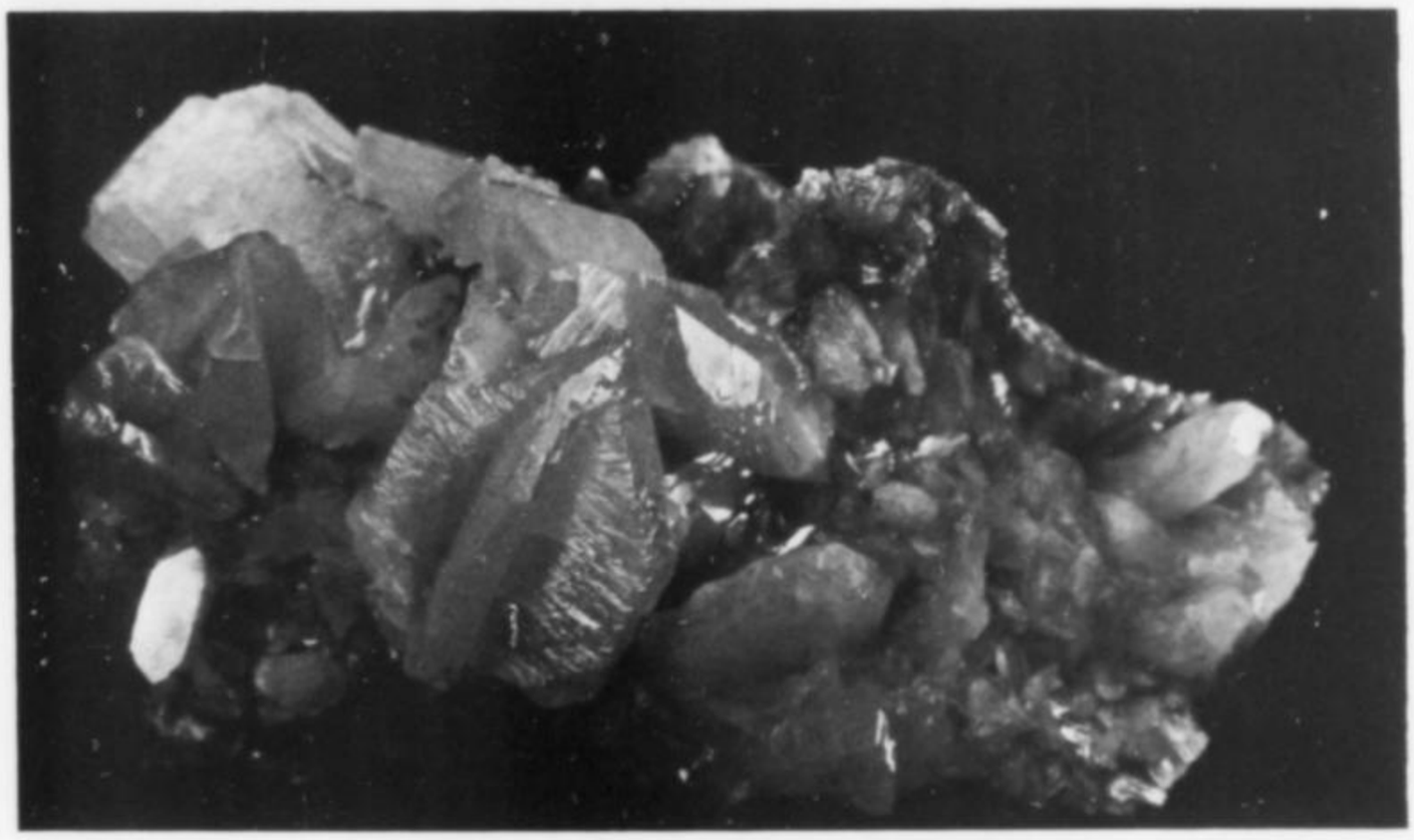


Figure 7. **Translucent white cerussite specimen 4 cm across from the 11 level, Orr orebody, Bunker Hill mine. Author's specimen and photo.**

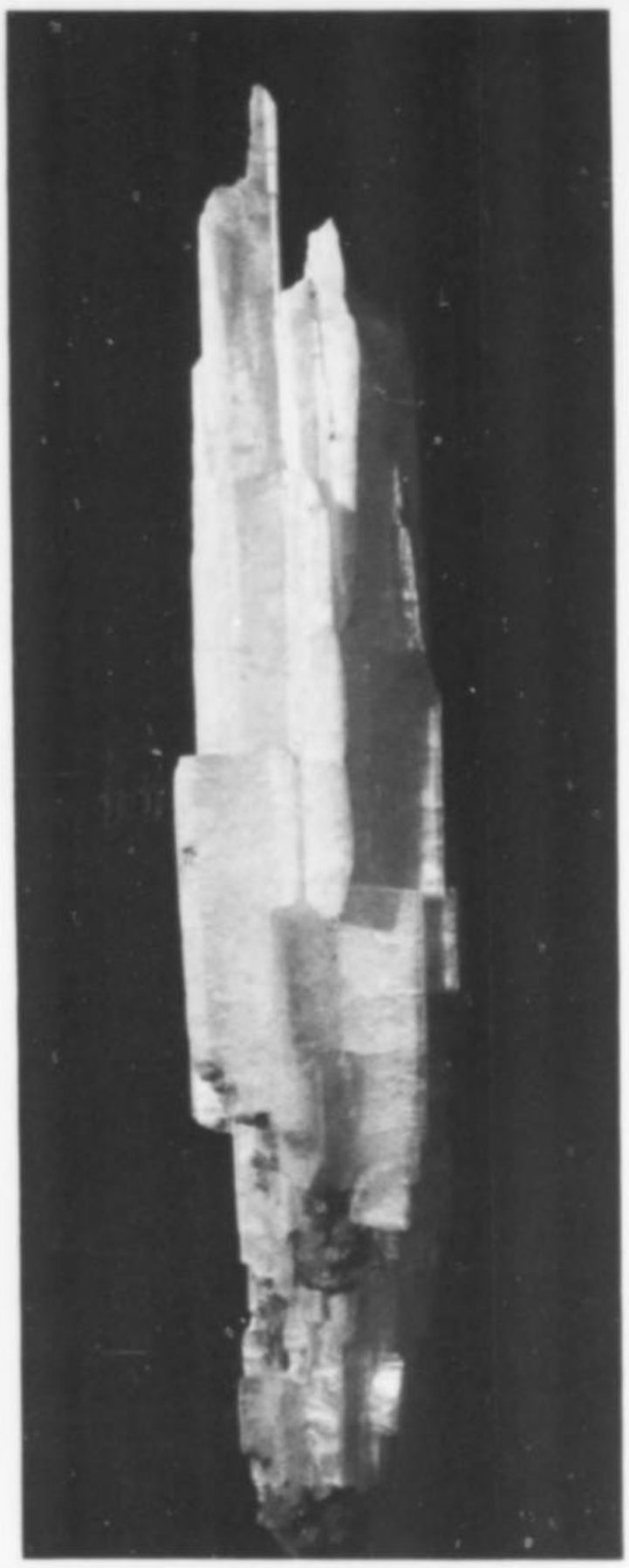


Figure 8. **A white, 8-cm cerussite crystal from the Orr orebody, Bunker Hill mine. John Davis collection; photo by the author.**

Areas of the Last Chance group and some old tunnels and stopes continued to produce excellent cerussite crystals until 1918. As an example, Drew Peeples leased the Sierra Nevada workings in Deadwood Gulch to remove old pillars left from previous mining. While mining the pillars he removed some exceedingly fine cerussites. Shannon (1926) describes butterfly twins of colorless transparent cerussite crystals up to 7.5 cm in the greatest diameter. The McBride lease in the Tyler workings (1912–1914) and the No. 1 level of the Last Chance produced some outstanding specimens. Shannon (1926) describes the McBride-Morrell lease in the Tyler upper workings, where they encountered "a small body of rich carbonate ore in which much fine crystalline cerussite appeared in places, mainly in the usual forms. These included coarse heavy columnar masses of brilliantly lustrous white material embedded in an ocherous impure manganese oxide, reticulated masses of platy crystals, and fibrous forms, often iridescent and steel-gray in color with metallic luster from thin outer coatings of manganese oxide. Other pure white masses of crystals were encrusted with dendritic wires and moss-like masses of native silver. Some specimens, yellow from a thin outer coating of limonite, were made up of small, model-perfect six-rayed penetration twins."

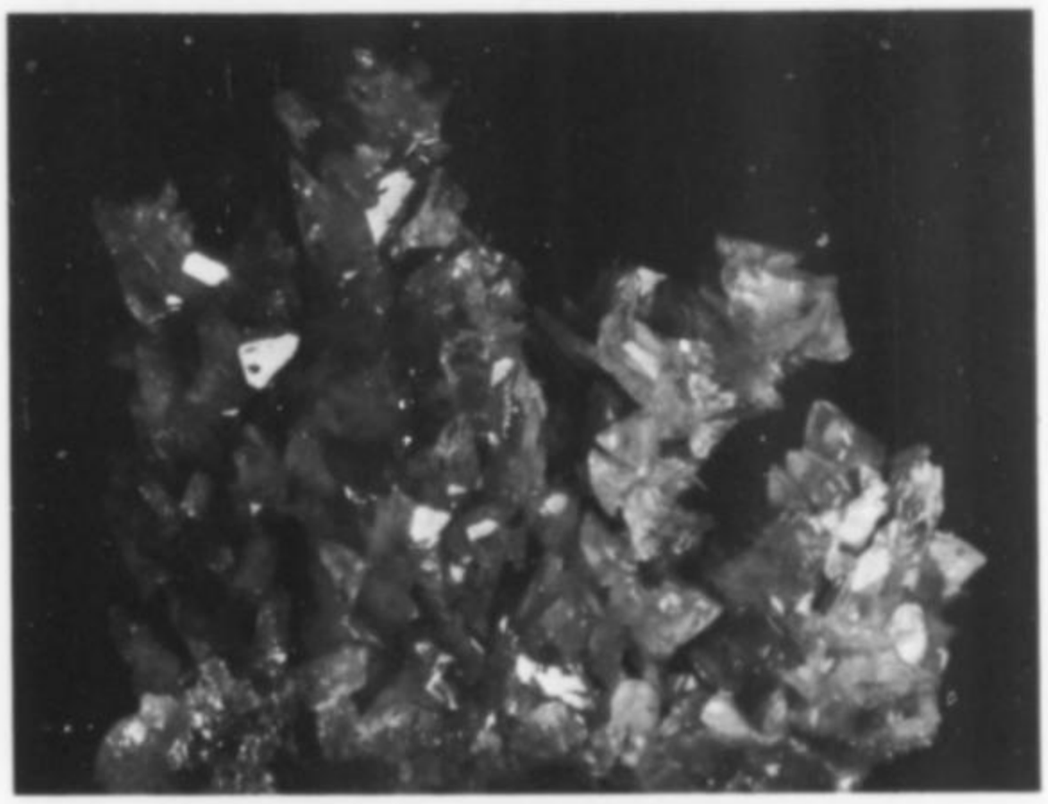


Figure 9. **White to cream-colored cerussite crystal group 8 cm across from the 11 level, Orr orebody, Bunker Hill mine. Author's specimen and photo.**

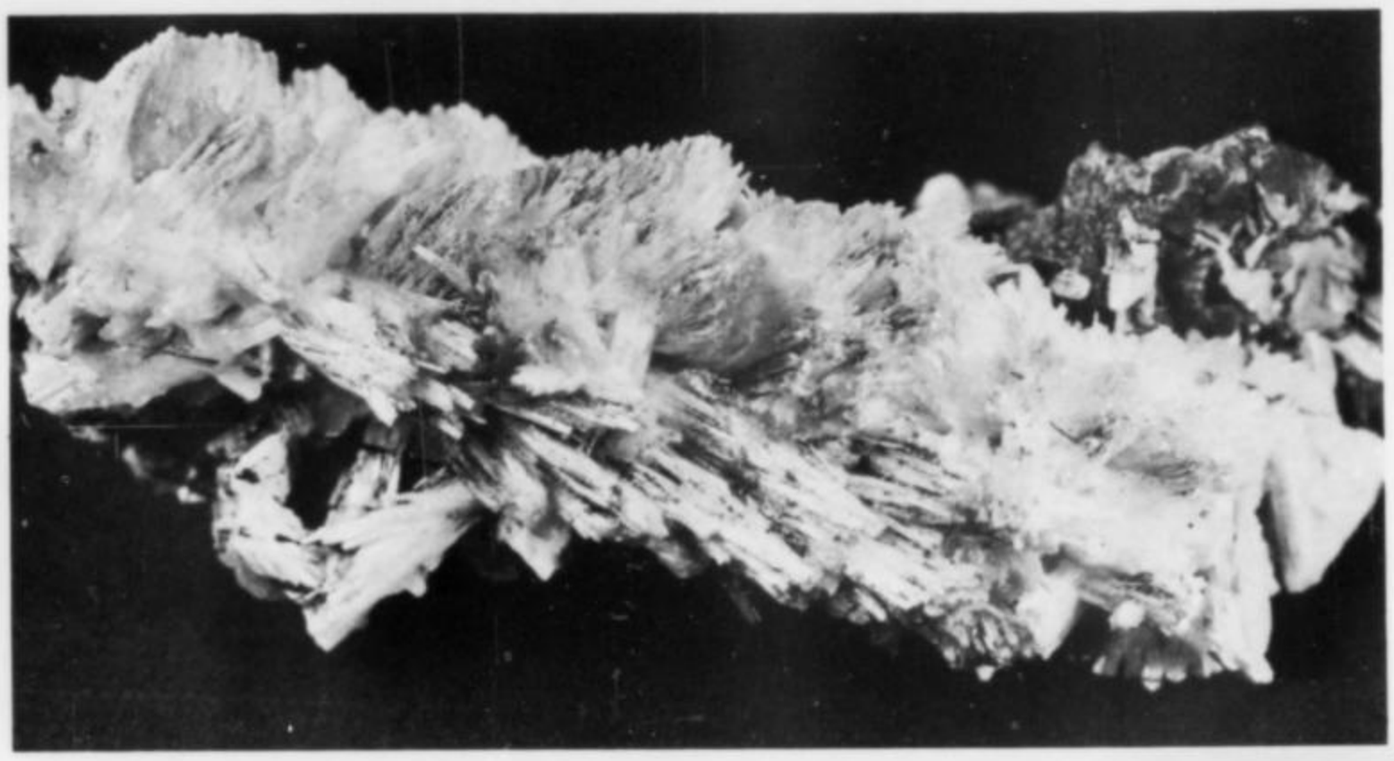
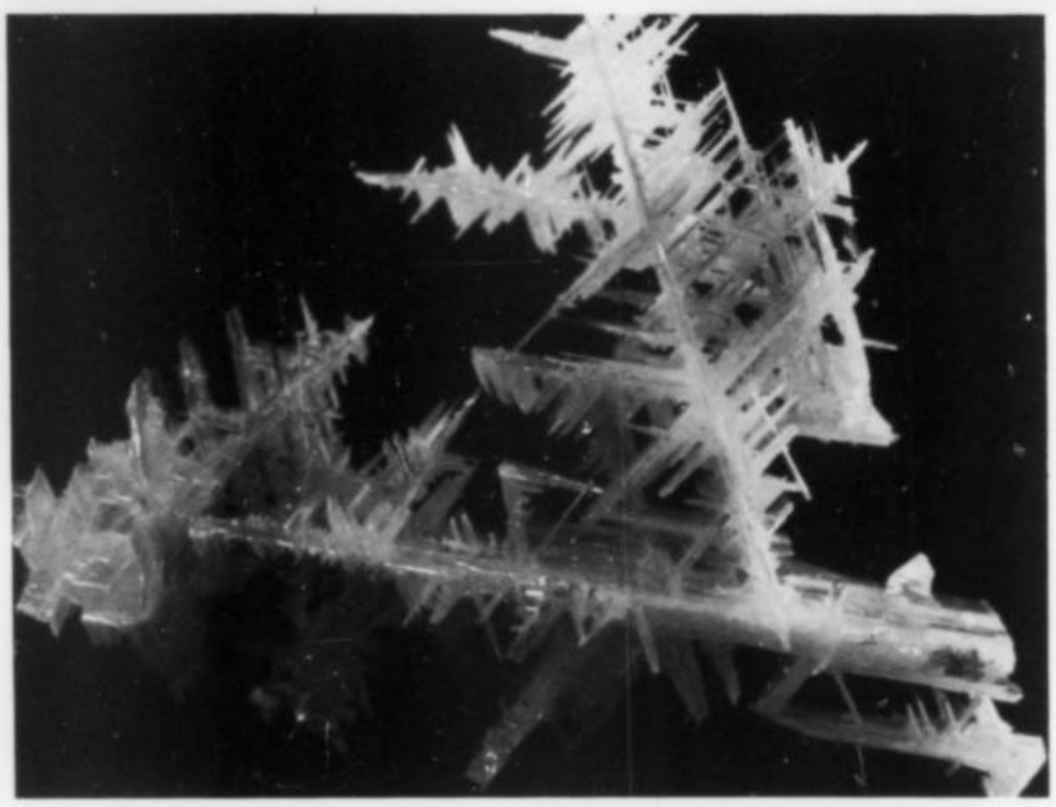


Figure 10. **White cerussite group 15 cm long from the Orr orebody, Bunker Hill mine. John Davis collection; photo by the author.**

Figure 11 **White, reticulated cerussite group 3 cm across from the 11 level, Orr orebody, Bunker Hill mine. Author's specimen and photo.**



Between 1910 and 1915, the Caledonia mine opened a shaft to the 300 and 500 foot levels. The shaft is west of Wardner and on the east side of Deadwood Gulch. Development in this mine encountered a large, rich cerussite orebody. Small, clear, glassy crystals were common but, on occasion, large glassy twins in large aggregates were found in clayey gouge. Malachite in some cases colors outer layers of fibrous to jackstraw specimens green (Shannon, 1926). Fine cerussite specimens have been collected from other workings in the Bunker Hill group, including the Stemwinder, Sullivan, and the upper workings of the Senator Stewart.

In recent years, some fine to excellent clear butterfly twins, and jackstraw and six-rayed penetration twins have been recovered from the Orr orebody. The oxidation zone in this orebody extends down to the 12 level of the Bunker Hill, consequently some specimens have been recovered from more recently abandoned, but as yet uncaved stope areas. Some crystals from this stope fluoresce a delicate light yellow under longwave ultraviolet light. Some of these cerussite crystals contain included anglesite.

Copper Cu

The oxidized ores of the Caledonia workings contained rather abundant native copper. Copper occurred in dendritic moss-like forms, somewhat resembling native silver in form and embedded in spongy limonite or resting on cerussite (Shannon, 1926). Nugget-like masses have been reported from the Boyle stope of the Caledonia, intimately mixed with masses of native silver. At the 700-foot level crystalline wires of copper were found plated with silver. Wire-like forms of copper were found in the Tyler mine (Shannon, 1926).

Covellite CuS

In a stope above the First level of the Last Chance workings some rich oxidized ore was accompanied by streaks of soft, black, sooty covellite which was indigo in color on the face of freshly broken lumps (Ransome, 1908).

Disseminated masses of pyrite and anglesite were found in the covellite of the Caledonia mine. The covellite was argentiferous and appeared to be replacing galena. Some galena masses were encrusted with layers of covellite 2 to 10 cm thick (Shannon, 1926).

Cuprite Cu_2O

Cuprite was common in the upper workings of the Caledonia mine. Beautiful specimens were frequently found showing residual cores of tetrahedrite surrounded by concentric rings of cuprite, azurite, malachite and chrysocolla. Some minute, brilliant cuprite crystals were mistakenly called ruby silver by the miners. Distorted and flattened crystals were found in fractures. The crystals are mostly octahedral and reach a maximum of about 6 mm in diameter. Specimens recovered in 1915 from the 500 level consist of rusty, limonite-stained quartzite, spangled with transparent, deep red cuprite crystals and associated cerussite crystals on a velvety limonite layer. The predominant form is the octahedron with or without cube or dodecahedron modifying faces (Shannon, 1926).

Hemimorphite $Zn_4Si_2O_7(OH)_2 \cdot H_2O$

Hemimorphite was identified in 1972 in the Newgard orebody above the 9 level. Most specimens were found as small white crystal spherulites connected to one another by crystalline hemimorphite. A narrow fissure cross-cutting white metasandstone contained the hemimorphite and some milky calcite crystals.

In 1979, some fine hemimorphite crystal spherulites were col-

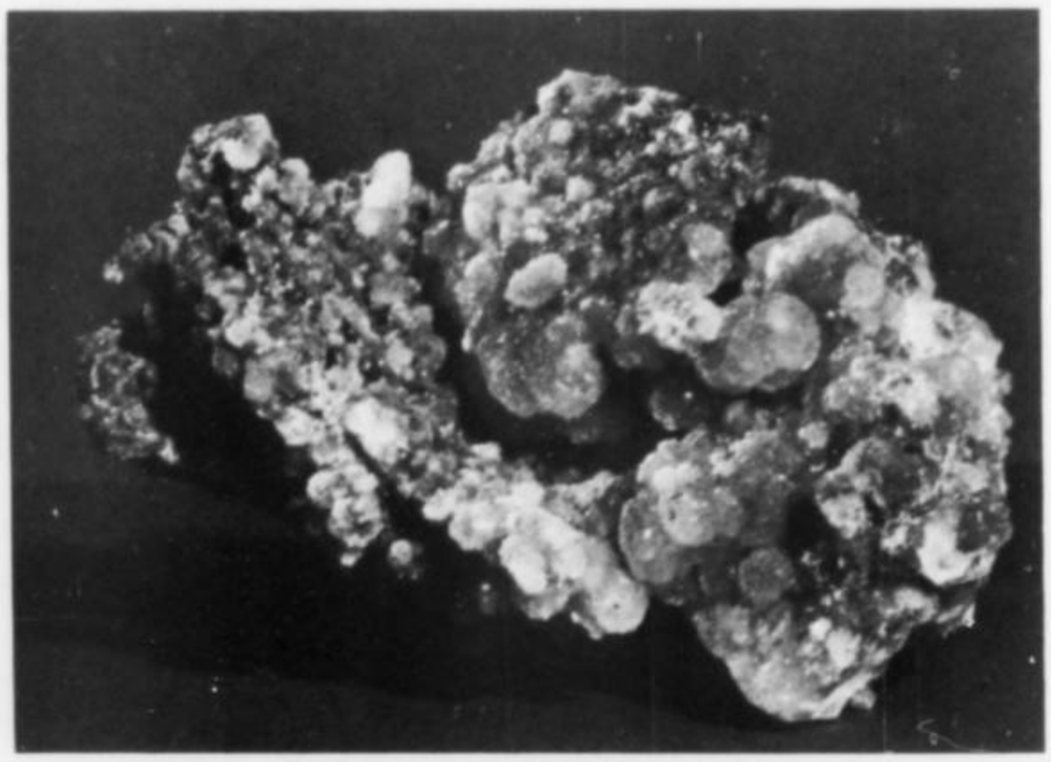


Figure 12. **Gray hemimorphite specimen 9 cm across from the 11 level, Quill orebody, Bunker Hill mine. Norm Radford specimen and photo.**

lected above the 11 level in the Quill orebody. The radiating crystal groups were moderately abundant in an open fissure along the footwall of a fault. Spherules reach 6 mm in diameter and are composed of snow-white crystals resting on massive brown sphalerite. More commonly the hemimorphite is found covering an earthy green chlorite overlaying a bornite film. Crystal groups are generally thumbnail in size, but attractive groups to 7.5 x 10 cm have

Figure 13. **Hydrocerussite (white to dark red-brown) altering surficially to cerussite, 8 cm across, from the 11 level, Orr orebody, Bunker Hill mine. Author's specimen and photo.**

Figure 14. **Tarnished dark reddish pink silver on a 5-mm white cerussite crystal from the 11 level, Orr orebody, Bunker Hill mine. Author's specimen and photo.**

been collected. One small group was collected with associated minute pyromorphite crystals.

Hydrocerussite $Pb_3(CO_3)_2(OH)_2$

Hydrocerussite was tentatively identified in 1950, in the Orr orebody on the 11 level of the Bunker Hill mine. In August, 1961, another tentative occurrence in a different stope along the same orebody was found. Here a white mineral with silver was found in the same area of the stope that had produced galena with pockets of anglesite. X-ray diffraction analyses on a few of these specimens have shown them to be an unusual form of cerussite. A few recent specimens, collected in the 1970's from the Orr orebody, have been identified by X-ray diffraction as hydrocerussite in part. The crystals have a tapered, long prismatic habit and are about 2 cm long, with the outer portion of individual crystals composed of cerussite, and the core, near the base of the crystals, composed of hydrocerussite. These appear to be cerussite replacing hydrocerussite.

Malachite $Cu_2(CO_3)(OH)_2$

Both the Sierra Nevada and Caledonia workings contained mammillary masses and fibrous radial groups of malachite. It is thought that the Caledonia workings produced more malachite than any lead mine in the Coeur d'Alene district. Malachite impregnated the quartzite surrounding the copper-rich areas. Most malachite occurred with cerussite and cuprite although delicate crystals were found in spongy masses of limonite. Some pearly crystals of cerussite are stained a light green by a thin layer of malachite (Shannon, 1926).

Linarite $PbCu(SO_4)(OH)_2$

Minute, well formed crystals of linarite and caledonite were collected from the Orr orebody in 1964 by Art Cooper. On occasion both minerals were found on the same specimen.

Massicot PbO

Ransome's (1908) identification of massicot was disputed by Shannon (1926). Shannon received assays for antimony in samples from several district mines. He believed most of this oxide to be bindheimite. Although both massicot and bindheimite occur, the mineral found in the Last Chance, Caledonia and Bunker Hill ores is predominantly massicot. Shannon (1926) reports masses of pure friable bindheimite (massicot?) to several feet in diameter in the oxidized ores of the Caledonia mine. He also reports the occurrence

of lumps of galena surrounded by crusts of bindheimite (massicot?). Some specimens of massicot retained the typical granular galena structure with traces of cubic galena.

Specimens of massicot collected in the mine are an earthy, bright yellow coating, primarily found on cerussite. The color dulls slightly when brought to the surface and the mineral frequently washes off. Some uncleaned cerussite specimens are somewhat enhanced by this yellow coloration.

Plattnerite PbO_2

This mineral was recovered from the Last Chance mine sorting belt in 1915. The plattnerite was found in a compact and massive form. Specimens were collected in the No. 1 tunnel and the Bunker Hill open cut (Shannon, 1926).

During the early 1930's, in the Hall lease of the upper Caledonia workings, some specimens of plattnerite were found in groups of rounded nodules that were thought to be masses of iron. An assay showed a high lead content. Further research revealed that it was plattnerite in spherical form covered by a coating of limonite giving the plattnerite a rough appearance.

Pyromorphite $Pb_5(PO_4)_3Cl$

In the Coeur d'Alene district pyromorphite has been somewhat localized in the upper half of the near-surface oxidized zones. Most specimens are found lining narrow shears or coating bedding planes. Crystals vary from white to deep green and are typically a prism with a basal pinacoid (Shannon, 1926).

In the Omaha prospect and the Caledonia mine, the mineral was found as large, beautiful, pale green crystals. The 900 level of the Caledonia produced peculiar pinkish pyromorphite crystals coating fractures in galena and quartzite (Shannon, 1913). One local mining engineer reported some small, well formed crystals growing on old mine timbers of the 200 level (Umpleby, 1923).

Crystalline masses were found in the Senator Stewart mine and small botryoidal coatings and crusts occurred in the Quaker tunnel. Mining in the No. 3 tunnel of the Senator Stewart mine produced large amounts of pyromorphite. One small stope yielded 30 tons of pyromorphite ore (Shannon, 1926). Fine crystals were also collected in 1912 by Oscar Hershey from the Sierra Nevada workings. A pyromorphite specimen originally from the E. William Chapman collection, reportedly mined about 1912 from the Sierra Nevada workings, is 7 x 15 cm in size, with a matrix of a dark brown, crumbly, limonitic-manganitic material. Half the specimen is covered with bright, lime-green, translucent pyromorphite crystals to over 5 mm in length.

In December, 1980, an open fracture zone was encountered in the Brown orebody. Groups of bright, clear, silvery to smoky brown pyromorphite were collected, some to more than 1 cm in length. The specimens look very similar to the white and brown pyromorphite specimens from the Bad Ems region in Germany. This zone of fracturing is about 70 m vertically lower than any other reported occurrence of oxidized zone minerals in the mine.

About this same time, above the 9 level in the Jersey vein, very attractive pyromorphite crystals in shades of yellow to greenish-yellow were encountered. These specimens had crystals up to 1 cm in length, a few even larger. The majority of these were considerably less than 1 cm in length, averaging about 5 mm. The best of these specimens are truly fine and easily rival the pyromorphite recently collected in France. Also encountered in the same area of the Jersey vein were a number of botryoidal pyromorphite specimens of the calcian-rich *polysphaerite* variety. These varied in color from white to yellow, orange and brown. Much of the *polysphaerite* material from along the footwall of the Jersey vein has stalactitic form. Limonitic vugs as large as 20 by 30 cm were found lined with these attractive specimens. All of the pyromorphite recovered from the Jersey vein is arsenian, but not sufficiently so as to be called mimetite.

Silver Ag

Silver commonly accompanies cerussite in oxidized silver-lead ores. It usually occurs as dendritic moss-like aggregates of distorted crystals strung into wires. Vugs in cerussite that contained native silver were found in the Bunker Hill, Tyler, Caledonia and Sierra Nevada mines. One small cavity collected by Shannon in the Tyler mine, in 1912, yielded 9 ounces of wires (Shannon, 1926). In the Barney stope of the Bunker Hill, enough loose silver from a vug was said to have filled a nail keg (Shannon, 1926). Silver was found attached to white cerussite crystals in the Blacksmith stope and the Orr stopes.

The Caledonia mine produced more silver than any of the Bunker Hill veins. It occurred as flattened wires in brecciated white quartzite, in cerussite and in limonite. Small silver slabs were found to 3 mm thickness and several centimeters in diameter in quartzite fractures. Coarse dendritic wires of native copper found in soft clayey gouge are in some cases silver plated.

In the Taylor stope brilliant cerussite crystals were found covered with a thick mat of finely felted wires of silver. Six sacks of tarnished silver were gathered from a series of flat pockets along the footwall.

In recent years some small but excellent silver specimens have been found in the Orr orebody between the 10 and 12 levels. Untarnished wires to 1¼ cm in length and covering areas up to 7½ square cm have been found resting on snow-white cerussite. The specimens are delicate and many are permanently damaged even when hand carried from the mine.

In December, 1980, in the footwall of the Jersey vein, several small pods to about 15 cm in length were encountered. They con-

Table 1. Minerals of the Bunker Hill Mine.

Primary Minerals		*Secondary Minerals*	
Arsenopyrite	U	Acanthite	R
Barite	C	Anglesite	C
Boulangerite	C	Azurite	R
Bournonite	R	Bindheimite	R
Chalcopyrite	C	Brochantite	R
Galena	C	Calcite	U
Magnetite	R	Caledonite	R
Pyrargyrite	C	Cerussite	C
Pyrite	C	Chalcanthite	R
Pyrrhotite	U	Copper	R
Sphalerite	C	Covellite	R
Tetrahedrite	C	Chrysocolla	R
Uraninite	R	Cuprite	R
		Goethite	C
		Gypsum	C
		Hematite	U
		Hemimorphite	U
Gangue Minerals		Hydrocerussite	R
		Leadhillite	R
Ankerite	U	Limonite	C
Calcite	C	Linarite	R
Chlorite	C	Malachite	U
Quartz	C	Massicot	C
Sericite	C	Melaconite	R
Siderite	C	Melanterite	C
		Plattnerite	R
		Pyrolusite	U
		Pyromorphite	C
C = Common (in some orebodies)		Silver	U
		Smithsonite	R
U = Uncommon		Stromeyerite	R
R = Rare to very rare		Sulfur	R

sisted of bright blue to green chrysocolla. Fractures crosscutting this chrysocolla were sparsely coated with thin, bright plates of silver to 3 mm in diameter, creating rather attractive specimens.

Smithsonite $ZnCO_3$

Minute, white, botryoidal blebs scattered across jackstraw cerussite from the 2 level, Sullivan mine, have been identified as smithsonite. Several specimens from the Orr orebody, 11 level, have been recently found with similar minute spherules on slightly red-stained but translucent cerussite crystals.

Sulfur S

Sulfur was reported as yellow earthy material in the upper workings of the Caledonia.

COLLECTING

Most early-day tunnels and mines mentioned in this paper are now caved or inaccessible. Only the Bunker Hill adit remains in good repair. The Bunker Hill workings are not open to collectors because of safety problems and because of the expense of furnishing a guide. Federal law now requires a formal hazards and familiarization course before one is allowed to enter an operating mine.

Local dealers and collectors may have a few duplicate specimens from this district that have been collected within the past ten years. Older specimens are seldom available and should be cherished. The present price of silver may give some encouragement to mining low grade ores near old mine workings. The workings may again produce quantities of superb specimens.

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Turquoise Crystals

from Britain and a review of related species

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Previously only two localities for crystallized turquoise were known: in Belgium, and at Lynch Station, Virginia. Now three new occurrences have been found in Cornwall.

INTRODUCTION

Turquoise, $CuAl_6(PO_4)_4(OH)_8 \cdot 4\text{–}5H_2O$, the aluminum end-member of the turquoise-chalcosiderite group, commonly occurs in opaque massive or nodular forms, as in the well-known gem material from Iran, the southwestern U.S., and elsewhere. Turquoise in distinct crystals, however, is decidedly rare; the only localities recorded in the literature are the Bishop mine, near Lynch Station, Campbell County, Virginia (Schaller, 1912) and, more recently, Ottré, near Vielsalm, Ardennes, Belgium (Van Wambeke, 1958), where 1-2 mm crystals have been found in manganiferous quartz veins. Turquoise crystals have now been identified from three British localities: Hensbarrow and Wheal Remfry china clay pits, on St. Austell Moor, and Wheal Phoenix (Stowe's mine), Linkinhorne, all in Cornwall.

THE TURQUOISE-CHALCOSIDERITE GROUP

The turquoise-chalcosiderite group is a diadochic series of triclinic basic copper phosphates of space group $P\bar{1}$, which are found as supergene minerals in the oxidation zone of copper deposits, ranging in composition from the aluminum end-member (turquoise) to the ferric end-member (chalcosiderite) $CuFe_6(PO_4)_4(OH)_8 \cdot 4H_2O$.

There is some uncertainty as to the degree of hydration in turquoise. X-ray diffraction measurements by Cid-Dresdner (1964, 1965) showed that the structure can only accommodate 4 molecules of water per unit cell (per copper atom), but some analyses (e.g. Jung, 1932; E. A. Vincent *in* Russell, 1952) show nearer 5 molecules, and Hey (1962) and Fleischer (1975) quote $5H_2O$ per formula unit. It may be significant in this context that the infrared spectrum of turquoise shows extra O-H stretching absorptions, not hydrogen bonded, over that of chalcosiderite.

British turquoise, as blue masses, was first described from several Cornish localities by Sir Arthur Russell and E. A. Vincent in 1952 (Russell and Vincent, 1952; Russell, 1952), a previous report by Sir Arthur (Russell, 1938) being later shown by the same author to be the then-new, closely related, aluminum-iron phase *rashleighite** (Russell, 1948). However, *henwoodite,* forming pale blue spheres on gossan was described as a "new mineral" from Wheal Phoenix, Linkinhorne, Cornwall by Collins (1876), but was later shown to be identical with turquoise (Bannister *in* Hey, 1950; Fischer, 1961).

Chalcosiderite is a rare mineral, only known from Wheal Phoenix, Cornwall (Maskelyne, 1875), Bisbee, Arizona, and two localities in Germany (Palache, *et al.,* 1951). It characteristically forms small green crystals of short prismatic habit, with a tendency to aggregate in globular clusters.

A complete compositional series can exist between turquoise and chalcosiderite, various unnecessary names having been given to intermediate members. *Ferri-turquoise* and *aluno-chalcosiderite* speak for themselves. Somewhere near the middle of the series lies *rashleighite,* discovered by Sir Arthur at the Bunny mine, St. Austell, and at Castle-an-Dinas mine, St. Columb Major, both in Cornwall, and subsequently found at other Cornish localities, including Wheal Phoenix (Kingsbury, 1952). Analyses of type material show Al:Fe approximately 1.6:1 (Russell, 1948). *Rashleighite,* like chalcosiderite, is distinctly green in color, the pure blue of turquoise being sensitive to iron substitution.

This group of minerals can be extended by further diadochic replacements. The ionic radius of Zn^{+2} is similar to that of Cu^{+2}, and can partly replace it in turquoise, giving faustite, $(Zn,Cu)Al_6(PO_4)_4(OH)_8 \cdot 5H_2O$ (Erd, *et al.,* 1953). The same applies to Ca^{+2}, giving coeruleolactite, $(C,Cu)Al_6(PO_4)_4(OH)_8 \cdot 4\text{–}5H_2O$ (Fischer, 1958), *planerite* (Cech, *et al.,* 1961) being a slightly calcian intermediate member.

Callainite of which certain Neolithic beads found in Brittany are made (Palache, *et al.,* 1951) has been shown to be a mixture of tur-

*Italicized names are not currently accepted as species names, and are used here only as part of a historical review. They should not be perpetuated.

quoise with wavellite (McConnell, 1942). *Harbortite,* described by Brandt (1932) as $Al_3(PO_4)_2(OH)_3 \cdot 2¾H_2O$ (?), and at one time considered to be possibly a member of the turquoise group (Jung, 1935; Hey, 1962) has been shown to be a mixture containing crandallite (Fleischer, 1966).

Andrewsite, $(Cu,Fe^{+2})_3Fe_6^{+3}(PO_4)_4(OH)_{12}$ (Frondel, 1949; Fleischer, 1975, gives $(Cu,Fe^{+2})Fe_3^{+3}(PO_4)_3(OH)_2$), found as greenish globular radiating masses with chalcosiderite at Wheal Phoenix (Maskelyne, 1875), is not a member of the turquoise-chalcosiderite group, but is related to laubmannite, $Fe_3^{+2}Fe_6^{+3}(PO_4)_4(OH)_{12}$, with which it is isostructural (Frondel, 1949).

Dufrenite (Kinch and Butler, 1886; Kinch, 1888), $Fe^{+2}Fe_4^{+3}(PO_4)_3(OH)_5 \cdot 2H_2O$, and rockbridgeite (Kingsbury, 1957), $(Fe^{+2},Mn)Fe_4^{+3}(PO_4)_3(OH)_5$, are two other related greenish globular radiating iron phosphates found at Wheal Phoenix, which readily alter to brown goethite, of which many specimens labeled "dufrenite" from Wheal Phoenix consist.

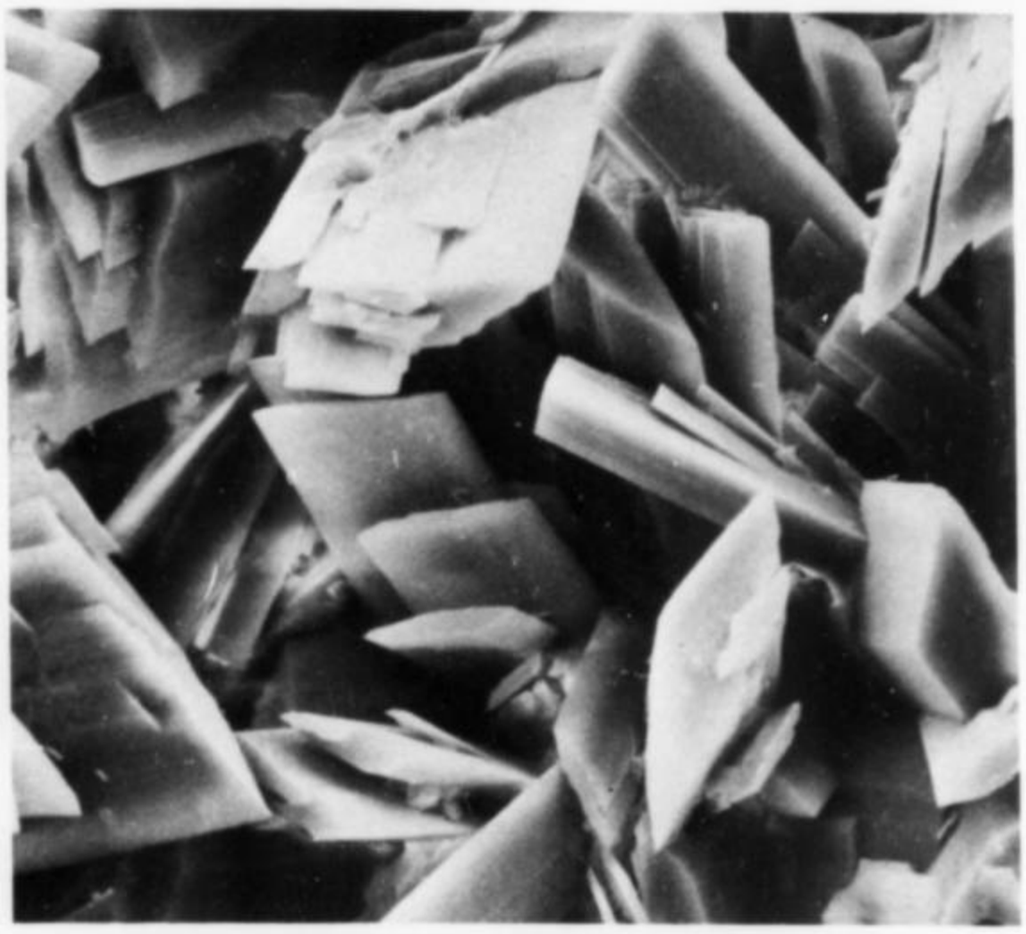

Figure 1. **Turquoise crystals from Hensbarrow pit, St. Austell, Cornwall (300x). Collected by the author in 1965; G. Ryback collection and photo.**

Figure 2. **Turquoise crystals on kaolinized granite, Hensbarrow Pit, Cornwall. Frame is 7 cm across. Collected by the author in 1965. Author's specimen (65-245) and photograph.**

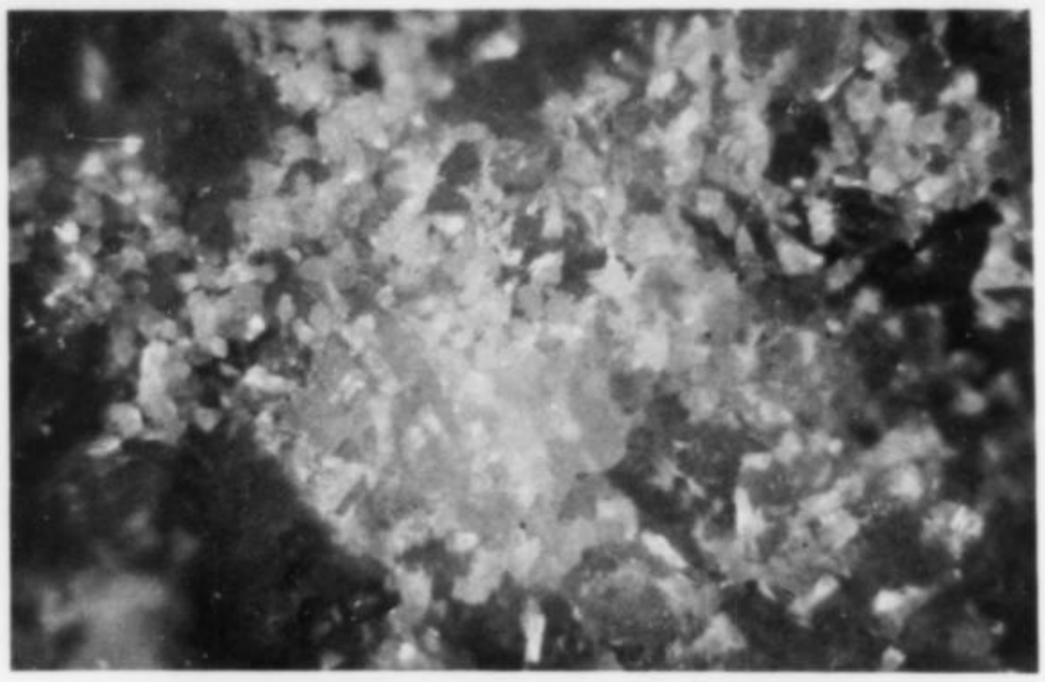

Figure 3. **Turquoise crystals on quartz, Hensbarrow Pit, Cornwall. Collected by the author in 1965. Author's specimen (65-286) and photomicrograph. Frame is 4.3 x 3 mm.**

THE NEW CORNISH OCCURRENCES

Hensbarrow china clay pit, St. Austell

Hensbarrow pit, on St. Austell Moor, centered on SX 005 571,** lies very close to the *rashleighite* and turquoise locality of the Bunny mine, and is a known locality for massive turquoise (Russell, 1952). In this working pit, in August 1965, the author found one small boulder of kaolinized granite containing several cavities lined with small, clear, discrete blue crystals, 0.1 - 0.25 mm long, which were identified as turquoise by X-ray diffraction (by E. E. Fejer of the British Museum, Natural History), and by infrared spectroscopy. This turquoise is a late-generation crystallization, growing on small quartz crystals which project into cavities in the kaolinized granite. Other associated minerals include yellowish muscovite, black schorl, purple fluorite, and almost white radiating films of wavellite, commonly overlying massive blue to green turquoise-*rashleighite*.

Specimens of this very attractive material have been presented to the British Museum (Natural History) and to the Geological Museum, Institute of Geological Sciences, South Kensington, London.

Wheal Remfry china clay pit, St. Enoder, Cornwall

Among material collected by B. V. Cooper and sent to the author for identification in January, 1979, is a specimen of altering granite from Wheal Remfry, a working china clay pit, centered on SW 925 575. A small cavity about 4 mm across on one side of the specimen is partly lined with pale blue micro-crystals of turquoise to 0.08 mm, with no greenish tint, growing on tourmaline (schorl) needles and on quartz. The amount of material was just sufficient to permit identification by infrared spectroscopy and to preserve a little of the turquoise in the cavity. The specimen is the only one found so far.

**National Grid Reference, the coordinates defining a point on all Ordnance Survey maps.

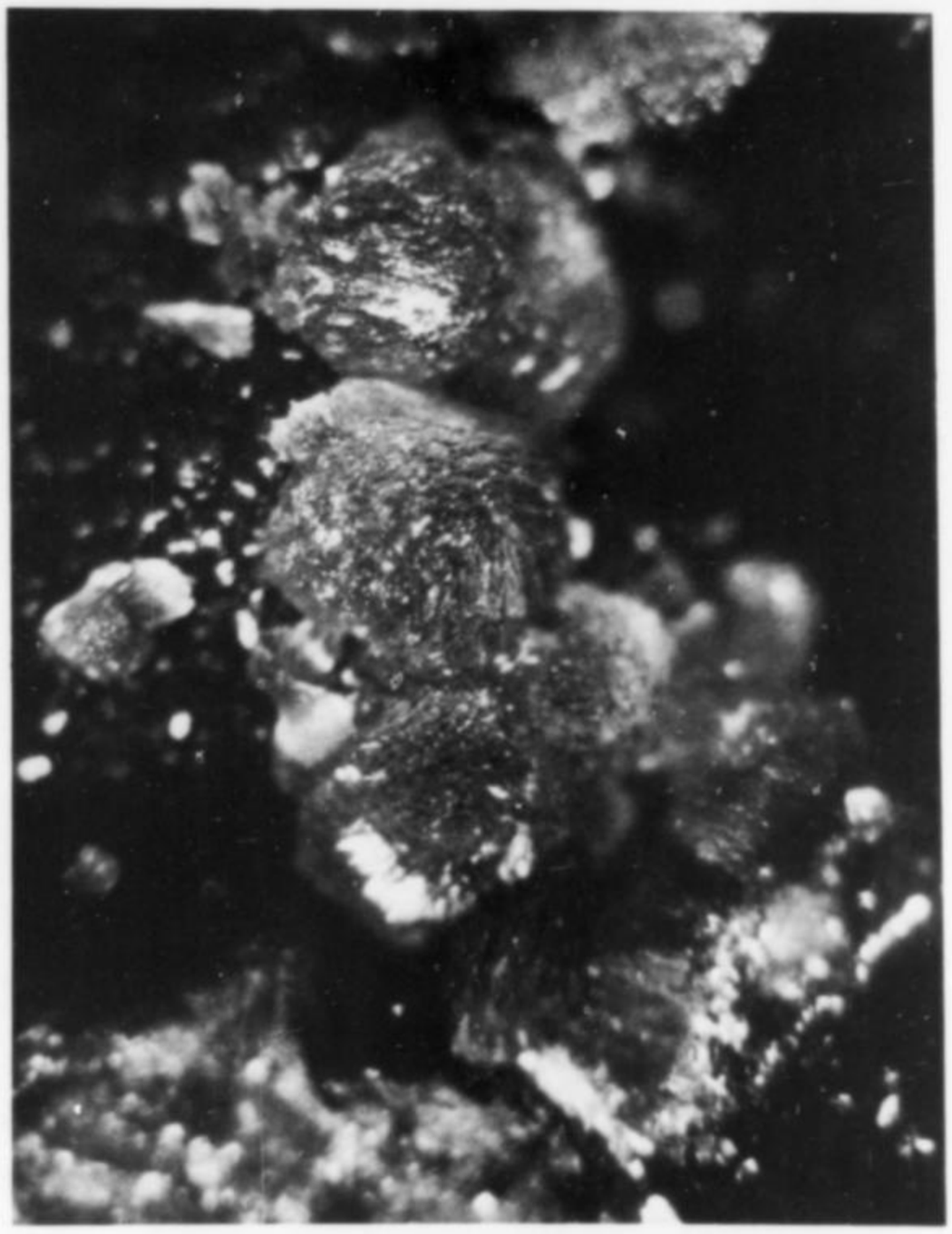

Figure 4. **Turquoise-*rashleighite* crystal aggregates on goethite, Wheal Phoenix, Cornwall. Collected by the author in 1965. Author's specimen (65-313) and photomicrograph. Frame is 4.3 x 3 mm.**

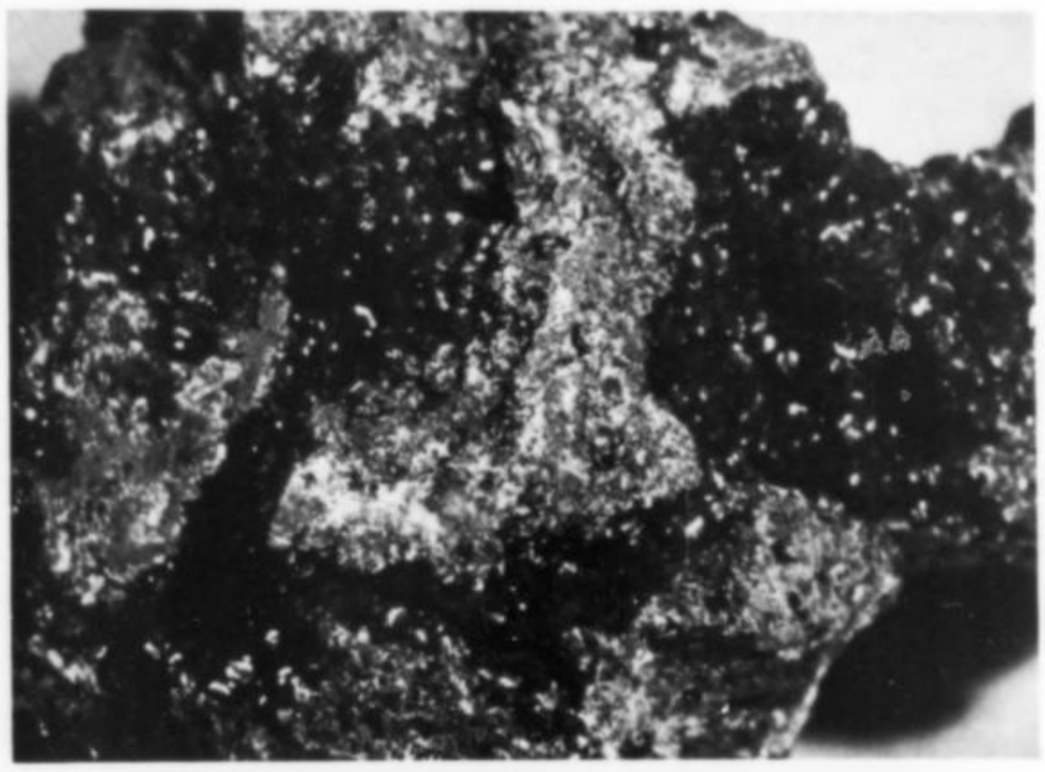

Figure 5. **Chalcosiderite on gossan, Wheal Phoenix, Cornwall (old specimen). Author's specimen (RSWB 58) and photograph. Specimen is 7 cm across.**

Wheal Phoenix (Stowe's) mine, Linkinhorne, Cornwall

Samples of a mineral forming small (up to 2 mm) globular aggregates of transparent green to pale greenish-blue crystals, with a superficial resemblance to the iron arsenate scorodite, were collected by the author from dumps in the western part of Wheal Phoenix, near SX 261 722 in 1965, and similar specimens bearing old labels inscribed "Scorodite, Wheal Phoenix, Cornwall" were purchased from a well-known mineral dealer. Examination of these specimens by infrared spectroscopy showed that the green mineral

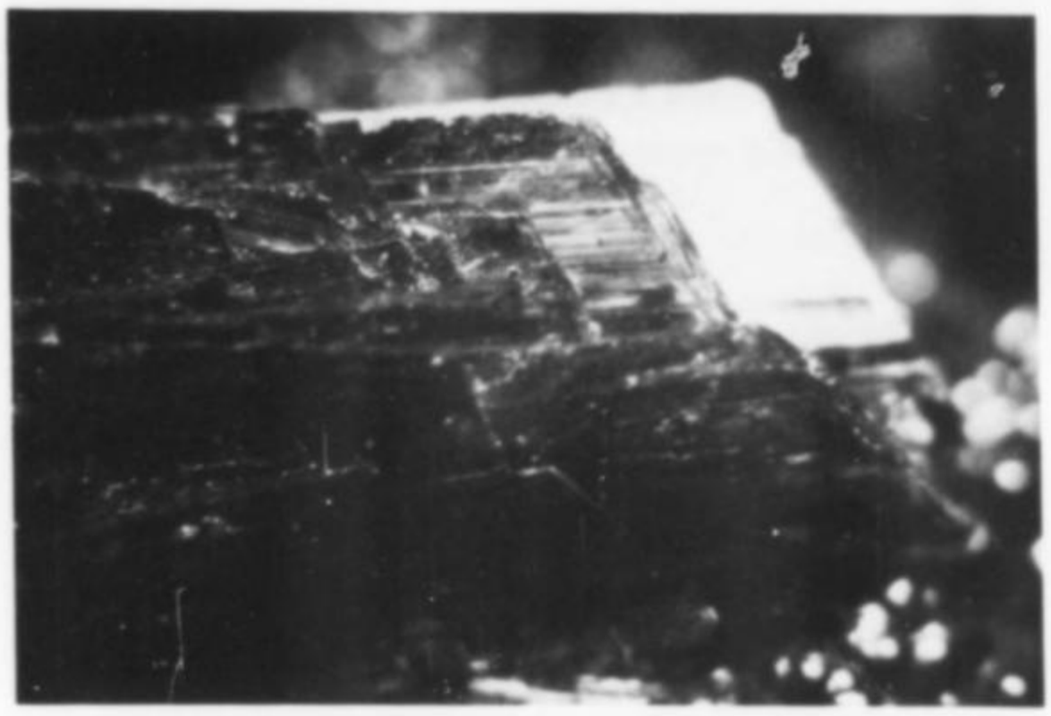

Figure 6. **Chalcosiderite crystals on goethite, Wheal Phoenix, Cornwall (old specimen). Author's specimen (65-446) and photomicrograph. Frame is 4.3 x 3 mm.**

was certainly not scorodite, but a phosphate of the turquoise-*rashleighite* series, in agreement with Kingsbury's (1952) observation that several old specimens labeled "scorodite" from Wheal Phoenix have proved to be *rashleighite*. The X-ray diffraction pattern of the bluish-green specimen was identified by E. E. Fejer of the British Museum (Natural History) as that of turquoise. Specimens labeled "scorodite" from Wheal Phoenix, on the characteristic goethite gossan matrix of that locality, should therefore be reexamined in case they are actually members of the turquoise-*rashleighite* series.

INFRARED SPECTRA

Infrared spectroscopy, which requires less than 1 mg of sample, is a useful and rapid method for the identification of many minerals, and can also yield much chemical and some structural information, the absorption bands being due to bond vibrations.

The infrared spectra of a number of turquoise, *rashleighite* and chalcosiderite specimens from various localities were measured in the 670-4000 cm^{-1} range, using a Perkin-Elmer 137 spectrophotometer with sodium chloride optics, calibrated against polystyrene, the finely powdered samples being suspended in "Nujol" mulls. Apart from extra bands due to kaolinite impurity in some specimens, the spectra are in agreement within their compositional ranges.

The infrared spectra of a blue polished turquoise of unknown provenance, blue turquoise crystals from Hensbarrow pit, blue-green turquoise-*rashleighite* from Wheal Phoenix, green *rashleighite* from Bunny mine, and chalcosiderite from Wheal Phoenix, in "Nujol" mulls, were measured over the 300-4000 cm^{-1} range using a Perkin-Elmer 621 spectrophotometer, calibrated against polystyrene, to give greater resolution and precision in wavenumber, and to cover a wider range to include the ν_2 and ν_4 regions of phosphate absorption. The absorption maxima are tabulated in Table 1. The spectrum of a "faustite" from Copper King mine, Maggie Creek District, Eureka County, Nevada, U.S.A. was also measured over this range, but the spectrum was dominated by absorptions due to kaolinite.

The broad absorption band in the 3200-3400 cm^{-1} region is due to overlapping O-H stretching vibrations of OH^- and of H_2O, broadened by hydrogen bonding in the lattice. The sharp extra O-H

Table 1. Wavenumbers and probable assignments of infrared absorption maxima of minerals in the turquoise-chalcosiderate series.

Absorption maxima, cm^{-1}					Assignments
1	2	3	4	5	
308 m	308 m	300 m	300 m	— —	Al-O ?
356 m	356 m	355 mw	350 mw	340 m	PO_4^3 ν_2 bend and metal-O
				370 m	
400 vw, br	(405)	(410) w	400 vw, br	— —	
445 w	425 m	450 m	450 vw, br	(440)	
475 m	470 m	— —	470 vw	460 m	
— —	— —	— —	— —	495 m	PO_4^3 ν_4 bend and metal-O
560 s, br	550 s	540 s	520 m, br	(510)	
— —	(580)	— —	(580)	580 m	
(650)	645 ms	(630)	— —	(615)	
— —	— —	— —	790 w	790 s	Fe-O-H
830 ms	830 ms	832 ms	830 ms	— —	Al-O-H
(935) m			(940) m	(930) m	PO_4^3 ν_1 symm. stretch
— —	— —	— —	— —	970 ms	
(995) ms	1000 s	1000 s	(1000) s	1000 s	PO_4^3 ν_3 stretch
1050 s	1040 s	1040 s	1040 s	1030 s	
1100 s	1100 s	1090 s	1080 s	(1070) ms	
(1150) s	1145 s	1145 s	(1140) s	(1140) m	
1630 s, br	1630 s, br	1620 s, br	1620 s, br	1610 s, br	H-O-H bend
3280 m, vbr	3280 m, vbr	3150 m, vbr	3180 m, vbr	3180 m, vbr	O-H stretch
3460 s, sh	3460 s, sh	3450 s	3320 m, vbr	3350 m, vbr	
3500 s, sh	3500 s, sh	(3500) w	(3450)	(3400)	

w = weak, m = medium, s = strong, v = very, br = broad, sh = sharp
Values in brackets are of shoulders.

1 Turquoise, blue polished stone of unknown provenance.
2 Turquoise, blue crystals, Hensbarrow pit, Cornwall. Off RSWB 65-286.
3 Turquoise-*rashleighite,* blue-green crystals, Wheal Phoenix, Cornwall. Off RSWB 68-393.
4 *Rashleighite,* green massive, Bunny mine, Cornwall. Off RSWB 66-140.
5 Chalcosiderite, green crystals, Wheal Phoenix, Cornwall. Off RSWB 65-446.

absorptions (not hydrogen bonded) in turquoise at 3500 cm^{-1} and 3460 cm^{-1} may be connected with the extra H_2O in turquoise over that in chalcosiderite reported in analyses. These extra absorptions are not due to absorbed water molecules, which would give rise to broader absorption at somewhat lower wavenumber. The 3460 cm^{-1} band is present but weakened in the blue-green Wheal Phoenix turquoise-*rashleighite,* and is reduced to a shoulder in the green Bunny mine *rashleighite.* The 3500 cm^{-1} band appears as a weak shoulder only in the Wheal Phoenix material.

An absorption band due to "scissor" bending vibrations of H_2O appears in all these spectra, centered near 1610 cm^{-1}.

The absorptions between 900 and 1200 cm^{-1} form a complex band, mainly the broad strong unsymmetrical stretch (ν_3) of the phosphate anion, overlapping the symmetrical stretch (ν_1, forbidden if the PO_4^3 is symmetrical, T_d), which appears in the 900-1000 cm^{-1} region (e.g. 922 cm^{-1} in pyromorphite, 960 cm^{-1} in apatite). The splitting of the absorption of the ν_3 band into several maxima is due to the distortion of the tetrahedral symmetry of the phosphate ion in the crystal lattices of these minerals, resulting in removal of spectroscopic degeneracy of the P-O vibrations which make up this band.

Turquoise and *rashleighite* show a distinct absorption at 830 cm^{-1}, which is not present in the spectrum of chalcosiderite. The chalcosiderite spectrum shows instead an absorption at 790 cm^{-1}, present but weak in that of the green *rashleighite,* but absent in those of turquoise and the blue-green Wheal Phoenix material. These absorptions are probably due to metal-O-H bending vibrations, Al-O-H at 830 cm^{-1} and Fe-O-H at 790 cm^{-1}.

The ν_4 bending mode of the phosphate ion lies in the 500-600 cm^{-1} region, as also can metal-oxygen absorptions, leading to difficulty in assignment.

The ν_2 bending mode of the phosphate ion is usually found in the 400-500 cm^{-1} region, and overlaps the ν_4 bending region. Metal-oxygen vibrations also occur here, and extend to lower wavenumbers. The spectra of the turquoise group minerals show a number of absorptions in this region, and it is difficult to make definite assignments. An absorption at 308 cm^{-1} in turquoise, shifting to 300 cm^{-1} in *rashleighite,* is not present in the spectrum of chalcosiderite and is probably an Al-O vibration.

Uncertainties in assignment make it difficult to count the numbers of absorptions in the various modes, and therefore to work out phosphate ion site symmetries, but infrared spectroscopy can be used to identify minerals of this group, and to broadly assess a sample's position in the series.

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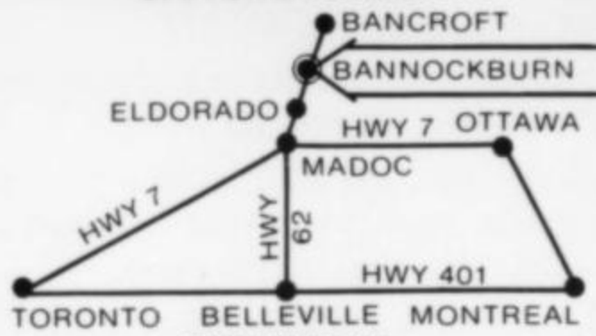
FOOTNOTE

Four specimens labeled "Wavellite crystals, Narooma mine, New South Wales" (Australia) (see H. Bunker's letter in *The Mineralogical Record,* 1978, **9**, 271) have been examined by the author. One specimen bore radial crusts of very pale yellowish, almost colorless, tightly packed blades of wavellite with sharp terminations on massive turquoise. Three others had tiny flat rhomb-shaped blue turquoise crystals, the largest 0.18 mm long, clustered on massive turquoise; a little colorless wavellite was present on one of these. The identity of the turquoise crystals was confirmed by infrared spectroscopy.

Yet another locality for turquoise crystals!

R. S. W. Braithwaite.

BANCROFT AREA



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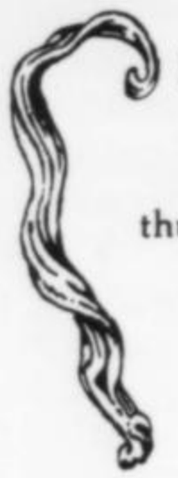

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Barite from the Niobec Mine
Chicoutimi, Quebec

by **Irwin Kennedy**
761 Boulevard Campbell
Chibougamau, Quebec G8P 2K7

and **Gilles Gagnon**
3108 Ch. Ste. Foy
Quebec, Quebec G1X 1P8

INTRODUCTION

Barite crystals occurring in vugs at the Niobec mine, Chicoutimi, Quebec, are beginning to attract widespread attention because of their large size and excellent form. Because the host vugs are only infrequently encountered and quickly lost to advancing mining operations there is very little advance notice of the crystals and the collecting period is necessarily brief, normally only a few days.

The Niobec mine is Canada's only producer of pyrochlore, the main ore mineral of niobium (columbium). The mine is located a short distance off Highway 172 at a point 13 km northwest of the town of Chicoutimi, about 200 km north of Quebec City. Owned jointly by the Quebec Mining Exploration Company (SOQUEM) and Teck Corporation, the Niobec mine began operations in 1976 and has been operating ever since. Proven ore reserves are estimated at some 8.5 million tonnes with an average grade of 0.72 percent Nb_2O_5 (Gagnon, 1979). An additional 40 million t of potential reserves has also been identified on the property (Gagnon, 1979). The ore is milled on site with the pyrochlore being separated and concentrated by selective flotation.

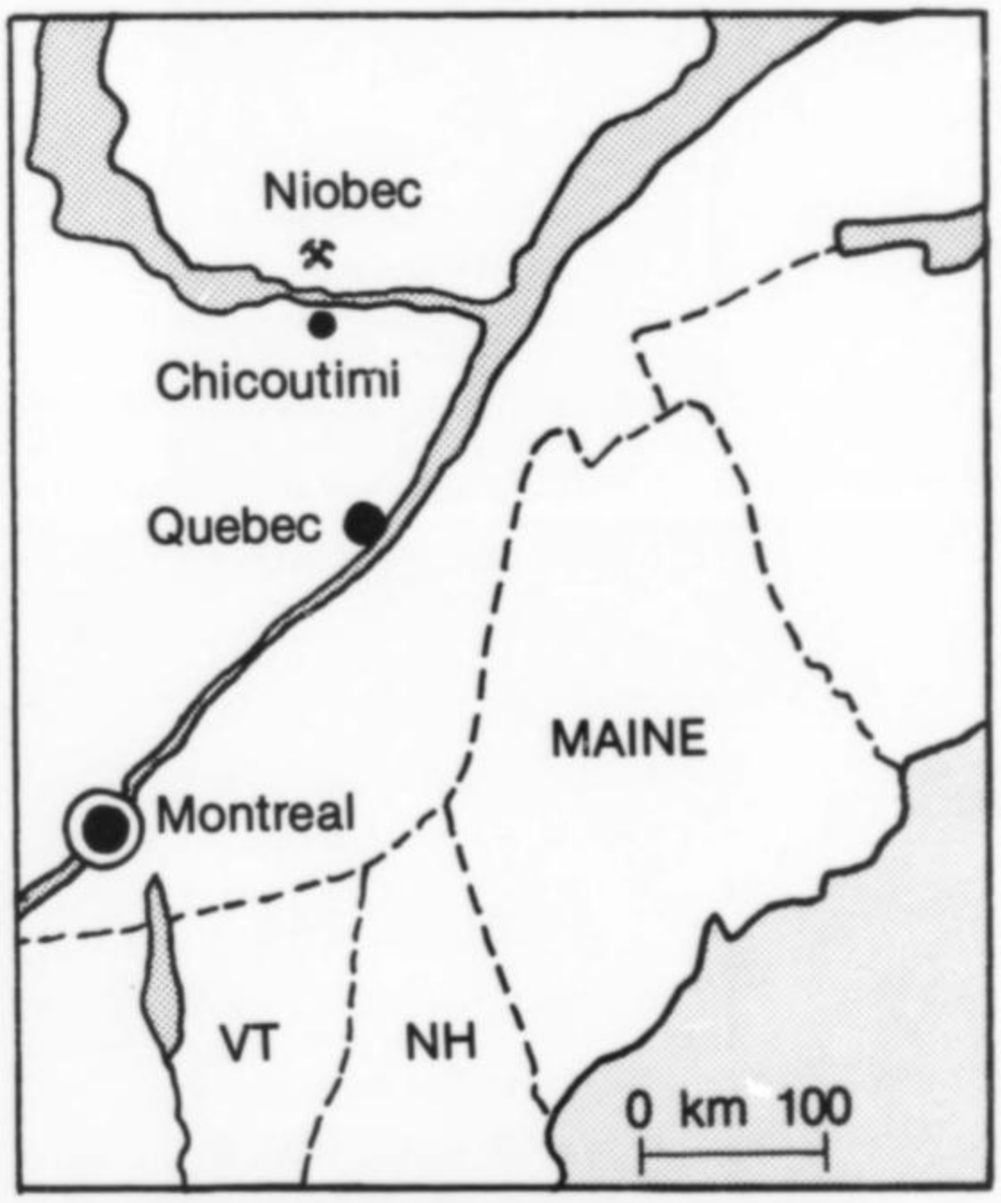

Figure 1. **Location of the Niobec mine in Quebec.**

GEOLOGY

The Chicoutimi area lies within the Grenville Province of the Canadian Shield. This southernmost division of the Shield forms a 400-km-wide band of mainly intensely folded Precambrian metamorphic and igneous rocks from Lake Huron to the Labrador coast. Regionally the area is characterized by large intrusions of anorthosite and locally by a small outlier of Trenton (Ordovician) limestone which is intruded by a near-circular, 20-square-km body of carbonatite. This carbonatite has a core of dolomite/ankerite rock enveloped by a zone of igneous carbonatite (dolomitite), which hosts the ore. Guy Perreault of the University of Montreal analyzed nine samples of Niobec ore and determined (Gagnon, 1979) the following average compositions:

dolomite	63.6 percent
hematite	13.0 percent
apatite	11.0 percent
calcite	5.7 percent
biotite	2.9 percent
chlorite	2.0 percent
pyrite	0.7 percent
pyrochlore (69 percent Nb_2O_5)	0.9 percent
columbite (73 percent Nb_2O_5)	0.3 percent

The pyrochlore occurs as red, octahedral dipyramids less than 1 mm in size, which are suitable only for micromounting. The columbite occurs as microscopic black grains.

OCCURRENCE

The barite crystals line vugs up to 7 m in diameter in the Trenton limestone. These vugs or, more properly, solution cavities are encountered from time to time as drifting passes through the limestone to the ore. At least six major vugs have been encountered to date (June, 1980) and additional ones may be expected. Most crystals are still attached to the walls but many are found in the floor rubble.

The crystals all exhibit the typical, thick, tabular form of barite with prominent basal pinacoids and first and second order prisms.

Figure 2. **The Niobec mine, headframe in foreground. Photo by G. G.**

Figure 3. **This pocket lined with barite crystals was encountered in April, 1980. Photo by G. G.**

Figure 4. **Barite crystals in place in a pocket. Photo by G. G.**

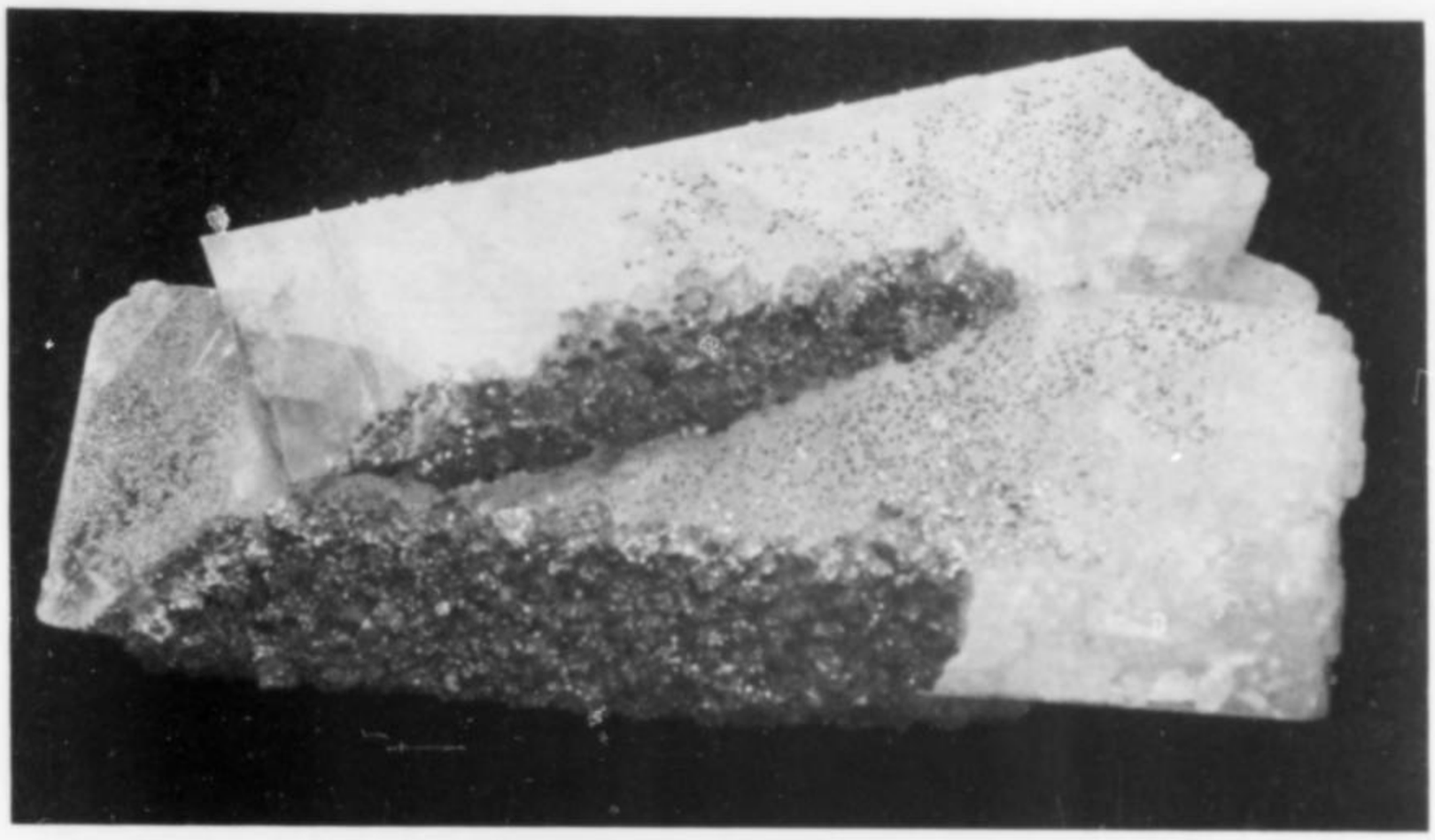

Figure 5. **Colorless, translucent barite crystals 11 cm long from the Niobec mine. The crystals are partially covered by a druse of pyrite and yellow fluorite crystals; collected April 1980. I. K. specimen and photo.**

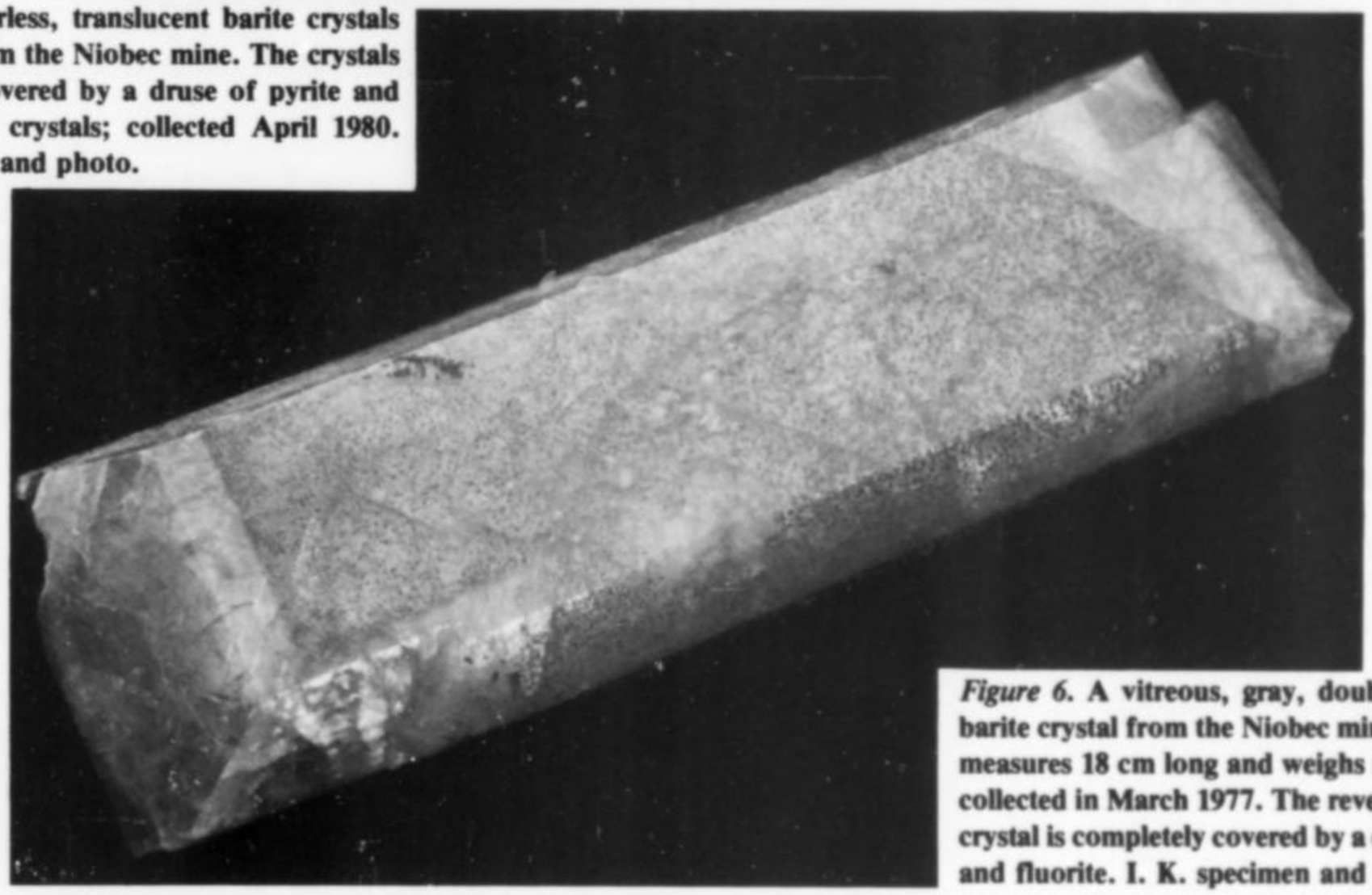

Figure 6. **A vitreous, gray, doubly terminated barite crystal from the Niobec mine. The crystal measures 18 cm long and weighs nearly 1½ kg; collected in March 1977. The reverse side of the crystal is completely covered by a druse of pyrite and fluorite. I. K. specimen and photo.**

They range up to 40 cm in length and up to 20 kg in weight. Most crystals are singly terminated but a few doubly terminated ones have been found. All are transparent and of a grayish color. About half the crystals are partly coated with a thin veneer of pyrite which, in turn, may be mantled by a thin overgrowth of barite. Calcite and fluorite are associated with, and later than, the barite. The calcite occurs as interesting flattened scalenohedrons from 2 cm to 10 cm in diameter, somewhat resembling the "poker chip" calcite from Coahuila, Mexico. Fluorite occurs sparingly as pale green cubes to 8 mm on an edge, on the calcite, and occasionally as pale yellow micro-crystals on the barite.

ACKNOWLEDGEMENTS

The recovery of these barite crystals and preservation of this particular facet of Canada's mineral heritage is due to the foresight and generosity of the Niobec mine officials for alerting members of the mineralogical community and for permitting collections to be made. Special thanks are due to Hal Steacy, of the Geological Survey of Canada, Ottawa, for suggestions regarding the manuscript; and to Piroska Bene for typing the several drafts.

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minerals of the Yates uranium mine pontiac county, quebec

by **Duane L. Leavitt**
Route 1, Box 140
Buckfield, Maine 04220

Allanite, thorianite, thorite, and a number of other well crystallized minerals occur at the Yates uranium mine, in mineralized skarns. The area is open to collecting.

INTRODUCTION

The Yates uranium mine is located in Huddersfield Township, Pontiac County, Quebec, Canada. Composed of several large open cuts, a 50-meter adit with at least two shafts which are now water-filled, and an undetermined number of prospect pits (upwards of 30), the area represents a classic example of the highly mineralized skarns of the Grenville marbles. Productive of a variety of quality mineral specimens for over 80 years, the location, which actually consists of four slightly different mineralized zones, is still a valuable and open collecting site today.

HISTORY

The deposits comprising the Yates mine were originally prospected in the very late 1800's. The Calumet Mica Company mined phlogopite and the dark purple fluorite from an open cut in the subsequently named Camp zone in the years 1906-1907. Sporadic mining for mica was continued by A. G. Martin of Ottawa, and J. Gratton. During the war years of 1943-1944, the Twin Valley Prospecting Syndicate mined 18 tons of fluorite from this deposit (Sabina, 1971). It was in this same fluorite that J. M. Yates first noticed the presence of radioactivity due primarily to the minerals thorite and thorianite in the early 1950's.

In 1953 the Yates Uranium Mines Incorporated was formed and a "permanent" camp was established in the northwestern corner of lot 19 Range IV. Core sampling was begun in 1954 with over 2500 m from 106 different holes logged in that year. In the fall of 1955 the camp was enlarged and the adit was driven, in addition to further core logging and radiometric surveying (Shaw, 1958). Work of this nature was continued for the next couple of years. The writer first visited the property in 1963 and found all previous operations overgrown and the mine company buildings being reclaimed by the bush. A variety of these structures were still standing but in a general state of disrepair; none now remain. Today access to the property may be gained through Niels Hanson who runs Deer Lake Park bordering the mine area.

GEOLOGY

In general the deposit (according to Shaw, 1958) is a series of skarns, that is, a series of coarse grained, crystalline rocks rich in calcium silicates. Such skarns are common occurrences in the Grenville subprovince of western Quebec, where this type of deposit is intimately associated with the highly folded intrusive rocks of the Precambrian Shield. Indeed, Wynne-Edwards *et al.* (1972) cite the presence of these carbonate-rich rocks as one of the definitive characteristics used to delineate the Grenville province.

The Yates deposit has four distinct zones of mineralization, three of which are very similar in their structural and mineralogical nature. A brief summary of the four zones based on Shaw (1958) provides the following.

The *Camp zone* (Lot 19 Range V), *Belanger zone* (lots 20 and 21, Range IV), and the *Belisle zone* (lot 18 Range IV) are lensoid, northwest trending bodies of variable width and generally shallow dip. The principal rock types are a variety of Precambrian skarns. Drill core analysis, based on personal observation and concurrent discussion with N. Hanson in 1974, shows an interlayering of subsurface skarns of similar nature with a variety of intrusives such as leucocratic granites, gneissic granites, syenites, and hybrid pyroxenite rocks. These rocks cut through the surface skarns in various places and in the southern end of the Camp zone partially surround the skarn. A variety of radioactive minerals—thorianite, uranothorite, uranophane, and allanite—are the attributable causes of the moderate to strong responses noted at all three skarns during radiometric surveying.

The fourth, dissimilar zone, is the *Matte zone* located in lots 16 and 17, Range V. Although still a radioactive skarn, it is much more coherent than the other three and has a different assemblage of accessory minerals. With a strike of N 25° W, a dip of 20° to 30° SW and an almost constant width of 17 m, the skarn of the Matte zone extends as a very uniform mass for almost 270 m, broken occasionally in its southern portion by an intrusive of hybrid pyroxenite that surrounds the exterior of the skarn. The skarn itself is

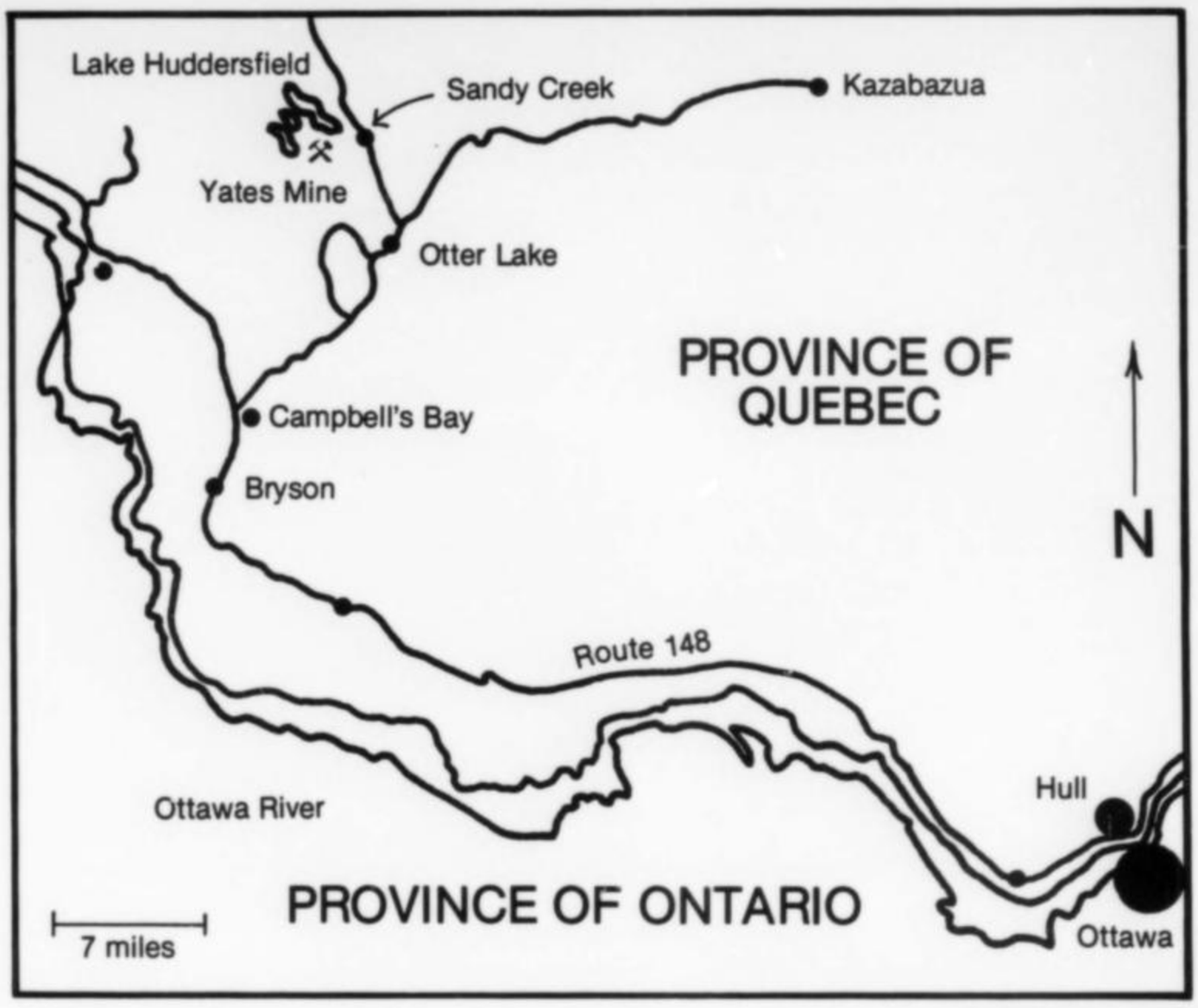

Figure 1. **Location of the Yates uranium mine in Quebec.**

Figure 2. **General geology of the Camp zone, Yates uranium mine (after Shaw, 1955).**

composed of large amounts of deep salmon pink calcite, interspersed with in some cases an almost equal volume of deep blue to near black fluorite. Imbedded indiscriminately in this mixture are crystals of red (rare) and green apatite and pyroxene (sometimes up to 50 percent of the rock) and lesser amounts of microcline, scapolite, allanite, uranothorite, and uranophane. Trace amounts of common sulfides also occur here.

MINERALOGY

The following descriptions cover those minerals which are of primary interest to the collector. Since the paragenesis of many of the major species was almost identical, specimens may contain well developed crystals of several species. References will be made in parentheses, in descending order, to the zones where the species are found in the best quality and greatest number.

Allanite (Camp zone, Matte zone)

Found in the bordering granites and pyroxenites, allanite occurs in thin blades and small, free-standing crystals. Averaging about 2 cm, specimens to 10 or 12 cm have been found. Associated with microline and dark, rounded quartz crystals, well developed allanite crystals have given Geiger probe readings of up to 0.1 mr/hr (milliroentgens per hour).

Calcite (all zones)

Calcite is ubiquitous throughout the entire deposit. It occurs as small, light colored crystals with rhombohedral faces and irregular sides, in minute vugs of massive material commonly associated with small quartz crystals. Much more striking is the massive material which ranges in color from a light pink to a deep salmon-pink all the way to a bright reddish orange. When calcite commonly forms a matrix for fluorapatite crystals, this combination is especially attractive in association with interbanded masses of pale blue to dark purple fluorite. This fluorite typically contains milky white scapolite crystals making for a truly unique matrix specimen. The calcite occurs in small masses up to boulders 2 or 3 m in diameter.

Diopside (Camp, Matte, Belisle)

While small amounts of other pyroxenes exist in this deposit, the primary species is diopside, which occurs abundantly in the Camp zone. Dark olive-green diopside crystals are most common at the contact between the skarn and the pyroxenite rocks, where clusters and drusy masses of crystals grade into granular, compact pyroxenite as one moves away from the contact. Relatively stubby crystals are formed of prisms and pinacoids in nearly equal development with totally flat and low, wedge-shaped terminations. Bevelling along the edges parallel to the *c* axis is common. While the average size of specimens from this zone is 1 cm to 5 cm in the longest direction, a large pocket 1.5 m in diameter was uncovered in a prospect pit due north of the Camp zone in 1969, which yielded superb single crystals to 15 cm in a single direction as well as excellent matrix clusters of slightly smaller crystals. As of 1978, while the main pocket is exhausted, small crystal-lined seams were still leading off into the massive pyroxenite indicating the possibility of

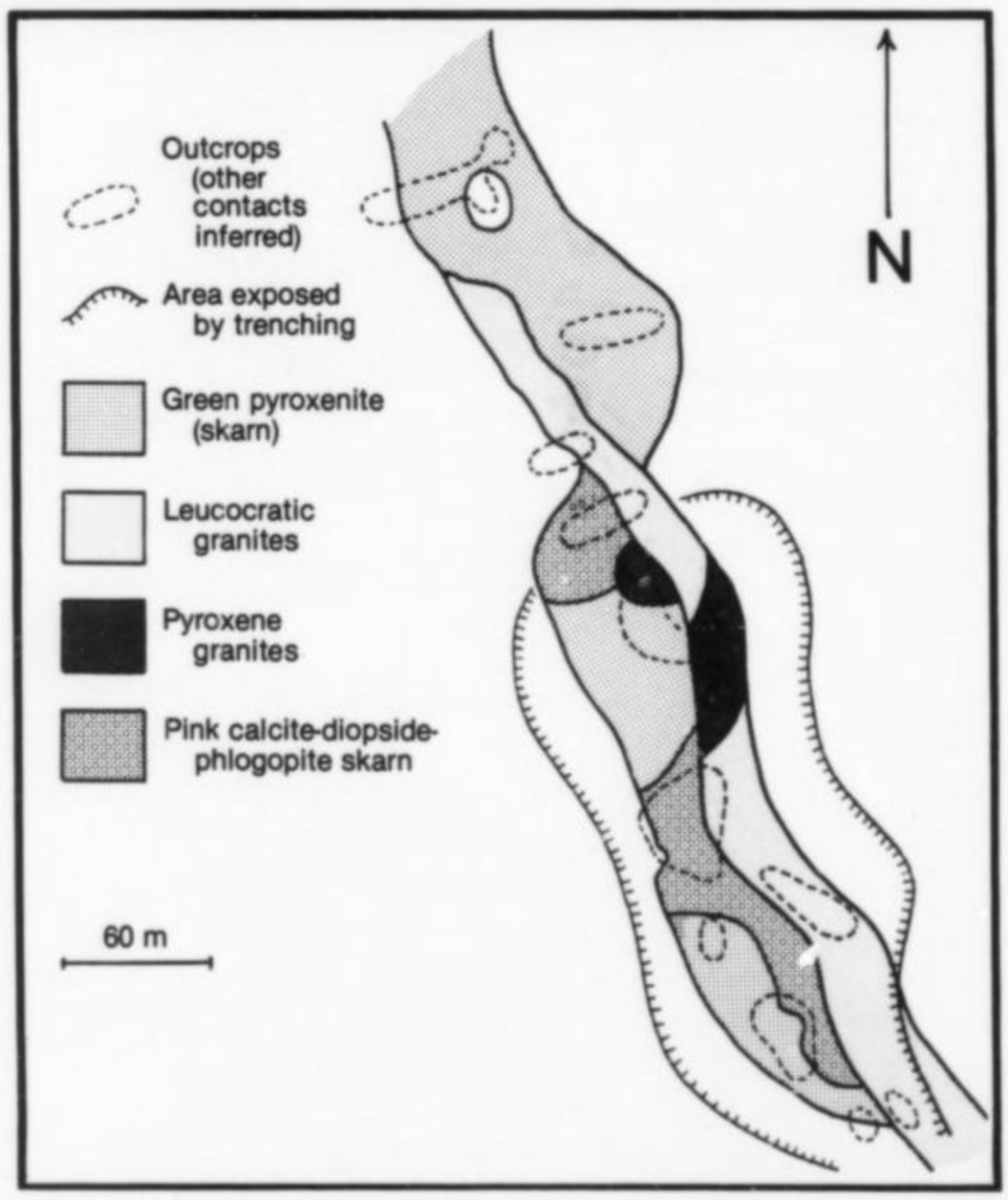

Figure 3. **Shiny to dull black allanite blades in matrix, 8 by 12 cm, from the Camp zone. Author's specimen and photo.**

Figure 4. **Dark olive-green diopside crystals to 4.5 cm each from the Camp zone. James C. Otis specimen; photo by the author.**

Figure 5. **Dark olive-green diopside crystals to 5 cm from a prospect pit due north of the Camp zone. Author's specimen and photo.**

other, yet undiscovered pockets. Diopside in the Belisle zone is similar to that of the Camp zone.

In the Matte zone, the diopside occurs mainly in the skarn with associated apatite and scapolite. Here the crystals are longer parallel to the *c* axis and are a much darker green to almost black. The crystals are generally small (2 to 3 cm) and have a characteristic rounded or melted look along the prism edges. Crystals from this zone also exhibit numerous cleavage planes parallel to the prism faces. Some specimens from this zone are coated with a black unknown mineral.

Fluorapatite (Matte, Camp, Belanger)

There are two distinct crystallizations of fluorapatite at this deposit. In the Matte zone, the apatite forms long hexagonal prisms of deep green, reddish brown and, rarely, red color. The terminations are first order dipyramids but are almost always rounded and distorted, while the actual prisms are quite sharp and distinct. Frozen in the calcite, the apatites are commonly doubly terminated and in some cases twins or even triplets are found. While the average crystal length is 3 to 7 cm, specimens to 18 cm are not uncommon, and at least three crystals to approximately 1 m have been found (though not removed intact). The crystals are always internally fractured and attempts to remove them from the calcite matrix are futile, the remains of such attempts litter the entire area of the Matte zone.

In the Belanger and northern Camp zones fluorapatite occurs as smaller, more equidimensional crystals of a pale lime-green color. From 2 cm down to microscopic grains the crystals occur in an almost tabular habit and are generally free of internal fractures. Many are translucent and when found in combination with a deep orange calcite often indicate the presence of thorianite. Careful

Figure 6. **Green fluorapatite crystal with traces of brown coloring, in pink calcite from the Matte zone. The crystal is 3 by 13 cm. Author's specimen and photo.**

Figure 7. **Green fluorapatite crystals to 7 cm in pink calcite from the Matte zone. Author's specimen and photo.**

etching away of the calcite with acid reveals small apatites that make outstanding miniature specimens.

Fluorite (All zones)

The fluorite of this deposit, like the calcite, is predominantly massive. The color ranges from a translucent pale blue and violet to a deep purple to almost black. The darker varieties qualify as the variety *antozonite,* that is, fluorite that has been structurally damaged by radiation and which gives off traces of free fluorine upon crushing or abrasion (Deer *et al.,* 1965). In the Matte zone the fluorite is especially dark and highly granular and is commonly the matrix for thorite. Masses of fluorite range in size from microscopic grains to many centimeters.

Figure 8. **Flesh-pink microcline crystal with blackish surface stain, from a prospect pit 50 m north of the Matte zone. The crystal measures 6.5 cm. Author's specimen and photo.**

Figure 9. **Off-white to flesh-pink microcline cyrstals to 3.5 cm, with minor apatite and diopside, from the Matte zone. Steven P. Jewell specimen; photo by the author.**

Microcline (Matte, Camp zones)

When found in the skarn itself, microcline forms intergrown masses of euhedral crystals with individuals up to 4 cm being common. They are off-white, lustrous and, when translucent, show evidence of internal fracturing. In the Matte zone they are found intimately intergrown with diopside and small apatite crystals. Microcline also occurs in the granites exposed by natural pits and prospect pits around the edges of both zones; in these areas the crystals are larger and better developed.

Molybdenite (Belanger, Camp zones)

While not extremely spectacular or common, occasional sharp hexagonal plates with very distinct edges occur in pale pink to white calcite. Molybdenite crystals to 1 cm have been recovered, usually associated with light amber-colored phlogopite. It is found also as distorted masses.

Figure 10. **Black phlogopite with copper-colored internal reflection, from the Camp zone. The mass is 21 cm across. Author's specimen and photo.**

Phlogopite (All zones)

Referred to in some of the literature as "amber mica," phlogopite was the mineral for which the deposit was originally worked. In the Matte zone it occurs as inconspicuous flakes and grains of dark brown to black color. In the southern end of the Camp zone and in the prospect pits to the South phlogopite occurs as intergrown masses of dark brown to almost black prismatic crystals which are typically elongated along the *c* axis. Also noticeable is a distinct warping of the crystals parallel to the *c* axis. When found in the calcite, the crystals often exhibit a cigar-like configuration. Since the skarn was most easily worked, the majority of good phlogopite specimens remaining are in the pyroxenite rocks in pockets intimately associated with diopside crystals. Specimens range from 2 cm to 35 cm but the average is around 7 cm in the longest direction, with pocket sections of intergrown masses of crystals up to 20 kilograms. In the extreme northern end of the Camp zone, unwarped, clear brown crystals to 1 cm occur in an orange calcite associated with euhedral apatite and small thorianite crystals.

Quartz (Matte)

Quartz occurs in the Matte zone either as druses of sharp terminations with small calcite crystals in the paler skarns or as dark, rounded-edged crystals associated with microcline and allanite in the granites which border the skarn. Here it also occurs as irregular blebby masses. In both cases the specimens are not at all striking.

Scapolite (Camp, Matte zones)

In the Camp zone scapolite occurs as well terminated crystals associated with fluorite and pyroxene. Off-white in color, and with

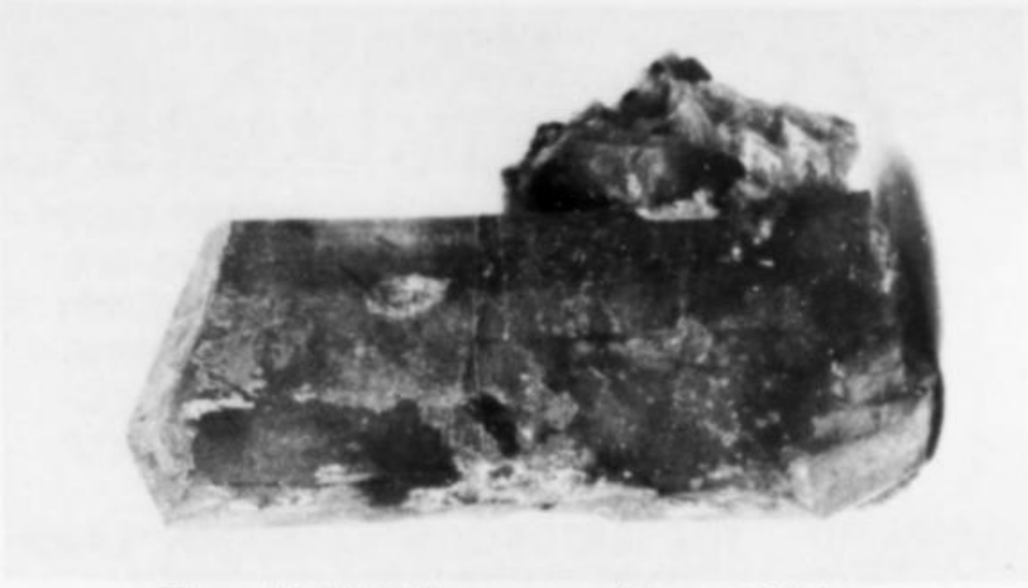

Figure 11. **Whitish gray scapolite crystal 7.3 cm tall, from the Camp zone. Steven P. Jewell specimen; photo by the author.**

Figure 12. **Lustrous black thorianite crystals about 4 mm in size, from the Belanger zone. The left crystal, twinned, is on brown apatite; collection of Mr. and Mrs. Larry Turcotte. The right crystal, on green apatite, is from the author's collection. Photos by Fred Graves.**

a waxy luster, crystals to 7 cm and groups of crystals to 15 cm are the average, but large single crystals to 20 cm have been recovered. The old dumps of the original mica workings tend to be especially rich in specimens as early miners thought the scapolite an inferior grade of feldspar and discarded it.

The Matte zone scapolite occurs as clusters of smaller, 1 to 3-cm, euhedral crystals with a more glassy luster. In translucent specimens one almost always finds evidences of internal partings and cleavages. In this zone it is most commonly associated with pyroxene and apatite, and small flakes of the phlogopite; commonly the entire specimen is coated with rusty traces of sulfides.

Thorite (Matte, Belisle, Camp)

Thorite is almost always found in small, less than 5-mm, crystals in the darker varieties of fluorite. While the crystals are tetragonal in nature, massive intergrowths of many small crystals give specimens the appearance of a small pile of rice grains. The reddish brown specimens are not visually striking but many will give Geiger probe readings of 0.4 to 0.5 mr/hr. Because of their physical appearance, small groups of thorite crystals are often passed over as being poor examples of small apatite, even though they are much less lustrous than apatite.

Thorianite (Belanger, Matte, and Camp zones)

Much of the thorianite in this deposit consists of small black grains and as such is very apt to go unnoticed. In the darker calcite however, it commonly forms superb, lustrous, black crystals to 5 mm. Almost all of these crystals are interpenetration twins (spinel law) on {111}. Again selective etching away of the calcite produces truly outstanding specimens. This material is highly radioactive, with Geiger probe readings much in excess of 0.5 mr/hr being recorded and is probably responsible for some of the company assay readings of up to 0.19 percent U_3O_8 per ton which were reported (Shaw, 1958). Since much of the darker (red orange) calcite is also intimately associated with euhedral apatite, it is not uncommon to find specimens of thorianite crystals perched on apatite crystals.

Titanite (Camp zone)

Titanite occurs as small, 0.5 cm to 1 cm, black, prismatic crystals commonly showing a slight to moderate "melted" appearance of the thinner edges. Its occurrence seems to be limited to the primary skarn rock type of this particular zone. Specimens are not particularly abundant.

Tremolite (Camp, Belanger zones)

Light green to pale, light blue, stubby crystals of tremolite occur near the contact of pyroxenite rocks and the coarsely crystalline calcite. The crystals range up to 3.5 cm in length and all of them exhibit an etched or partially dissolved nature. Specimens are not outstanding, and appear to be fragile.

DISCUSSION

The variability of the rock types associated with the Yates deposit and the tendency of these rocks to resemble similar species of rock normally devoid of radioactive minerals leads to the suggestion that, at least in part, these rocks were derived from previously existing rocks. Wynne-Edwards *et al.* (1972) state that the marbles and other metamorphosed sedimentary rocks of the Grenville series are actually a deep section of an orogenic belt which has been eroded to such a level that the reworked basement complex is well exposed. Thus where limestones existed skarns were formed by metasomatizing fluids rich in silicates as well as elements such as fluorine, uranium and thorium. It is not known if the metamorphism and intrusions were concurrent events or if the calcareous muds of the sedimentary series were first metamorphosed and then, as a reactive host rock, subsequently intruded and enriched at a slightly later time. Radiometric dating places the last metamorphic event as happening in middle Proterozoic time between 900 and 1,100 million years ago.

ACKNOWLEDGMENTS

The author would like to gratefully extend thanks to the following people: Fred Graves for photographic assistance, Mr. and Mrs. S. P. Jewell, James C. Otis, and Mr. and Mrs. Larry Turcotte for the loan of specimens, Neils Hanson for access to logged drill cores, and to John Creasy of Bates College for critical review.

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Shavano Peak... a new Mt. Antero?

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Figure 2. **Photo of Shavano Peak from the south. The arrow indicates the location of miarolitic cavities in the Mt. Antero granite stock.**

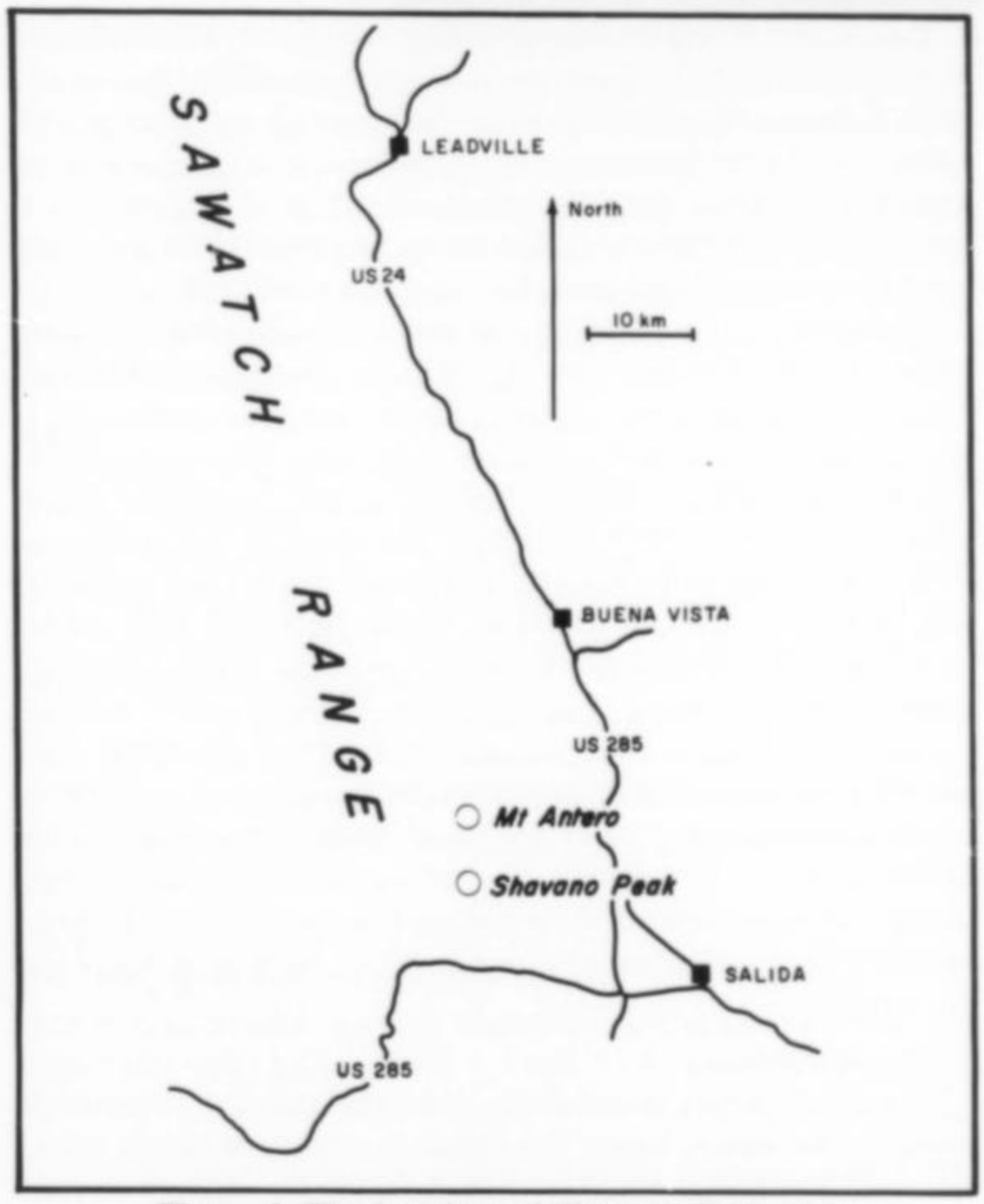

Figure 1. **The location of Shavano Peak and Mt. Antero in the Sawatch Range of central Colorado (all illustrations and photos by the author).**

The large, well known Mt. Antero-Mt. White locality in Colorado is situated within a stock of Mt. Antero granite. Outstanding specimens of beryl (aquamarine), phenakite, and bertrandite, as well as other species, have been found in small pegmatites having miarolitic cavities, and in veins related to the pegmatites. A second, little known stock of Mt. Antero granite is exposed on Shavano Peak, 3 miles south of Mt. Antero (see Fig. 1).

In August of 1977, Brian Dale and I began a reconaissance of Shavano Peak by checking the ridge southwest of McCoy Creek (U.S.G.S., 1940). At the crest of the ridge (about 11,300 feet in elevation) four pegmatites were found near a conspicuous granite tower about 100 feet high. Three of the pegmatites contained miarolitic cavities.

We spent the next day approaching the east side of the mountain by way of Blank Gulch (U.S.G.S., 1956). Blank Gulch terminates in a large cirque. The course grained Mt. Antero granite we saw as float along the trail sometimes approached graphic texture, but we saw no euhedral crystals of pegmatite minerals. Bad weather and the difficulties of high altitude forced us to quit before we reached the granite dikes exposed in the headwall of the cirque.

On a later, solo expedition, I climbed the south slopes of Shavano Peak (Fig. 2). At about 12,250 feet, east of a prominent *couloir* (gully), the float looked very promising. Smoky quartz crystals were common in the talus, and the float patterns were typical of pegmatite pockets. Tracing such float uphill commonly led to a pocket which had been spilling its contents onto the surface of the ground. In comparison to the picked over slopes of Mt. Antero, this was a collector's paradise.

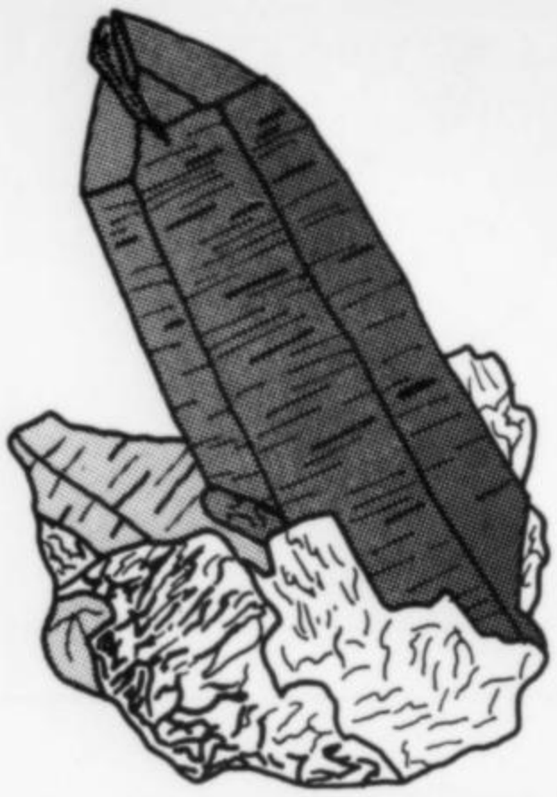

Figure 3. **Smoky quartz on potassium feldspar with minor plagioclase. The major crystal is 2.7 inches long; Truebe collection.**

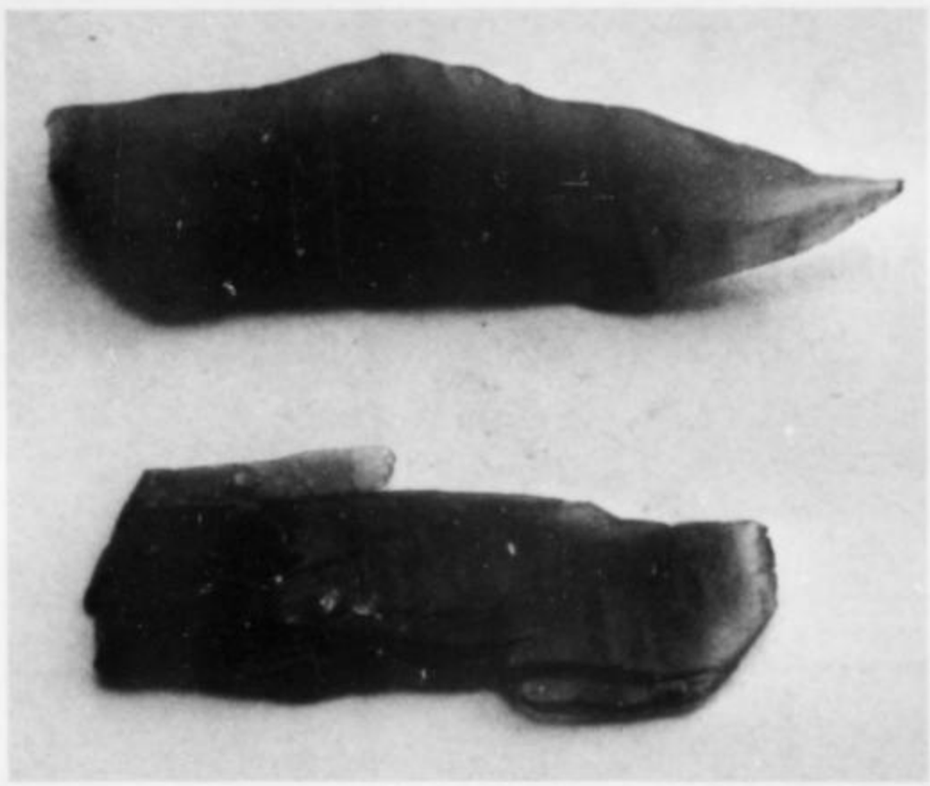

Figure 4. **Bizarre habits of healed quartz fragments. Both specimens about 2 inches long; Truebe collection.**

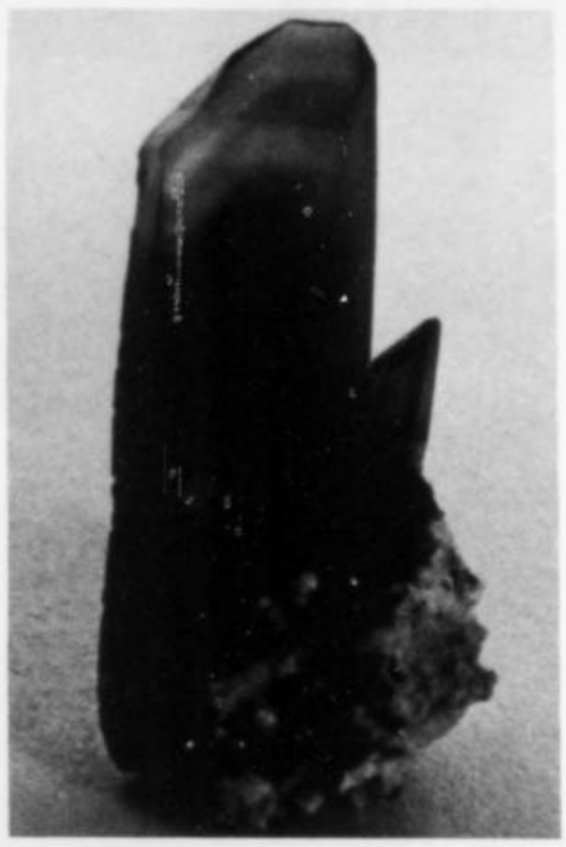

Figure 5. **Zoned crystal of second generation quartz about 2 inches long; Truebe collection.**

I dug carefully into one of the open pockets, selecting quartz and microcline specimens to be packed out. Amid the debris in the center of the pocket, one chunk caught my eye. I rubbed the dirt from it and held it up to the light. The translucent blue-green caused some excitement—an untouched locality for aquamarine! After a while, I noticed it was a crude octahedron. A hardness test confirmed my fears—fluorite!

GEOLOGY

Shavano Peak is the southernmost peak in the main part of the Sawatch Range (this part of the Sawatch Range is sometimes called the Collegiate Range), where peaks commonly reach 14,000 feet. The core of the range is formed of pre-Paleozoic metamorphic rocks and Tertiary intrusives (Tweto, Ogden, *et al.,* 1976). Dings and Robinson (1957, plate 1) show 15 intrusive rock types of Tertiary age in this part of the Sawatch range. The Mt. Princeton quartz monzonite batholith is the largest.

The Mt. Antero granite forms a stock within the Mt. Princeton batholith. The intrusive on Mt. Antero is about 3 miles long in a north-south direction and about 2½ miles wide. A smaller stock forms the southern shoulder of Shavano Peak. Its dimensions are about 5000 feet, east to west, and 1500 feet, north to south.[1]

The granite is conspicuously white to light gray in outcrop and is composed mainly of feldspar and quartz. The feldspars are predominantly orthoclase and albite; and the quartz occurs as rounded, embayed grains, in clusters of grains, and as micrographic intergrowths with orthoclase. Biotite, apatite, zircon and titanite are found as accessory minerals.

The Mt. Antero granite commonly contains miarolitic cavities. These cavities and related, late stage veins are the source of fine specimens of beryl, phenakite, bertrandite, topaz, and examples of 15 other species. All the renowned specimens of these minerals have come from the northern stock.

MINERALS

To date, three pockets have been opened in the Shavano Peak area, and ten species have been noted. Smoky quartz is probably the only mineral of interest to collectors, but many of these crystals have a surface etching which renders them unattractive. The absence of beryllium-bearing species is disappointing.[2]

Quartz

Quartz is common and has been found in all the pockets opened thus far. One small crystal was found west of the *couloir* (Fig. 2), but its source was not located. The quartz displays two habits; black, smoky, first generation crystals, and gray to brown, second generation crystals.

The quartz found in the miarolitic cavities on Mt. Antero is typically black; the Shavano material is the same (Fig. 3). Formed early to late in the pegmatite cycle, the quartz is found as graphic intergrowths with feldspars in cavity walls, and as overgrowths on potassium feldspar and plagioclase crystals in the cavities. It is generally internally fractured and commonly broken. Some crystals are crudely tapered and some have multiple terminations.

The second generation quartz crystals display a variety of bizarre habits (Fig. 4). Typically, the crystal faces are irregular, but their habits could be described as flakes, blades, points or needles. Crystals can have 2, 3, 4, or 6 prominent prism faces. The best explanation for the unusual habits is that the second generation quartz grew on fragments of first generation quartz which provided nuclei for a short period of later quartz deposition. The growth continued long enough to smooth the faces of the fragments with crystal faces, but not long enough to obscure the shape of the underlying fragment. In one pocket, fracturing was relatively minor, producing tapered and multiply terminated habits of first generation crystals. In another pocket it appears that crystals were reduced to sand-sized fragments. These healed to produce a pocket full of needles of second generation quartz about 0.4 inch in length. Some of the secondary crystals show zoning from a dark core to paler borders (Fig. 5). Crystals with similar habits have been found on Mt. Antero.

Potassium Feldspar

Potassium feldspar is common in the pegmatite pockets, and is probably microcline. Rarely it is found in crystals of simple habit,

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[1] Sinkankas (1959, page 84) notes a report of aquamarine on the south slopes of Mt. Princeton, 5 miles north of Mt. Antero. Examination of the literature, and the debris in *couloirs* draining the south side of Mt. Princeton, gave no indication of Mt. Antero granite in the area.

[2] Specimens from the Shavano Peak area have been marketed by Alpine Exploration. They were labeled as coming from area L, Mt. Antero, to maintain secrecy of the Shavano Peak locality.

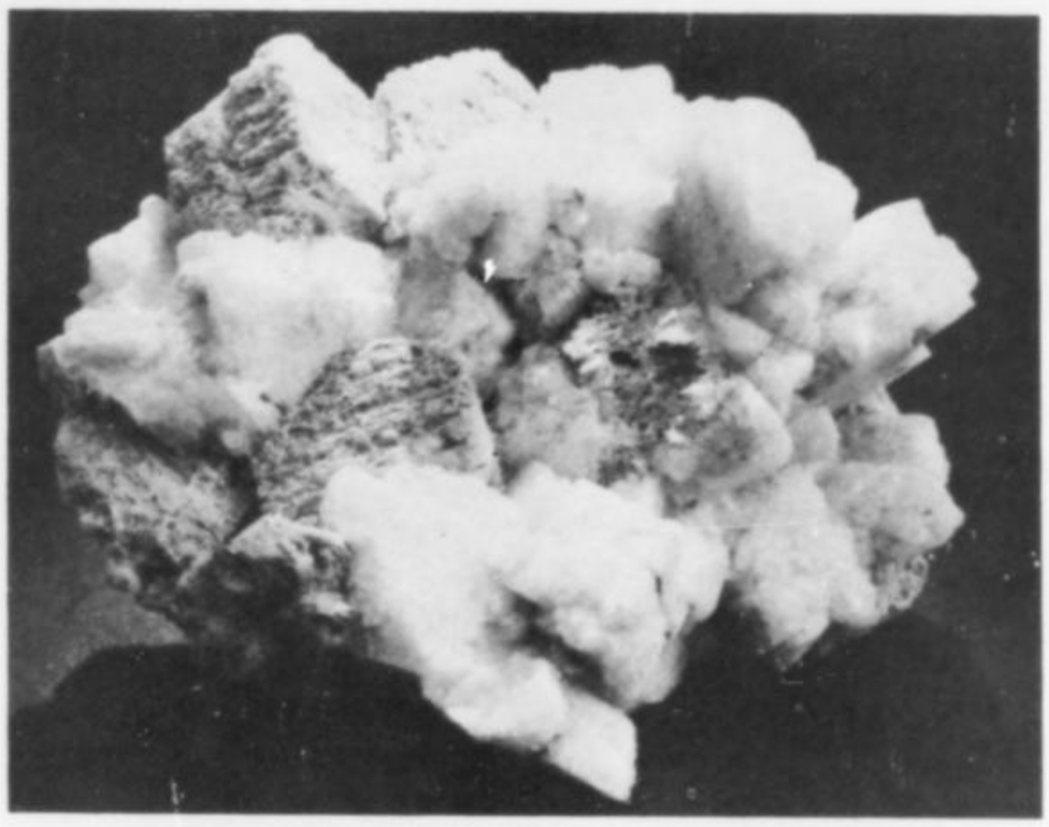

Figure 6. **Etched, Carlsbad twinned potassium feldspars, and plagioclase. Specimen 2.4 inches wide; Truebe collection.**

more commonly as Carlsbad twins (Fig. 6), and occasionally as Baveno twins (Fig. 7). The feldspar commonly shows exsolution lamellae and these have usually been etched away by corrosive, late-stage fluids.

Plagioclase

Plagioclase feldspar, probably albite, is found intergrown with the potassium feldspar and quartz (Fig. 6). It is a translucent white, and commonly forms cockscomb aggregates of platy crystals.

Fluorite

Two specimens of fluorite were recovered from one pocket at the locality. Both are large, simple octahedra, with considerable internal cleaving. The specimens have a suggestion of color zoning, from pale green in the center to colorless rims. Both specimens show the effects of weathering.

Fluorite from Mt. Antero is also octahedral in habit, but crystals are usually distorted to form disc-like, or elongated crystals. The color, deep purple, is also different than the Shavano material. Switzer (1939, page 805) notes that light green fluorite may form a thin coating on purple crystals.

Micas

Muscovite is found as equant, hexagonal prisms about 0.4 inch in size, embedded in "frothy" aggregates of tiny plagioclase crystals. Minute crystals of "sericite," probably a late-stage alteration product, are found in the pocket debris and coating feldspars. Chlorite-group micas are found coating feldspars and quartz in pockets, but they are not common.

Iron Oxides

Specular hematite, usually coated with dull, black goethite (?), was found in one pocket. Rare "limonite" noted at the locality is probably an oxidation product of hematite.

Tabular unidentified

A grey-black mineral with sub-metallic luster was observed, intergrown with orthoclase and plagioclase. It is generally in thin (less than 0.004 inch) plates (about 0.4 inch in diameter) and blades. It has a grey streak and is non-magnetic. Identification is pending.

CLOSING REMARKS

The small stock of Mt. Antero granite on Shavano Peak is in many ways similar to the larger stock on Mt. Antero. The mineralogies of the miarolitic cavities are almost the same at both localities,

Figure 7. **Baveno twinned potassium feldspar, viewed parallel to composition plane (021). Specimen 2.4 inches long; Truebe collection.**

and the presence of fractured, healed quartz fragments at both locations suggests similar emplacement histories. But the absence of beryllium-bearing minerals makes the Shavano Peak locality of less interest to collectors. The area would provide a good site for research on the nature and distribution of the miarolitic cavities in the granite. The results of this research could be applied to further understanding of localities like Mt. Antero and Mt. White.

Reference specimens of the Shavano Peak species have been sent to the Denver Museum of Natural History and to the U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C.

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Ogdensburgite

a new calcium-zinc-ferric iron arsenate mineral from Sterling Hill, New Jersey

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ABSTRACT

Ogdensburgite, ideally $Ca_3ZnFe_6^{+3}(AsO_4)_5(OH)_{11} \cdot 5H_2O$, is a new mineral from the Sterling Hill mine in Ogdensburg, New Jersey. The strongest lines in the X-ray powder diffraction pattern (*d* in Å, I/Io) are: 14.8 *100;* 2.656 *30;* 4.52 *30;* 2.734 *25;* 2.793 *25*. Chemical analysis by electron microprobe yielded Fe_2O_3 = 31.3, Al_2O_3 = 1.0, SiO_2 = 0.5, MgO = 0.5, CaO = 10.8, ZnO = 3.1, MnO = 2.2, As_2O_5 = 38.2 percent, together with 12.4 percent H_2O by difference.

Ogdensburgite occurs as dark reddish brown platelets associated with secondary arsenates and several pitticite-like compounds. Ogdensburgite is biaxial (+) with refractive indices α = 1.765, β = 1.775 and γ = 1.800 (all $\pm$0.005). The density is 2.92 g/cm³; the hardness (Mohs) is approximately 2; the streak is bright reddish orange. Ogdensburgite was locally abundant. The name is for the locality.

INTRODUCTION

In 1972 and 1973, some suites of secondary arsenate minerals were encountered in the Sterling Hill mine, Ogdensburg, Sussex County, New Jersey. Many of the rare arsenates known only from localities in Sweden, such as synadelphite, magnussonite, akrochordite, retzian, manganese-hoernesite and allactite, have been found at the Sterling Hill mine in recent years, and more species may be forthcoming. The assemblage described here contains three compounds which were referred to locally as pitticite. Two of these, one waxy in texture and the other as remnant laths after parasymplesite, are very likely related to pitticite or yukonite and are still under study. A third one, possessing a perfect cleavage and micaceous appearance, is a new species, here named ogdensburgite after the town of Ogdensburg.

The new mineral and the name were approved by the Commission on New Minerals and Mineral Names, IMA. Holotype material is preserved in the Smithsonian Institution under catalog # NMNH 146880. Cotype samples are preserved in the Spex-Gerstmann mineral collection in the town of Franklin, New Jersey.

PHYSICAL and OPTICAL PROPERTIES

Ogdensburgite occurs as thin encrustations of dark brownish red platelets, arranged with the direction of cleavage normal to the surface of the specimens. On all samples examined, the crusts are exceedingly (0.1 mm) thin, in some cases forming botryoidal knobs or protuberances. In hand-specimen ogdensburgite resembles dark red velvet. This dark surface color is likely the result of oxidation; the true color is a very bright reddish orange. The streak is light orange; the luster is resinous on cleavage surfaces; the hardness (Mohs) is approximately 2; the density, determined with heavy liquid techniques, is 2.92 g/cm³ (meas.). There is one perfect cleavage, easily developed but with undetermined orientation.

Optically, ogdensburgite is biaxial (+) with 2V approximately 25°. The refractive indices are α = 1.765, β = 1.775 and γ = 1.800 (all $\pm$ 0.005). Pleochroism is moderate, absorption X < Y = Z. Extinctions are undulatory; β and γ are in the plane of the cleavage. Ogdensburgite is not fluorescent under ultraviolet radiation.

CHEMISTRY

Ogdensburgite was chemically analyzed using an ARL-SEMQ electron microprobe utilizing an operating voltage of 15 kV and a beam current of 0.15 μA. Two standard-sets were used in the analysis: analysis #1 was made with olivenite (As), zincite (Zn), hornblende (Ca,Fe,Mg,Al Si) and manganite (Mn); analysis #2 was made with the same standards except Mazapil arseniosiderite (using the composition of Moore and Araki, 1977) for Fe, Ca and As. The data were corrected using a modified version of the *MAGIC-4* program. There was too little material for the direct determination of water. These analyses are presented in Table 2 and their average yields the empirical formula:

$$(Ca_{2.81}Mn_{0.45}Zn_{0.56}Mg_{0.18})_{\Sigma 4.00}(Fe_{5.73}^{+3}Al_{0.29})_{\Sigma 6.02}$$
$$(As_{4.86}Si_{0.12})_{\Sigma 4.98}O_{19.92}(OH)_{11.00} \cdot 4.64H_2O$$

or, ideally, $Ca_4Fe_6^{+3}(AsO_4)_5(OH)_{11} \cdot 5H_2O$. Ogdensburgite gave a strong reaction for Fe^{+3} by microchemical test and a very weak one

Table 1. Microprobe analyses of ogdensburgite.

	Analysis #1	Analysis #2	Average	Theory*
SiO_2	0.5	0.5	0.5	
Al_2O_3	1.0	1.0	1.0	
Fe_2O_3	30.1	32.5	31.3	32.10
MgO	0.5	0.5	0.5	
CaO	10.5	11.1	10.8	11.27
ZnO	3.1	3.1	3.1	5.45
MnO	2.1	2.2	2.2	
As_2O_5	39.2	37.3	38.2	38.50
H_2O			12.4**	12.68
Total			100.0	100.00

Accuracy of data: $\pm$3% of the amount present.
*Theory for $Ca_3ZnFe_6^{+3}(AsO_4)_5(OH)_{11} \cdot 5H_2O$.
**Water by difference.

for Fe^{+2}. Accordingly, all the iron was calculated as ferric. The formula must be considered tentative in the absence of the direct determination of water, or a crystal structure determination.

Ionic radius considerations and the geochemical environment at Sterling Hill suggest that zinc may be essential to ogdensburgite. An alternative formula, here preferred, would assume limited substitution of manganese for calcium and yield:

$$(Ca_{2.81}Mn_{0.19})_{\Sigma 3.00}(Zn_{0.56}Mg_{0.18}Mn_{0.26})_{\Sigma 1.00}$$
$$(Fe^{+3}_{5.73}Al_{0.29})_{\Sigma 6.02}(As_{4.86}Si_{0.12})_{\Sigma 4.98}O_{19.92}(OH)_{11.00}\cdot 4.64H_2O$$

or ideally, $\mathbf{Ca_3ZnFe^{+3}_6(AsO_4)_5(OH)_{11}\cdot 5H_2O}$.

Table 2. X-ray powder diffraction data for ogdensburgite.

*d*Å	I/Io	*d*Å	I/Io
14.8	100	1.996	2
7.47	20	1.975	2
5.70	20	1.895	2
5.32	20	1.884	2
4.52	30	1.852	2
3.731	15	1.838	2
3.284	20	1.770	5
3.198	10	1.748	5
3.132	10	1.639	15
2.998	10	1.629	15
2.836	2	1.563	5
2.793	25	1.513	2
2.734	25	1.498	2
2.656	30	1.485	5
2.488	15	1.437	2b
2.475	15	1.419	2b
2.287	5	1.400	2b
2.270	5	1.368	5
2.222	2	1.360	5
2.149	5	1.332	2
2.134	2		

Data obtained with a polycrystalline sample in a Gandolfi 114.6 mm camera utilizing nickel-filtered CuKα X-radiation, and NBS silicon as an internal standard. b = broad line.

Ogdensburgite is chemically homogeneous and analysis of a cotype specimen (presumably from the same occurrence) indicated the composition is relatively invariant for the two samples.

X-RAY POWDER DIFFRACTION DATA

No single-crystals of ogdensburgite were found. Those examined were of mosaic texture and unsuitable for single-crystal studies. X-ray powder diffraction data for ogdensburgite were obtained using a polycrystalline sample in a 114.6 mm diameter Gandolfi camera, employing NBS silicon as an internal standard. The powder data are presented in Table 2.

OCCURRENCE

Ogdensburgite was found in 1972 in the Sterling Hill mine, Ogdensburg, Sussex County, New Jersey. The specimens were reported to have come from the 960 stope at the 340 level of the mine. Ogdensburgite is associated with parasymplesite, koettigite, a mineral similar to pharmacosiderite, and several ill-defined ferric iron arsenates possibly related to pitticite or yukonite. These minerals encrust a low-grade willemite-franklinite-calcite-sphalerite ore which has been severely weathered. Ogdensburgite, together with the associated koettigite, may have been locally abundant, and at least a dozen specimens are estimated to have been preserved in public and private collections.

ACKNOWLEDGMENTS

The author is indebted to Ewald Gerstmann, John Kolic and George Pigeon for providing specimens of ogdensburgite for study. I thank Donald Peacor for his confirmation of the lack of single crystals. This study was supported, in part, by a grant from Mrs. E. Hadley Stuart, Jr.

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Sjögrenite on Pyroaurite
from Sterling Hill, New Jersey

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Pyroaurite crystals have been found in the Sterling Hill mine in years past, and the aluminum analog, hydrotalcite, was found on old specimens from the Franklin mine several years ago.

A new occurrence of pyroaurite was found in the spring of 1981 by John Kolic, a miner in the Sterling Hill mine. The specimens were found in the 1020 stope on the 1300 foot level. The vein assemblage described here coats willemite-franklinite ore containing abundant calcite. The secondary minerals on the surface of the specimen are tetrahedral crystals (2 mm) of light yellowish green sphalerite, white clumps of chlorophoenicite, light brown and dark green clumps of barite crystals, and small spherules of unidentified clays. The last minerals to form are acicular crystals of secondary willemite and pyroaurite. The pyroaurite crystals are white, opaque, with pearly luster, and occur as "floaters" perched among willemite crystals (Fig. 1).

Bright orange platy crystals were observed epitaxially overgrown on the white pyroaurite and were identified on the basis of X-ray powder diffraction and microchemical tests as sjögrenite, $Mg_6Fe_2^{+3}(CO_3)(OH)_{16}\cdot 4H_2O$, a dimorph of pyroaurite. Sjögrenite crystals encrust etched and slightly decomposed pyroaurite crystals (Figs. 2 and 3) and are quite sharp and euhedral, in contrast to the underlying corroded pyroaurite. The congruency of symmetry is obvious from the photographs. Sjögrenite crystals are formed of stepped, plate-like units which exceed the thickness of the underlying pyroaurite. Some smaller crystals, shown in Figure 4, were too small for testing, but appear to be composed of epitaxially oriented sjögrenite crystals on uncorroded pyroaurite.

Parallel intergrowths of sjögrenite and pyroaurite from Långban, Sweden, were discussed by Frondel (1941). The minerals are prone to intergrowths because they are stacking polymorphs; sjögrenite is hexagonal (a = 3.113, c = 15.61 Å) and pyroaurite is rhombohedral (a = 3.1094, c = 23.4117 Å) (Allmann, 1968). Hence, it is not surprising that the two form oriented intergrowths. Indeed, Allmann (1968) suggested that one might expect mixed-layer structures to form, but found none during his determination of the crystal structure of pyroaurite. Instead, he found intergrowths formed of an inner zone of sjögrenite and outer layers of pyroaurite. He attributed this pattern of intergrowth to decreasing temperature during deposition of the two minerals. Certainly in polymorphic transformations the high-temperature form commonly has the higher symmetry.

In the present case, however, the relationship is sjögrenite on corroded pyroaurite, which would require rising temperature according to Allmann's model. There might be other chemical factors such as pH which could play a part in determining which polymorph is deposited, as is the case for calcite and aragonite in low temperature environments.

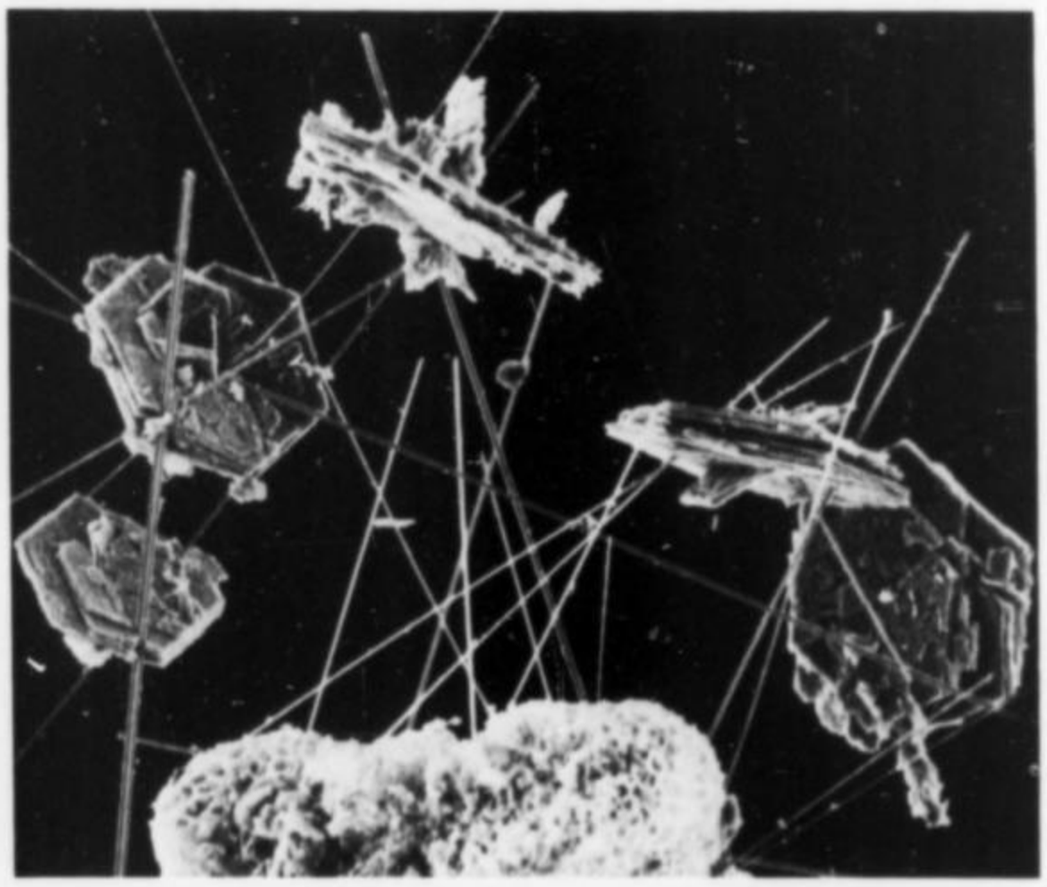

Figure 1. **Pyroaurite crystals on willemite crystals from Sterling Hill. NMNH #148583 (SEM photomicrograph at 250x).**

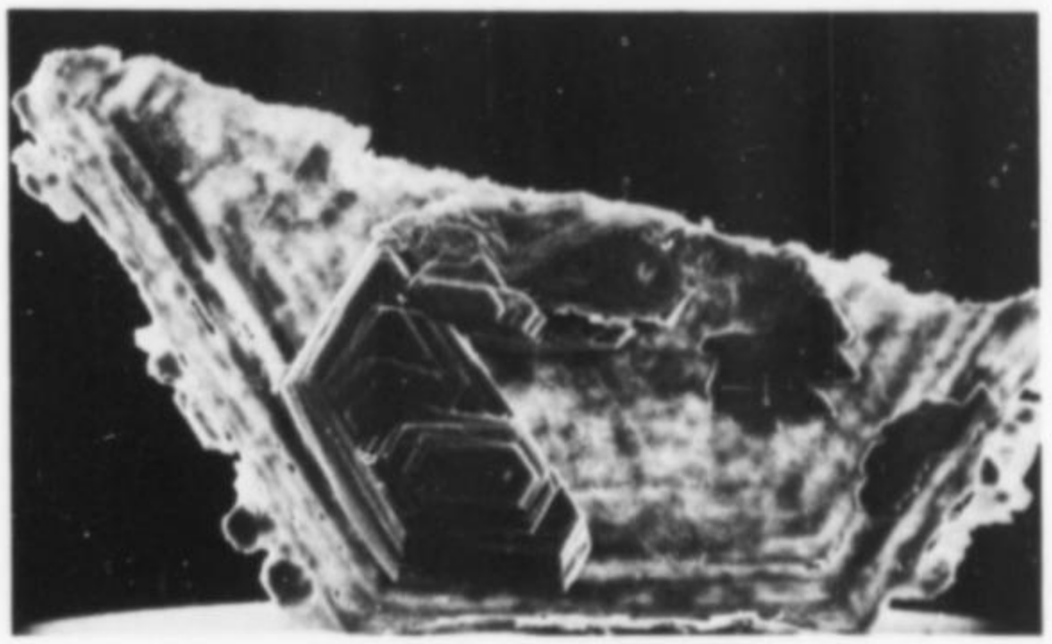

Figure 2. **Sjögrenite crystals epitaxially overgrown on corroded pyroaurite from Sterling Hill. NMNH #148583 (SEM photomicrograph at 175x).**

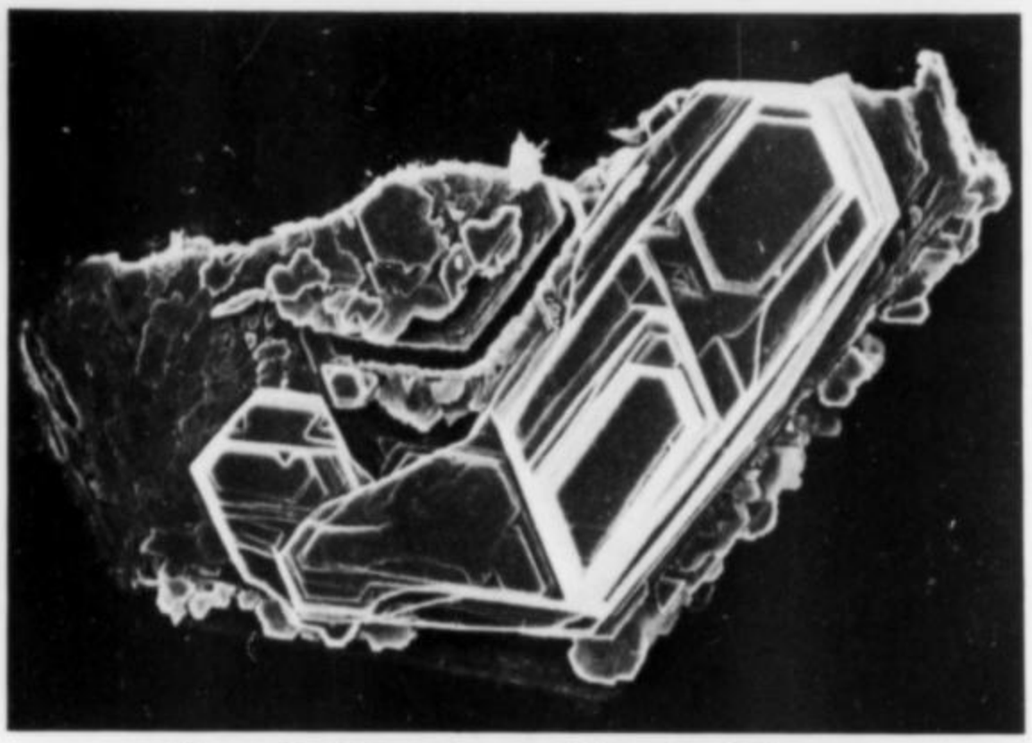

Figure 3. **Sjögrenite crystals epitaxially overgrown on corroded pyroaurite from Sterling Hill. NMNH #148583 (SEM photomicrograph at 170x).**

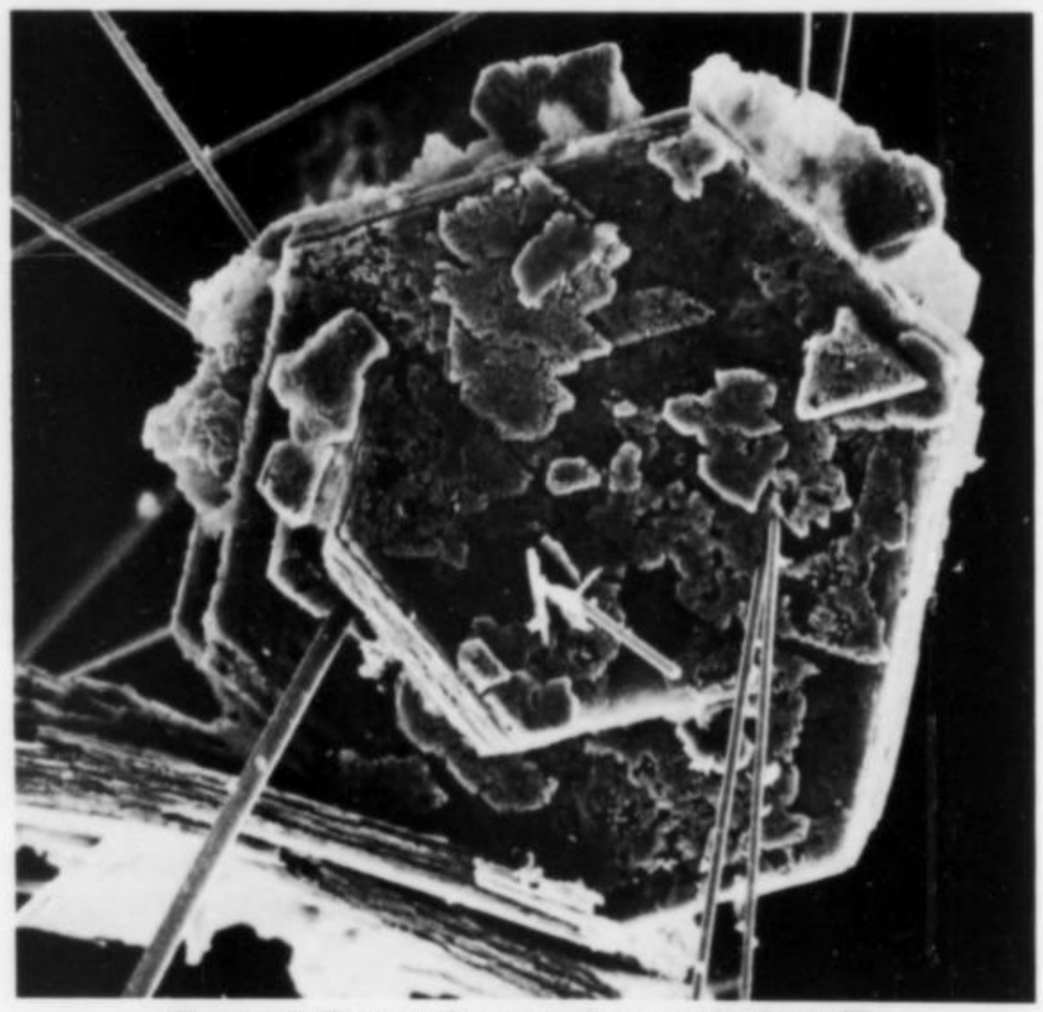

Figure 4. **Pyroaurite crystals on acicular willemite with epitaxially overgrown crystals likely to be sjögrenite. NMNH #148583 (SEM photomicrograph at 370x).**

ACKNOWLEDGMENTS

The authors are indebted to John Kolic for bringing these crystals to our attention, and stimulating our interest in the assemblage. This project was supported, in part, by a grant from Mrs. E. Hadley Stuart, Jr.

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Holdenite

from Sterling Hill and new chemical data

by **Pete J. Dunn**
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PREVIOUS WORK

Holdenite was first described by Palache and Shannon (1927) as a new manganese-zinc arsenate from Franklin, Sussex County, New Jersey. The original analysis was of admittedly impure material and the authors discounted the silica content as being due to admixed willemite. Holdenite was later re-investigated by Prewitt-Hopkins (1949) but the data she presented were corrected by Moore and Araki (1977) who solved the crystal structure, provided the new formula, $Mn_6Zn_3(OH)_8(AsO_4)_2(SiO_4)$, and gave new X-ray powder data. They proved that the silica reported by Palache and Shannon (1927) was indeed essential to holdenite, but questioned parts of the original analysis. To date there exist no good chemical analyses of holdenite and the present study was initiated to obtain such data and to describe new parageneses of holdenite.

FRANKLIN HOLDENITE

I have visually examined the type specimens in both the Smithsonian collection and the Harvard University collection. There is little to add to the original description except to state that they both have kolicite (Dunn *et al.,* 1979) as an associated mineral, in very small quantities. This kolicite appears to have formed subsequent to or at the same time as the holdenite. Kolicite was thus found in the Franklin mine some 50 years ago but its characterization awaited the Sterling Hill occurrence which provided very beautiful crystals (Figs. 1 and 2).

Yet another paragenesis for holdenite was noted by Charles Key of Sarasota, Florida. On Key's specimen, the matrix is a granular, slightly banded willemite-franklinite-rhodochrosite ore. The surface of the specimen consists of light orange willemite, followed in sequence by euhedral light green willemite and rhodochrosite, which is in turn followed by dull white barite. The last minerals deposited are light gray subhedral hemimorphite, holdenite and sphalerite. The sphalerite occurs as colorless, parallel, acicular crystals which appear to be overgrowths on rhodochrosite and holdenite.

All holdenite seen previously has a glassy luster. Although Palache noted a weak cleavage, it is seldom evident. The above described holdenite crystals are quite unusual in that they are fibrous. Although there is fibrous sphalerite intimately associated with the holdenite, none was detected in holdenite during microprobe analysis, and no diffractions attributable to sphalerite were evident on a long-exposure X-ray powder diffraction pattern of holdenite.

The crystals (Fig. 4) are a very rich pink color, much lighter in hue than previously known holdenite. The habit of the crystals is highly irregular. There is no significant chemical distinction between this material and other holdenite specimens studied.

Subsequent to the completion of the analytical section of this paper, a third assemblage for Franklin holdenite was found on a

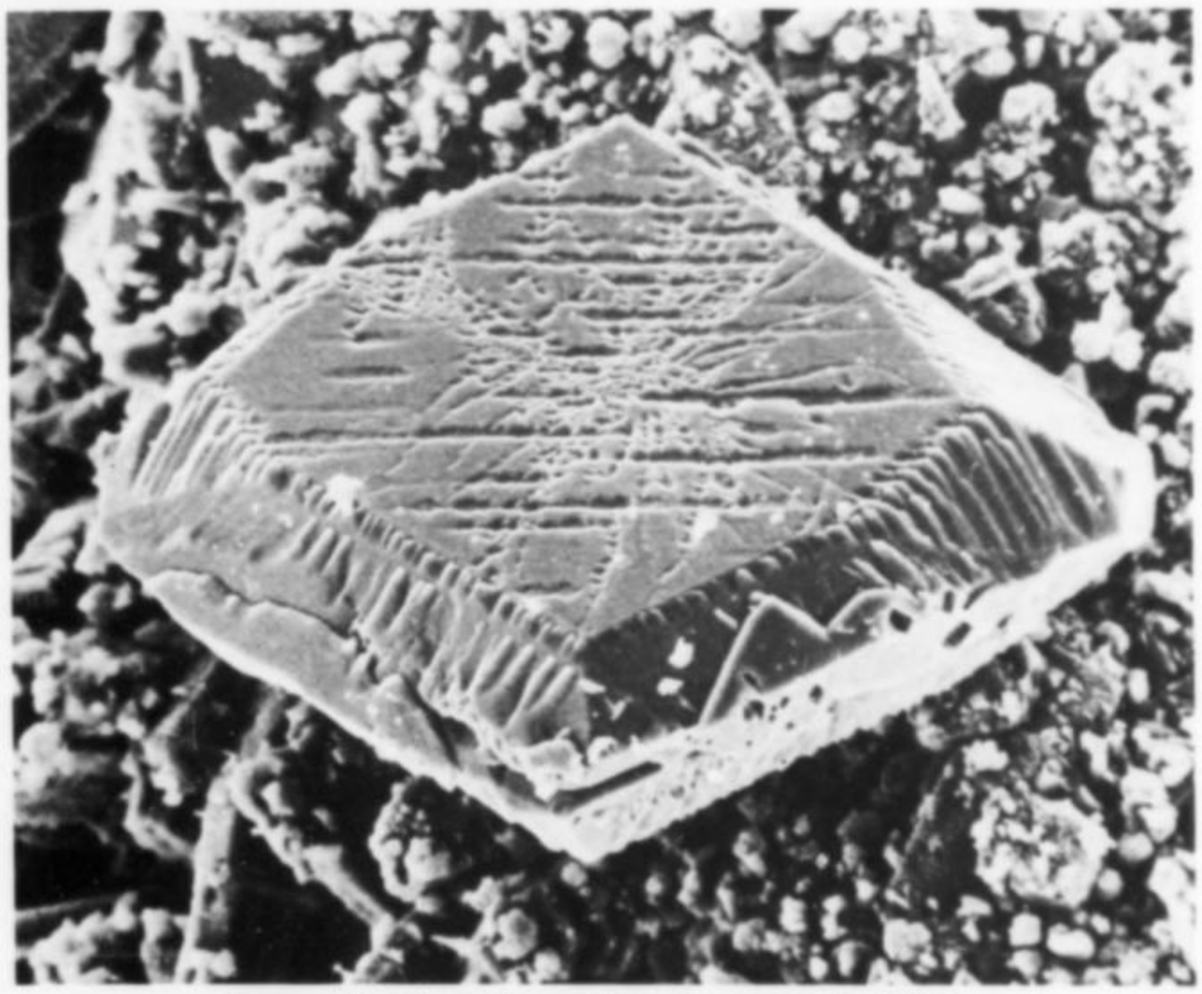


Figure 1. **Typical crystal of orange kolicite (600x).**

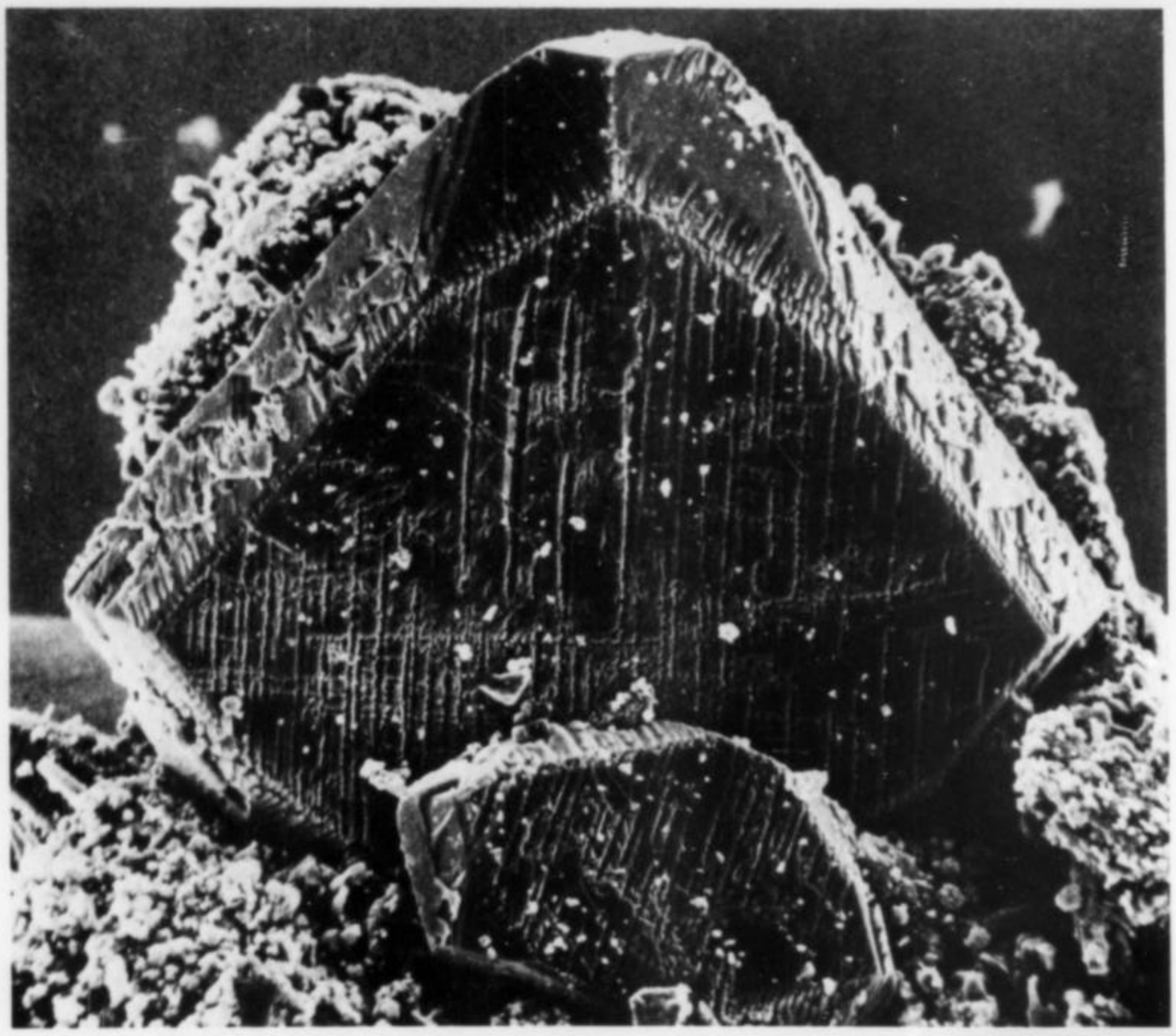


Figure 2. **Several crystals of kolicite (400x).**

Figure 3. **Irregular, possibly distorted crystals of Sterling Hill holdenite (490x).**

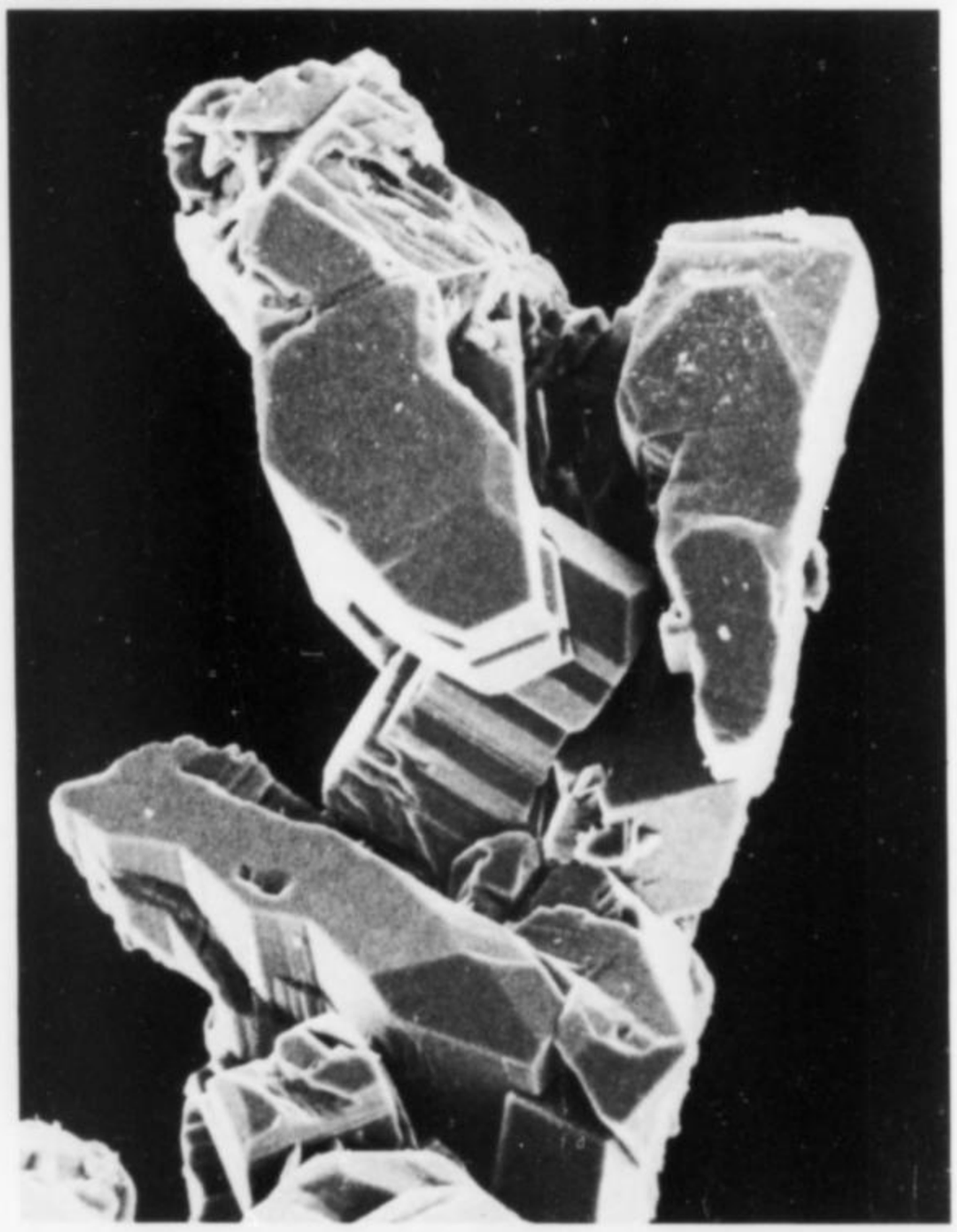
Smithsonian specimen which had been labeled "allactite." On this specimen, NMNH C6278, holdenite occurs as massive pink to orange material along a shear in franklinite ore. Zincite and barite are abundant and predate holdenite. Sussexite and calcite are present in minor amounts and appear to be coeval with holdenite.

STERLING HILL HOLDENITE

Holdenite was identified in 1977 from the Sterling Hill mine by Fred Parker using the newly published X-ray powder diffraction data of Moore and Araki (1977). Given the fact that the new occurrence has provided hundreds of specimens, and holdenite is now known from both Franklin and Sterling Hill, the apparent paucity of material in previous years may have been due to the older, erroneous X-ray powder data. Material from the recent find was widely dispersed; holdenite specimens now repose in many systematic collections.

The Sterling Hill holdenite occurred in the 1340 and 1380 pillars, between the 1200 and 1300-foot levels of the Sterling Hill mine. Holdenite occurred on slip surfaces on rather rich willemite-franklinite ore which is notable for the absence of calcite. The holdenite also occurs in veinlets which cross-cut the ore-banding and as interstitial fillings in fractured willemite and franklinite ore. In this occurrence as interstitial fillings, the holdenite sometimes comprises up to 10 percent of the volume of some specimens. On samples where veins are evident, holdenite occurs in very small, highly irregular microcrystals (Fig. 3) which bear little or no resemblance to the original Franklin crystals described by Palache and Shannon (1927). In massive material, fine-grained, randomly-oriented holdenite occurs in layers which alternate with layers of fine-grained secondary willemite. Kraisslite occurs within the massive holdenite as warped folia. On one specimen of Sterling Hill material, the holdenite is in contact with kolicite, a relationship to be expected in view of the close structural simiiarity of these species (Peacor, 1980). This unique association among the many Sterling Hill specimens was noted by John Kolic.

Application of the Gladstone-Dale relationship to holdenite using the constants of Mandarino (1976) yields a value K_C from the chemical composition of 0.191 for an average of values obtained from the five analyses in Table 1. This compares favorably with the value K_P of 0.188 from the refractive indices of Palache and Shannon (1927) and the observed density of 4.11 of Prewitt-Hopkins (1949). The compatibility of the data (Mandarino, 1979) is 0.016, indicating superior agreement.



CHEMISTRY

The holdenite samples studied herein were chemically analyzed with an ARL-SEMQ electron microprobe utilizing an operating voltage of 15 kV and a beam current of 0.15 μA. The standards

Table 1. Microprobe analyses of holdenite.

Sample #	Theory*	95434	Key	144262	142665	147827
Locality		Franklin		Sterling Hill		
SiO_2	5.92	6.4	6.2	6.3	5.9	6.0
MgO	2.18	3.5	1.3	2.1	2.5	2.1
MnO	38.10	38.1	40.2	39.1	39.1	39.5
ZnO	24.06	23.9	23.5	23.7	23.4	23.8
As_2O_5	22.65	21.4	21.5	21.9	22.3	22.1
H_2O	7.09	7.1**	7.1**	7.1**	7.1**	7.1**
Total	100.00	100.4	99.8	100.2	100.3	100.6

Accuracy of data: ±3% of the amount present.
* Theoretical composition for:
$(Mn_{5.45}Mg_{0.55})Zn_3(OH)_8(AsO_4)_2(SiO_4)$ Moore and Araki (1977).
**Water from theoretical composition above.

***Figure 4.* V-shaped crystal of holdenite in Key collection (15x).**

used were hornblende for Si, Fe, Ca and Mg; synthetic ZnO for Zn; synthetic olivenite for As; and manganite for Mn. The data were corrected using a modified version of the *MAGIC-4* computer program.

The resultant analyses are presented in Table 1. An inspection of the data indicates that the composition of holdenite is remarkably constant and in excellent agreement with the composition derived by structural methods by Moore and Araki (1977). The magnesium reported in the original analysis is likely accurate. Indeed, none of the holdenite samples examined is free of magnesium.

ACKNOWLEDGMENTS

The author is indebted to Fred Parker for calling his attention to the occurrence, to John Kolic for specimens of Sterling Hill holdenite, and to Mary Jacque Mann for assistance with SEM photomicrography. This project was supported, in part, by a grant from Mrs. E. Hadley Stuart, Jr.

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Grothine discredited, equals Norbergite

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The Smithsonian Institution was given the Washington A. Roebling mineral collection in 1927. At the time of transmittal the collection comprised some seven or eight thousand specimens. The Roebling collection continues to grow, however, as Colonel Roebling also endowed the museum with money for the continued purchasing of minerals. While Roebling's collection included a great number of exhibition-quality specimens, there were of equal importance, at least, many samples of minerals introduced as new species while Roebling was actively collecting. It was his practice to solicit such samples from the describers at the time when the descriptions first appeared, so that he was able to obtain a significant number of very important "type" specimens.

One of these types is grothine, a mineral described by Ferruccio Zambonini in 1913, and preserved by Roebling in a glass pill bottle from Stuckert's Prescription Drug Store, dated January 12, 1914. In Figure 1 are reproduced three labels found with the sample; one of which surely is Zambonini's, another clearly is that of Roebling as it is in his own handwriting, and the third label indicates that the sample must have been examined by W. T. Schaller, a distinguished mineralogist with the U.S. Geological Survey who died in 1967. This examination could have been made before Roebling received the specimen because Schaller was in Munich in 1912 where he

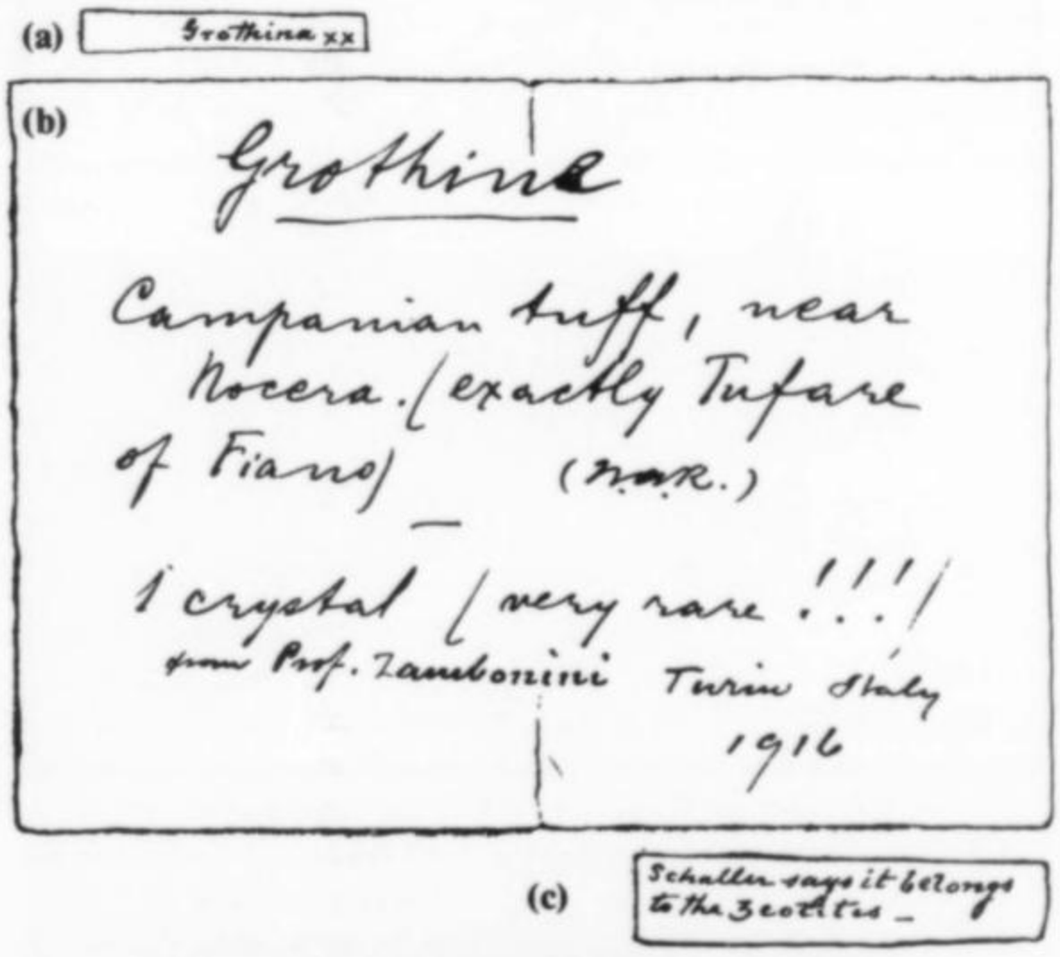

Figure 1. **Labels accompanying Roebling's specimen of grothine: (a) Zambonini's label, (b) Roebling's label, (c) Roebling's appended comment.**

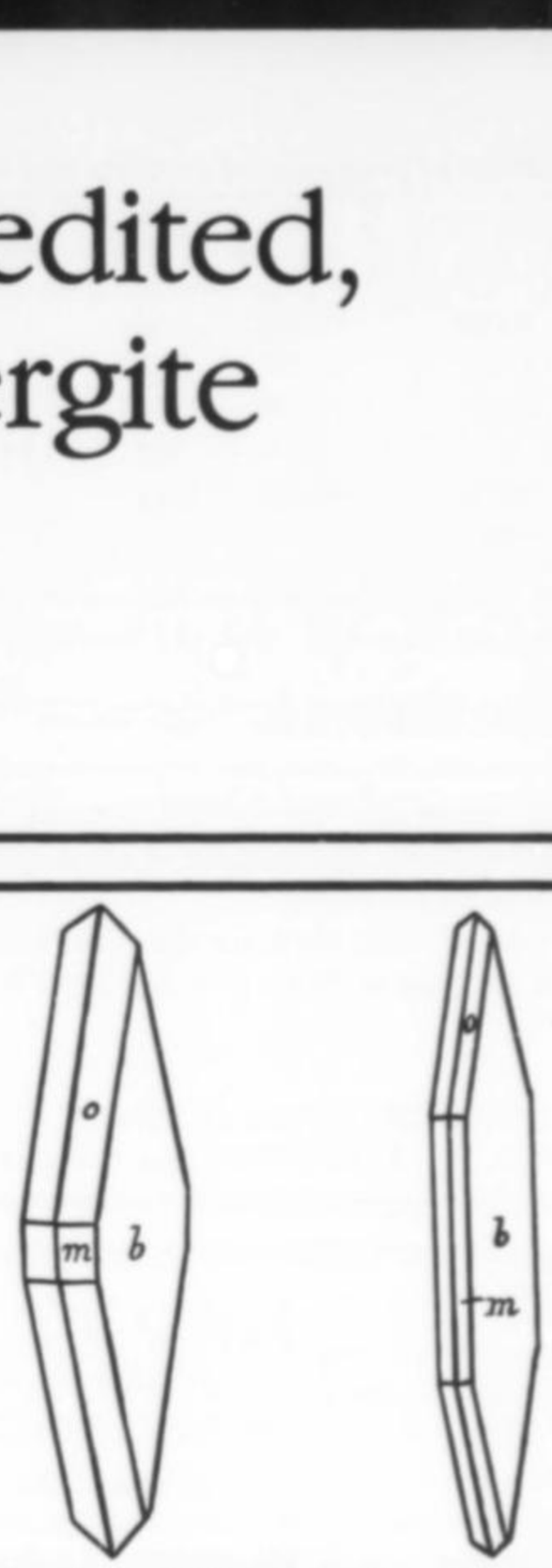

Figure 2. **Crystal drawings of grothine by Zambonini (1913).**

received his Ph.D. after having studied under Professor Paul von Groth, for whom Zambonini named the mineral.

Grothine was described as an aluminosilicate of calcium by Zambonini, "Grothina, un nuova minerale," in a preliminary note published in 1913. This composition was based upon qualitative analysis only. The Roebling specimen is from "near Nocera (exactly Tufare of Friano)," Campania, Italy. The crystals are transparent and colorless, and are vitreous in luster. The various crystal forms (six in all) are given, and a table of interfacial angles is provided along with crystal drawings (Fig. 2). The density and some optical data are also included.

The one crystal comprising the type sample of grothine (NMNH #R4347), being only about 2 mm in its greatest dimension, was broken into three tiny pieces. One was used for a powder pattern (using the Gandolfi camera). Another was used for optical measurements (spindle stage, Na light) and the third was glued to a glass slide for microprobe analysis. All three efforts support the conclusion that grothine is not a valid species, but is norbergite. The powder pattern is that of norbergite, the optics (Table 1) are within the range reported for synthetic hydroxyl and fluorine endmembers (Van Valkenburg, 1961), and the partial analysis (unrefined) (Table 2) is clearly that of norbergite. In addition, the density, although low, is acceptably close. Most of the published data for norbergite are from studies of crystals containing enough iron to raise both the refractive indices and the density.

Although grothine can no longer be considered a valid species, the occurrence is significant for norbergite, a mineral never having otherwise been found in measurable crystals.

In concluding this paper it is interesting to note that it is also a Roebling specimen that was used for determining the crystal struc-

Table 1. Comparison of properties of grothine and norbergite.

	Grothine[1]	Norbergite[2] a.	Norbergite[2] b.	Norbergite[3]
	1.554	1.563	1.567	1.559
β	1.557	1.567	1.570	1.564
	1.579	1.590	1.593	1.584
2V	52°	44°	50°	53.4° (calc)
D	3.079	3.181	3.153	
	3.09			

[1] spindle stage, Na light (Leavens) (D from Zambonini, 1913).

[2] Deer, Howie and Zussman, 1962 (a. Piukkala, Finland, b. Norberg, Sweden.

[3] Gibbs and Ribbe, 1969 (Franklin, New Jersey).

Table 2. Chemical analysis of norbergite (partial).

	Grothine[1]	Norbergite[2] a.	Norbergite[2] b.	Norbergite[3]
SiO_2	28	29.60	27.56	29.74
MgO	61	58.70	59.35	58.73
CaO	0.6	—	—	0.15
FeO	0.1	0.96	1.91	0.06
Fe_2O_3	—	0.60	0.28	—

[1] E. Jarosewich.

[2] Deer, Howie and Zussman, 1962 (a. Piukkala, Finland, b. Norberg, Sweden).

[3] Gibbs and Ribbe, 1969 (Franklin, New Jersey).

ture of norbergite (Gibbs and Ribbe, 1969). Readers are cautioned to avoid confusing grothine with grothite, a similarly invalid name synonymous with titanite (sphene).

I would like to acknowledge the assistance of the following in this study: Pete J. Dunn, Eugene Jarosewich and Peter B. Leavens.

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Barian Goyazite from Brazil

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Through the courtesy of Luizhelio Barreto, of Recife, Brazil, the Smithsonian has received three excellent specimens of barian goyazite, a phosphate of strontium and aluminum. Barium and, to a lesser degree, calcium substitute for strontium. The specimens were collected by Barreto and submitted to the museum for identification. They came from Alto Bernardino, about 20 km northwest of Picui, Paraiba, Brazil. According to Barreto, about 100 specimens were recovered from one quartz pocket in a pegmatite that had been worked for tantalite. It is also known to have produced the phosphates purpurite and triphylite.

All three of the specimens received by the Smithsonian consist of quartz crystals which appear to have been "floaters"; that is, there are no obvious points of attachment. The largest is a plate 12 by 7 by 2 cm and the smallest is a single normal-looking crystal 6 cm in length. Goyazite is scattered over all surfaces of these crystals, although very sparsely on some. In limited areas goyazite crystals are densely packed to form solid druses. The crystals are simple rhombohedrons, milky white in color when not stained tan to brown by surficial iron oxide. Most are very small, about 0.25 mm, some approaching 1 mm in maximum size.

An electron microprobe analysis by J. A. Nelen, of the Smithsonian, revealed that this goyazite contains a substantial amount of barium. In fact, one spot on a crystal reached 5.9 percent BaO. The precise nature of the substitution is puzzling because the strontium content does not inversely reflect either the barium or the barium-plus-calcium content. Also present is an average of 2.8 percent fluorine. Table 1 contains the average analysis based upon data from seven different spots on the sample. The summation is low because hydroxyl, water and the very light elements were not determined.

Table 1. Analysis of barian goyazite (NMNH #146643).

BaO	5.1	—
SrO	14.8	22.45
CaO	2.0	—
MgO	0.3	—
Al_2O_3	33.9	33.12
F	2.8	—
SiO_2	0.2	—
P_2O_5	28.9	30.77
H_2O	n.d.	13.66
	85.2	100.00

The earliest phosphate to crystallize on quartz at this locality is herderite, which appears in two distinctly different crystal sizes. There are a small number of relatively large herderite crystals approximately 1.5 cm in size, and there are more numerous smaller crystals about 1 mm in size. Barreto reported that the largest herderite crystal in the lot is nearly 9 cm in its greatest dimension. Only a few of the smaller herderite crystals have goyazite upon their surfaces and it is on the basis of finding goyazite on herderite that herderite is named the earlier of the two phosphates. Partial analysis indicates that the herderite is barium-free but contains 4.1 percent fluorine.

The last phase to crystallize is apatite, which occurs growing upon goyazite and quartz in perfectly transparent, colorless, long-prismatic crystals. These are commonly solitary but some groups of parallel bundles were observed. Most lie flat on the surface upon which they grew, some few others stand upright at random angles.

The three specimens now reside in the Smithsonian collections and carry the catalog numbers 146643, 146644 and 146645.

Figure 1. **Minute barian goyazite crystals on a milky quartz crystal from Alto Bernardino, Paraiba, Brazil. Dane Penland photo.**

Microminerals

by **Bill Henderson**

A MINERALOGICAL POTPOURRI

Every collector of microminerals, after a certain period of time, develops a secret liking for a few select species. Occasionally, his predilection is for a rare species from the type locality, perhaps one he has since acquired from other localities as well. Sometimes, the species may be quite common but he has it in unusual crystal forms or strange associations. It's fun to contrast and compare such species, so in this column, I'm going to relax a bit and describe a few of my favorites.

Prehnite is a rather common, low-temperature mineral, a calcium-aluminum silicate found in basalts, granites and gneisses. Most commonly, in basalts at least, it occurs in druses of crude crystals with a bright apple-green color. Far more interesting to me are the little round balls of prehnite such as that seen in Figure 1.

Figure 1. **Prehnite ball, 4 mm in diameter, on albite from Cheshire, Connecticut. Bill Henderson photo.**

These very pale green crystals on well-formed albite crystals look as though they began as a "bow tie" which filled in so as to bite its own tail. The crystals are from an abandoned trap quarry where are also found quite large, tabular crystals of apophyllite.

The colorless and, in part, transparent crystals shown in Figure 2 are labeled, "Cornog, Pennsylvania," and are probably from an occurrence in gneiss at the Keystone Trappe Rock quarry, Cornog, Chester County, Pennsylvania. The acicular mineral is byssolite (probably actinolite), and in some cases the euhedral prehnite laths are impaled on and supported by the byssolite needles.

Figure 2. **Lathlike, colorless prehnite crystals to 3 mm with byssolite; Cornog, Pennsylvania. Bill Henderson photo.**

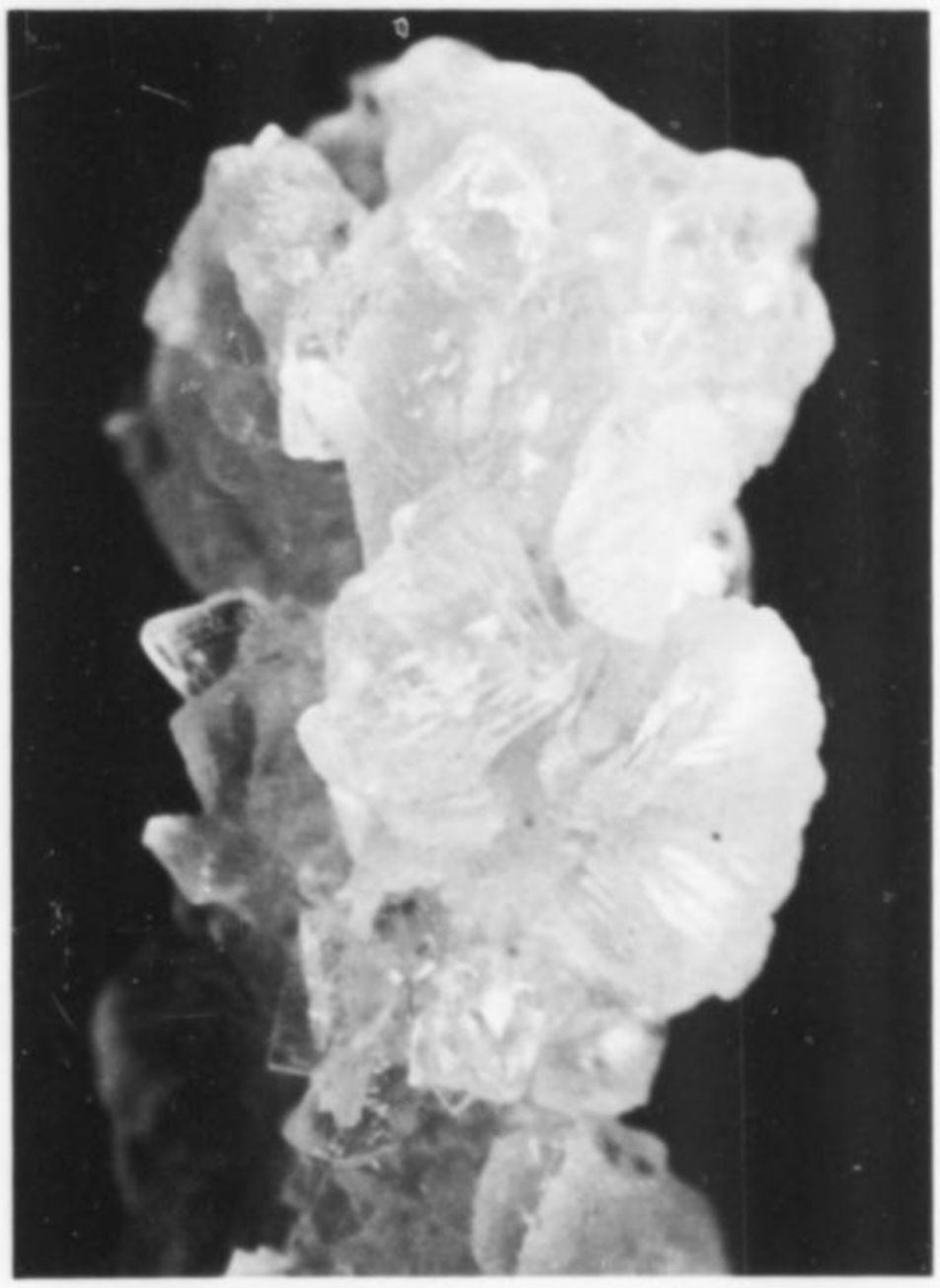

Figure 3. **Saddle-shape aggregates of pale green prehnite crystals on calcite from Poona, India; size of group 25 mm. Photo by Bill Henderson.**

The bright green prehnite in Figure 3 is growing on calcite, and many of the sub-parallel aggregates form saddle-shape groups. This specimen from Poona, India, is perhaps closest of those shown to the "typical" prehnite habit. The Indian occurrences are in basalts or closely related rocks.

Figure 4. **Colorless, euhedral, floater prehnite crystals, the largest 14 mm, from the Jeffery mine, Asbestos, Quebec. Photo by Bill Henderson.**

The finest euhedral prehnite crystals in the world are those from the Jeffery mine, Asbestos, Quebec. These transparent and colorless to translucent and white crystals (Fig. 4) occur as floaters with no visible point of attachment, and are found only in localized areas in that immense asbestos mine.

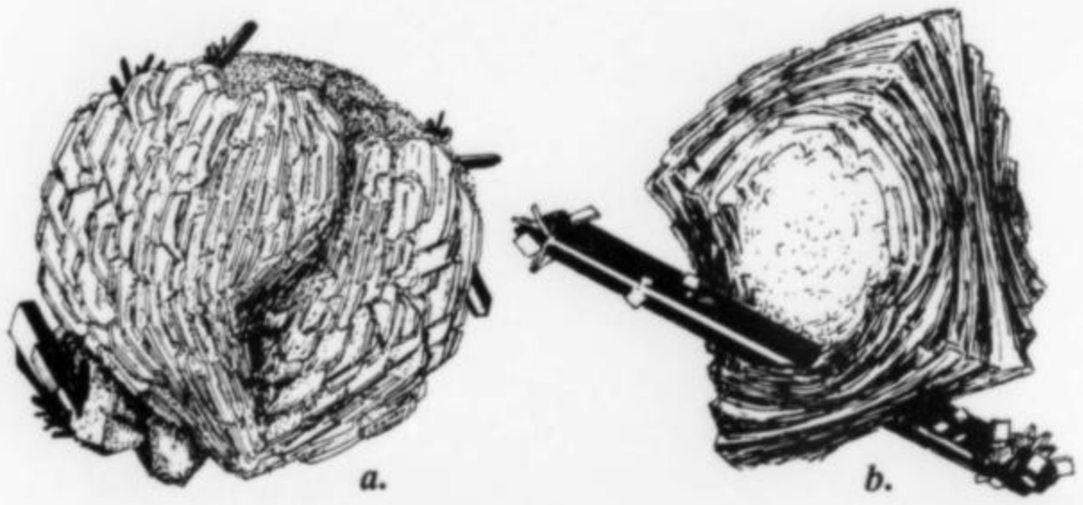

Figure 5a. **Mammilary group of pale green, transparent prehnite laths, 4 mm across, associated with bottle-green epidote crystals, from Arrigo, Italy. Sketch by Bart Cannon.**

Figure 5b. **Epidote crystal penetrating prehnite plates and dusted with still smaller prehnites, 4 mm across, Arrigo, Italy. Bart Cannon sketch.**

The last prehnite shown (Fig. 5) is interesting for its associates and occurrence. The crystals, flat plates forming transparent balls and rosettes of a very pale green color, are from an occurrence in gneiss at Arrigo, Italy. The specimens are interesting for their close association with well-formed, bottle-green epidote crystals. This is typical of prehnite in gneisses and granites. This specimen was sent me by Otmar Förster (Millöcker-Strasse 70, D-8011 Munich-Vaterstatten, West Germany), who also sent from the same locality terminated (!) transparent scolecites associated with pink titanite. I should mention that I am very much indebted to Bart Cannon for these fine sketches of minerals I found impossible to photograph.

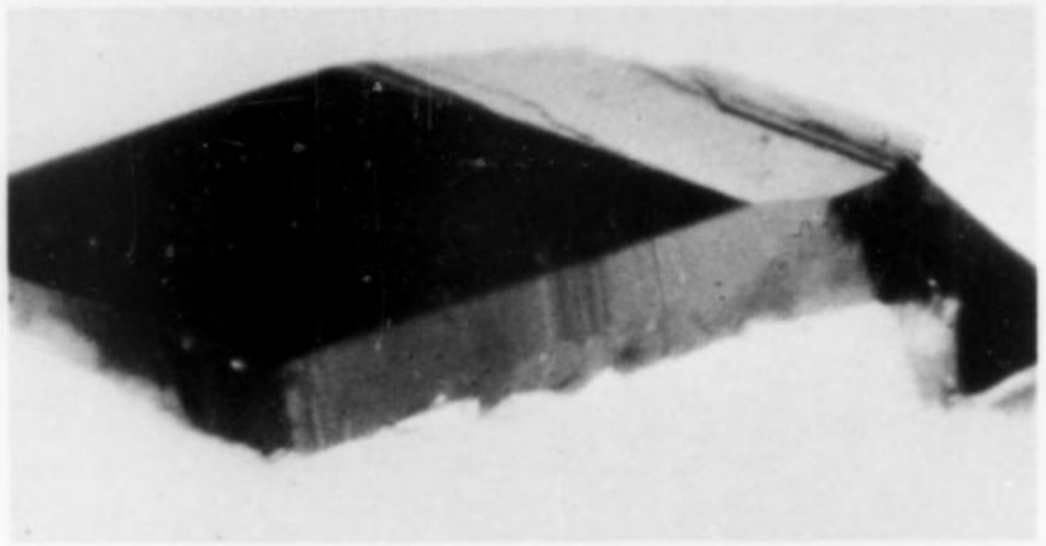

Figure 6. **Babingtonite, single jet black crystal 1.5 mm in size on colorless prehnite, Wind Gap or New Haven Trap Rock quarry, Wallingford, Connecticut. Photo by Vi Anderson.**

Closely associated with prehnite and another favorite mineral of mine is babingtonite. The single brilliant, jet-black crystal shown in Figure 6 is perhaps typical of the mineral. It is from a basalt or diabase quarry, and the crystal is sitting on a druse of prehnite. The mineral is found quite regularly at this and similar locations, and is best located by looking for old and weathered seams coated with prehnite.

Figure 7. **Jet-black, flattened laths of babingtonite to 2 mm covered with cream-colored "hairs" of acmite from Lincoln Park, New Jersey. Bill Henderson photo.**

Quite different in appearance are the short laths shown in Figure 7. These are covered with almost parallel hairs of light cream-colored acmite, apparently an alteration product of the babingtonite. The specimen is from Lincoln Park, New Jersey. Another atypical form of babingtonite was found at Rikers Hill, Livingston, New Jersey. There the babingtonite occurred in columnar crystals with a length-to-width ratio as high as ten to one.

Very fine babingtonite is still to be found in the abandoned quarry at Blueberry Mountain, Woburn, Massachusetts (Fig. 8). The crystals there occur in thinly scattered druses with epidote in an altered granite, and the best and freshest crystals are obtained by etching away a protective coating of calcite with dilute hydrochloric acid. Very large crystals, the world's best, were once obtainable at the Lane Trap Rock quarry in Westfield, Massachusetts. Occa-

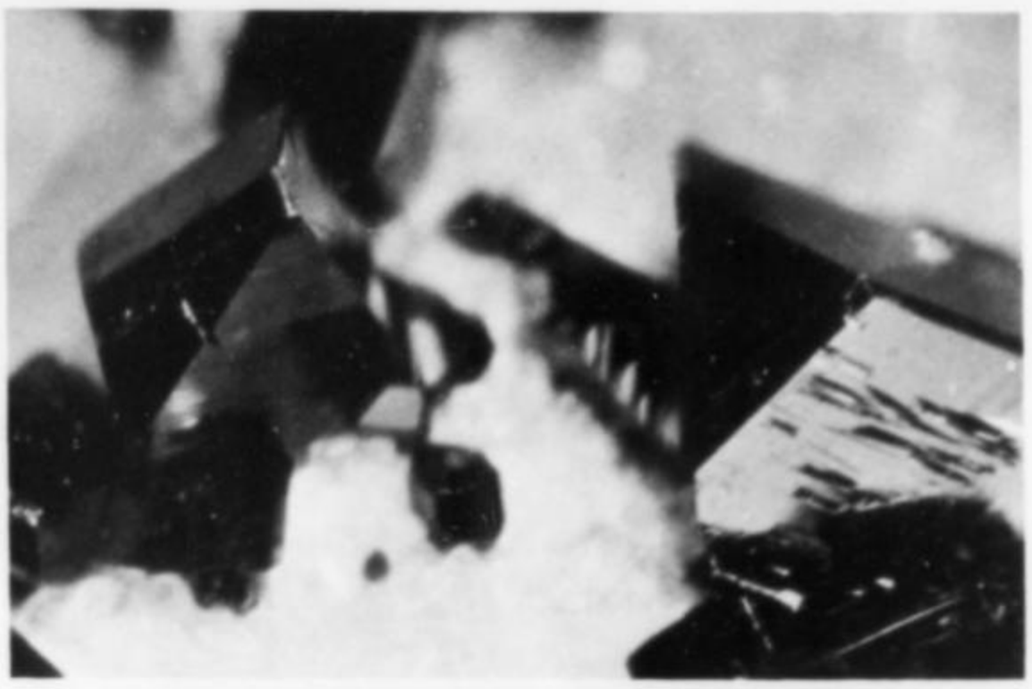

Figure 8. **Brilliant black babingtonite crystals, the largest 2 mm, slightly etched, with epidote on adularia from the Blueberry Mountain quarry, Woburn, Massachusetts. Photo by Bill Henderson.**

sionally, the crystals are small enough to qualify as micros, and the associates are again epidote and prehnite.

Melanophlogite, a quite rare species, is another favorite of mine, perhaps because I have it from three of the four or five known localities. An excellent article on this mineral by Sergio Gallo is to be found in an early issue of the *Mineralogical Record* (Vol. 5, p. 207). Melanophlogite is an unusual mineral in that it contains essential quantities of organic materials, sulfur and hydrocarbons. Otherwise, it contains only silica, and a typical formula for the mineral is given as $46SiO_2 \cdot C_2H_{17}O_5S_{0.1}$. The organic material acts as a space-filling template around which the silica can crystallize. Were the organic material not present, the silica would crystallize as some other low temperature and low pressure polymorph of quartz, probably cristobalite to which it alters when the organics are eliminated by heating. Recently, it has been found that certain synthetic zeolites can be formed only when large organic counter ions (tetraalkylammonium ions) are present to act as templates. I'll write more about this similar phenomenon another time.

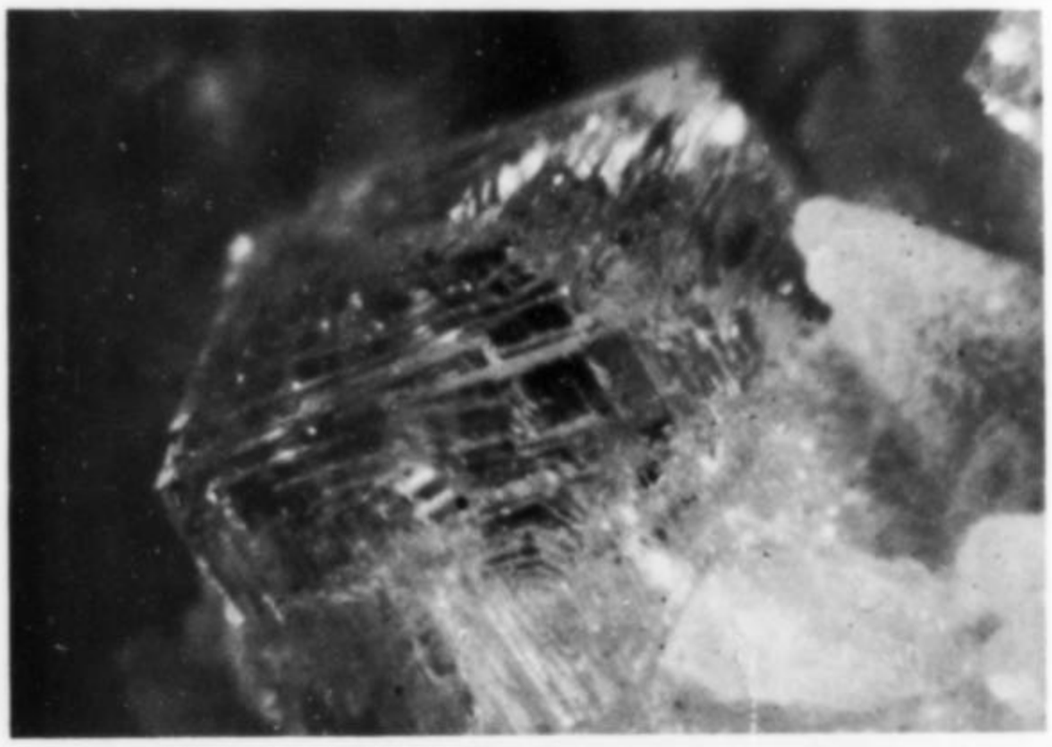

Figure 9. **Subparallel, transparent, colorless 1.5-mm crystals of melanophlogite on sulfur; Racalmuto, Sicily. Photo by Vi Anderson.**

Sub-parallel, cubic crystals of melanophlogite are shown in Figure 9. These colorless and transparent crystals are from Racalmuto, Sicily, and are associated with sulfur. The crystals described by Gallo are close to perfect spheres (Fig. 10). The crystals are colorless and clear as glass, so clear that the character of the underlying matrix is easily discerned. It is interesting to speculate why these

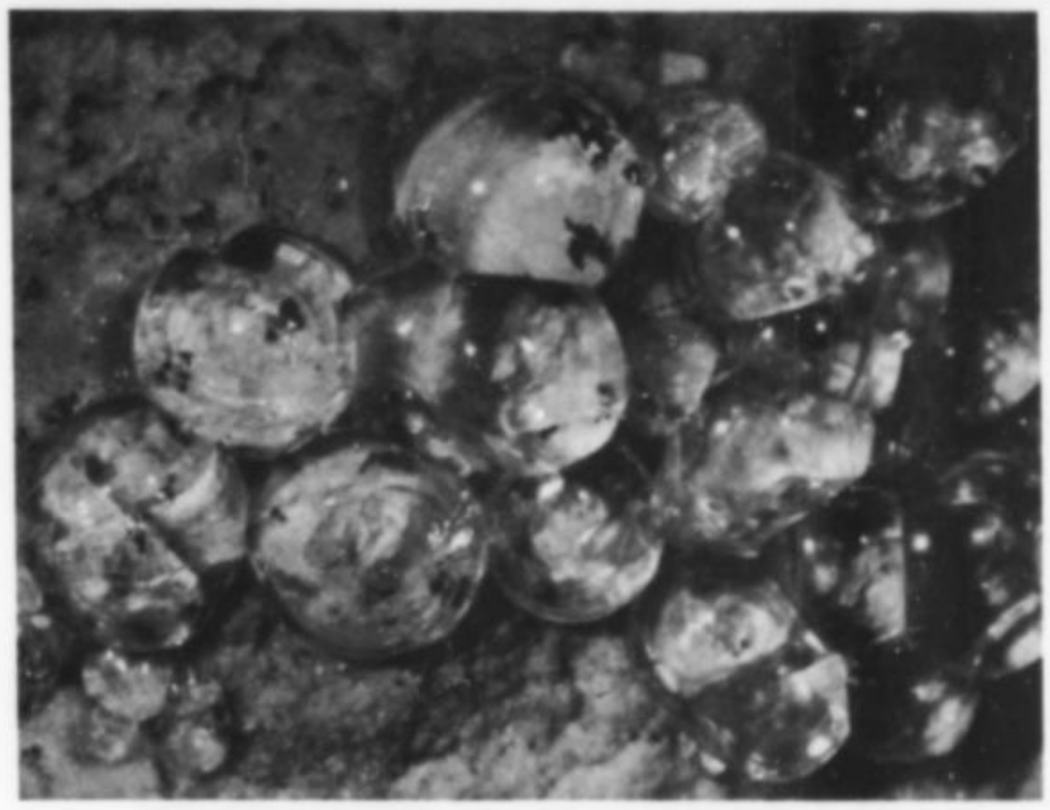

Figure 10. **Perfectly transparent 2-mm spheres of colorless melanophlogite from Livorno, Italy. Vi Anderson photo.**

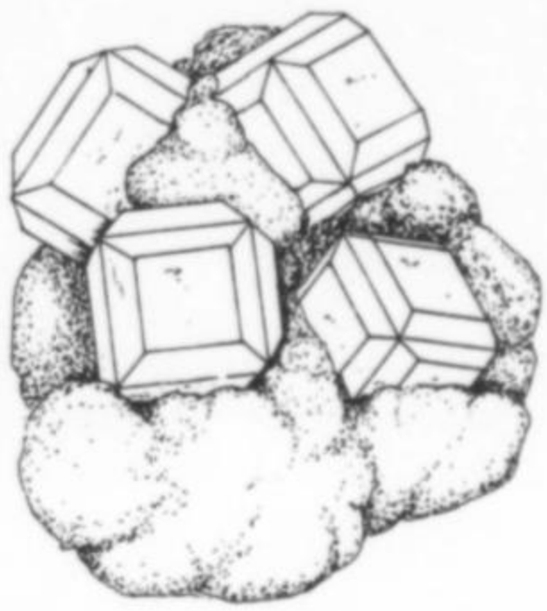

Figure 11. **Four 1.5-mm crystals of melanophlogite showing the cube and tetrahexahedron. Colorless and transparent, the crystals are from Mount Hamilton, Santa Clara County, California. Sketch by Bart Cannon.**

crystals from Fortullino, Livorno, Italy, should grow as spheres and only occasionally in their "proper" cubic form. They do not appear to have been etched to their current shape. The New World melanophlogite in Figure 11 is from Mount Hamilton, Santa Clara County, California. The crystals are so clear and transparent that they are virtually impossible to photograph, hence the sketch. The interfacial angle between the cube and the tetrahexahedron measured on my old homemade optical goniometer (*Mineralogical Record,* **1**, 56 (1970)) came out to 26°36', so the tetrahexahedron on these crystals must be that with the Miller Indices (210), for which the angle measured is 26°34'. These crystals appear to be growing on chalcedony.

Osumilite is a fairly rare hexagonal mineral, interesting for its extremely strong pleochroism. It is so strong that it is easily observable without the use of polarized light. Almost all micros of osumilite appear a deep, almost midnight-blue when viewed down the *c*-axis, but appear a light to dark tan color when viewed through the side. The mineral occurs most commonly in rhyolites or related felsic rocks.

In Figure 12 is shown a very complex crystal of osumilite from the type locality at Sakabira, Japan. Viewed through the prism, it is possible to see the internal features of the crystal (see the lower left

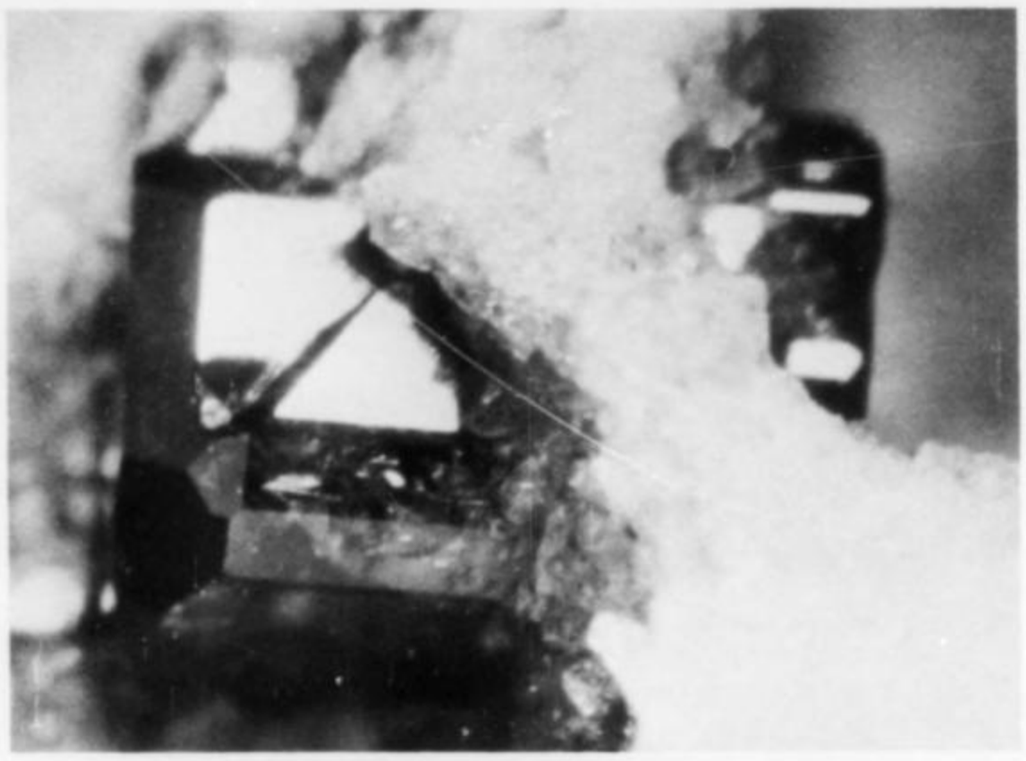

Figure 12. **Complex, 2-mm crystal of osumilite, pleochroic dark blue and brown, from Sakabira, Japan. Bill Henderson photo.**

Figure 13. **Flat, 3-mm crystals of osumilite, very dark blue, with faint light colored markings on *c*-face (see largest crystal), from Three Sisters, Lane County, Oregon. Photo by Bill Henderson.**

portion of the crystal photographed). Viewed through the *c*-face, it is opaque and a very deep blue. Only a single crystal is shown, penetrating or partially covered by matrix. Completely different from the equant crystal described above are the typically tabular crystals from the Three Sisters Peaks, Lane County, Oregon shown in Figure 13. These have been sent me on several occasions by Mike Groben (1590 Olive Barber Road, Coos Bay, Oregon, 97420). Although Mike is not primarily a micro collector, he is an ardent trader and appreciates rare micros on good-size pieces of matrix. Just discernible on the *c*-face of the largest crystal are faint lighter markings which meander across the faces of all these crystals. They are not etch marks, and their origin is something of a puzzle. They contrast markedly with the blue-black color of the face.

The deeply etched, midnight-blue crystal in Figure 14 is from Marrubiu, Sardinia. A number of Italian collectors have this material for exchange; the pronounced corrosion of the crystals makes the material very interesting.

Also from Europe are the much more perfectly formed crystals of osumilite shown in Figure 15. These crystals from Bellerberg, Lacher See district, West Germany, were received in an exchange with Dr. Gerhard Hentschel (Pfitznerstrasse 5, D-6200 Wiesbaden, West Germany), the author of an excellent article on the minerals of the Lacher See area (*Mineralogical Record,* **8**, 313 (1977)).

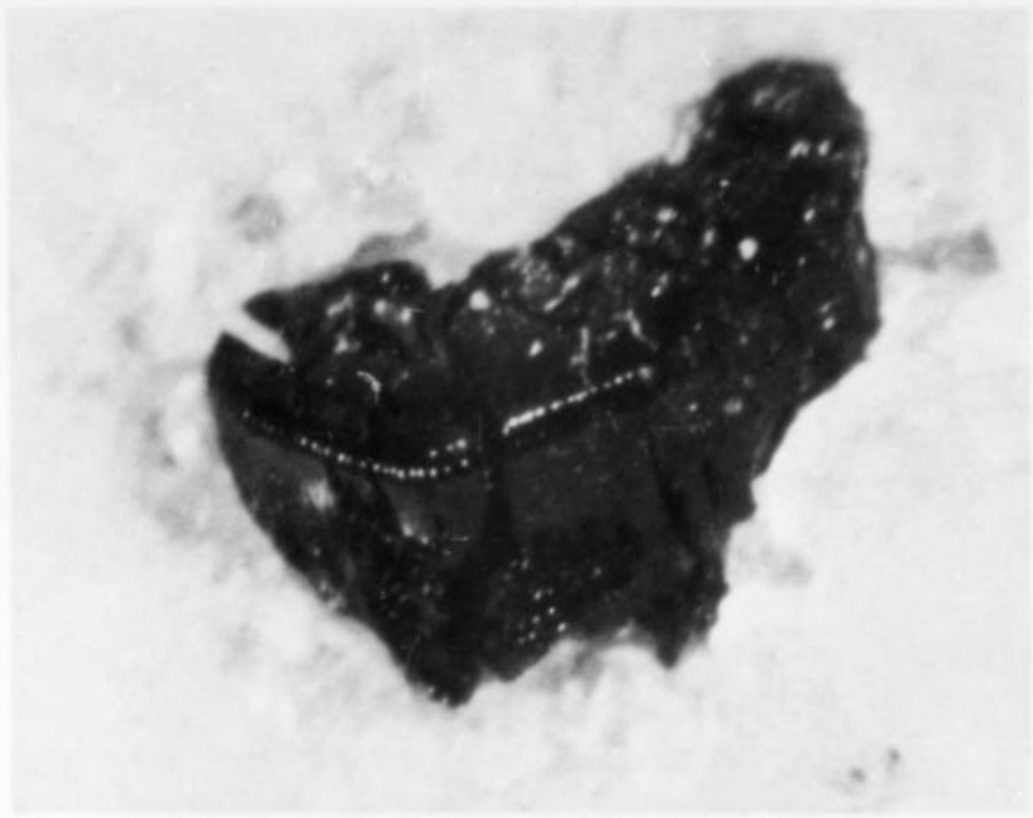

Figure 14. **Deeply etched, midnight-blue, 2-mm crystal of osumilite from Marrubiu, Sardinia. Bill Henderson photo.**

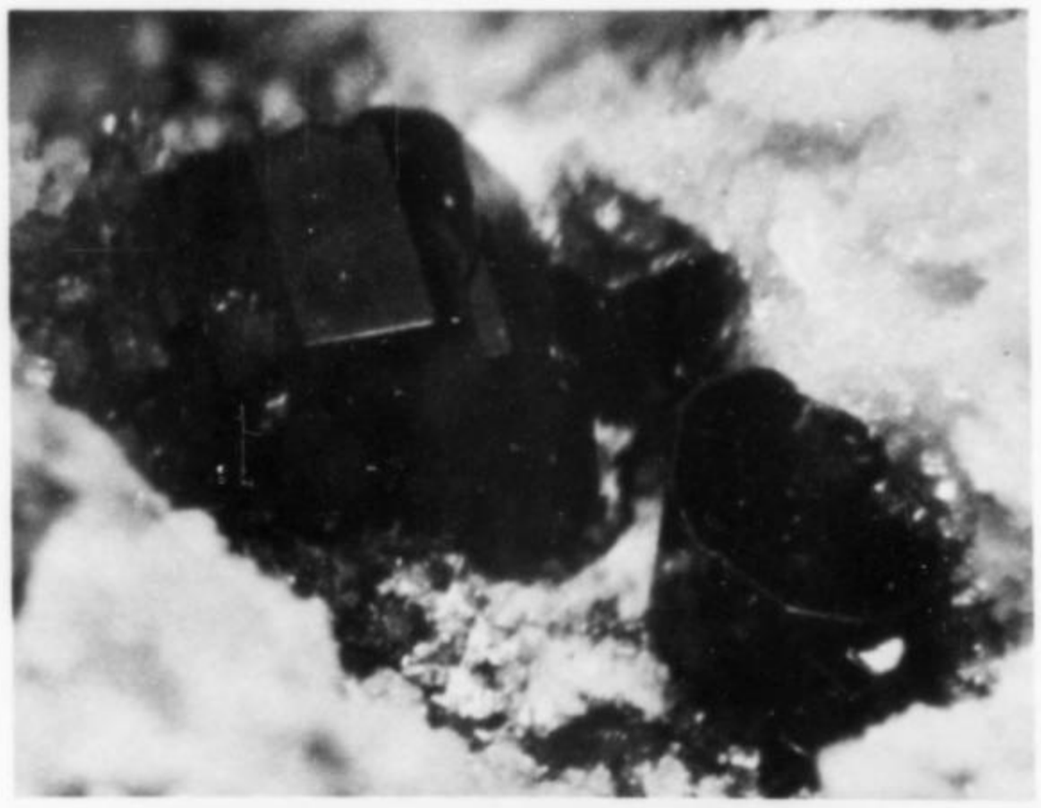

Figure 15. **A pair of equant osumilite crystals, strongly pleochroic dark blue and brown, the larger crystal 1.5 mm. From Bellerberg, Lacher See district, West Germany; photo by Bill Henderson.**

Again, the pleochroism of the crystals is remarkable, but the most interesting thing is the associated minerals. These are very pale violet mullite in radiating hairlike crystals, brick red and opaque cordierite in equant crystals and brilliant brown pseudobrookite in well formed laths, all of these occasionally found in the same micro specimen. In Figure 16 is shown one of the perfectly transparent, canary-yellow roedderites from the same locality, another member of the osumilite family. The inclusions in the crystal are euhedral crystals of pseudobrookite!

Much more common but of interest for its varying crystal forms is millerite. The brass-yellow radiating needles shown in Figure 17 were "liberated" from a specimen of massive hematite ore just before it was broken up for students' study material. The crystals, from Antwerp, New York, are lying on plates of brass-colored stilpnomelane and tabular hematite crystals. Quite different in crystal form and association are the crystals from Brummet Creek, Indiana (Fig. 18). These are in smoothly curving, brass-colored ribbons, and are lying in a small vug in quartz. Not shown but among the finest millerites known to the author are the thick columnar, terminated ones, striated lengthwise, formerly available from the

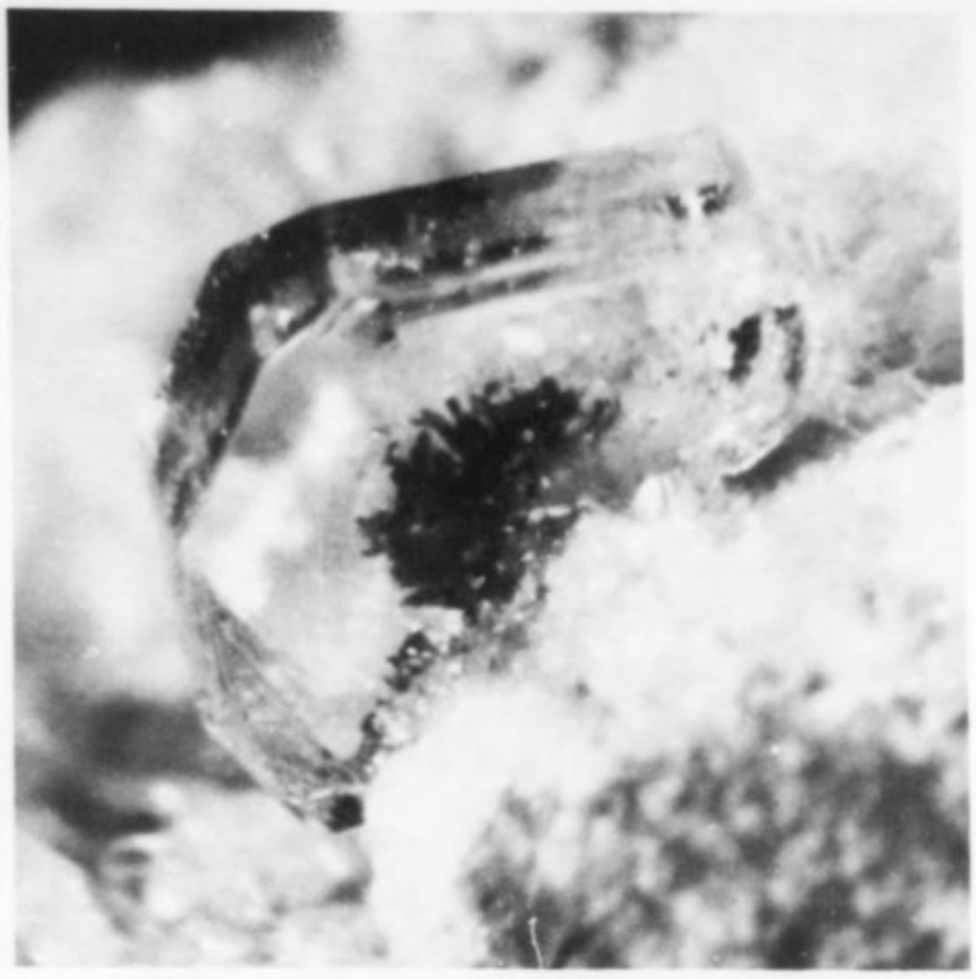

Figure 16. **Transparent, canary-yellow, 1.5-mm crystal of roedderite with inclusions of bright red pseudobrookite, associated with yellow needles of a pyroxene. From Bellerberg, Lacher See district, West Germany. Bill Henderson photo.**

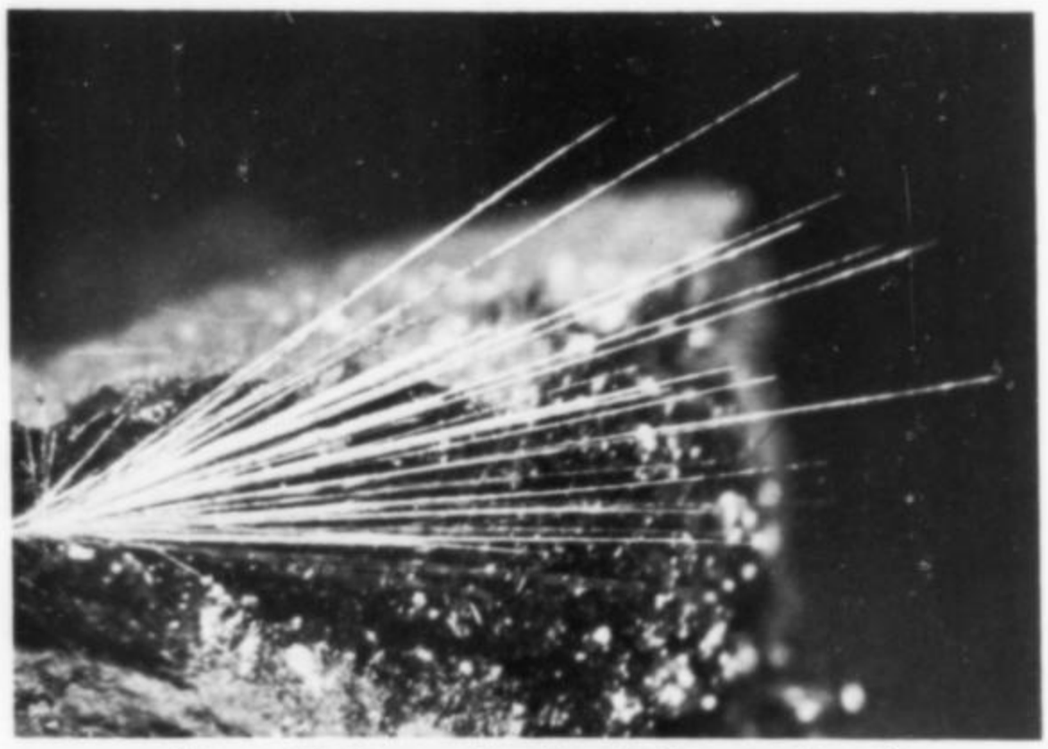

Figure 17. **Brass-colored radiating needles of millerite to 6 mm, with golden yellow stilpnomelane and jet-black hematite on massive red hematite. From Antwerp, New York; photo by Bill Henderson.**

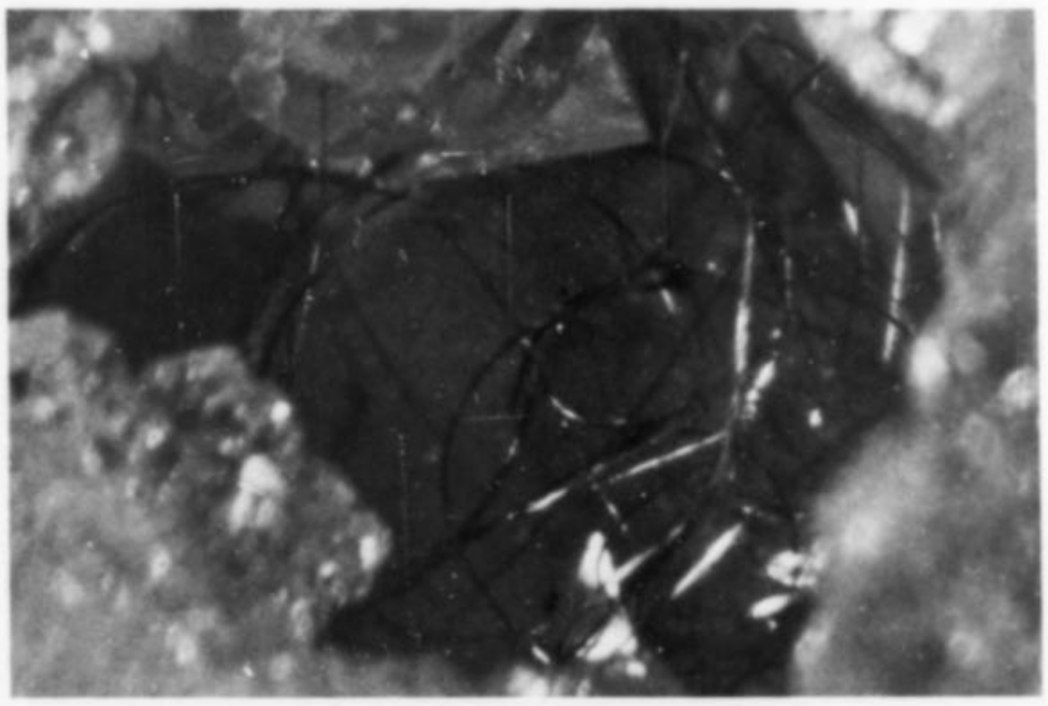

Figure 18. **Metallic, gold-colored, twisting wires of millerite in vug in quartz from Brummet Creek, Brown County, Indiana; the size of the vug is 3 mm. Bill Henderson photo.**

Figure 19. **A 10-mm group of thomsenolite crystals in parallel growth on cryolite. The crystals are colorless but slightly coated with an unknown brown mineral; from Ivigtut, Greenland. Photo by Bill Henderson.**

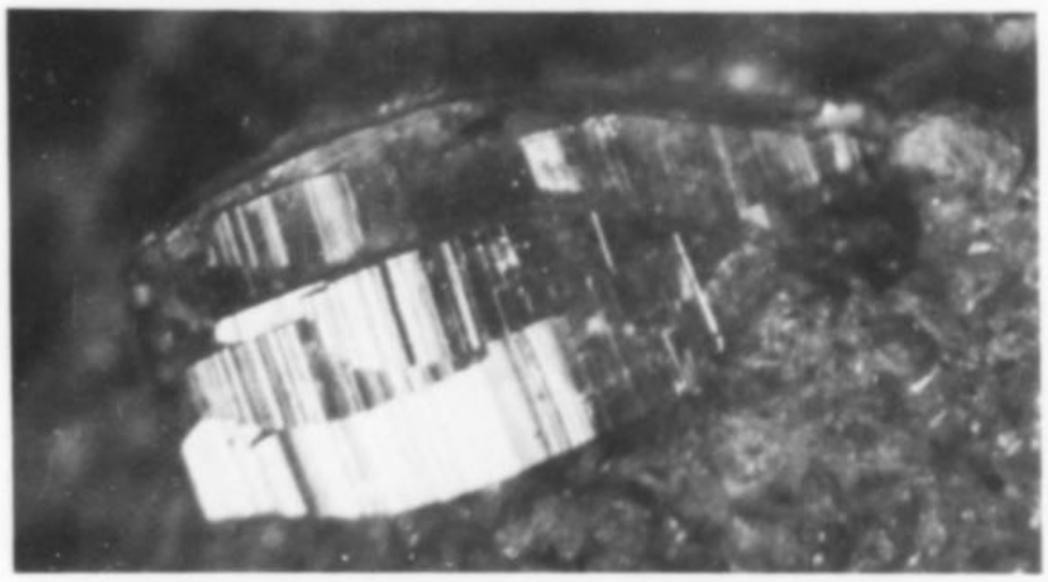

Figure 20. **Transparent, colorless crystals of thomsenolite in parallel growth; the size of the group is 3 mm, from the Spider Mine, Honeycomb Hills, Utah. Bill Henderson photo.**

Orford Nickel mine, Brompton Lake, Quebec. These are associated with the much rarer nickel mineral maucherite, also to be found in euhedral crystals.

The last mineral shown is the rare fluoride thomsenolite, found in the cryolite deposit at Ivigtut, Greenland. A group of crystals in parallel growth on cryolite is shown in Figure 19. It has a marked resemblance to the skyscrapers of Manhattan. Although thomsenolite is automatically associated with Ivigtut by most collectors, there are other less well-known localities for the mineral. Crystals which rival those from Greenland as to clarity and crystal form were found at the Spider mine, Honeycomb Hills, Utah (Fig. 20). These came from a very small vein, since worked out, so small that only one person could work the location at a time. The crystals are perfectly clear, of good size, and show striations similar to the Greenland material. They tend to form in parallel growth.

As stated at the beginning of this column, these are a few of the mineral species which particularly turn me on. I'll probably write similar columns about other such minerals in the future.

Good hunting!

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Stamford, Connecticut 06903

What's New in Minerals?

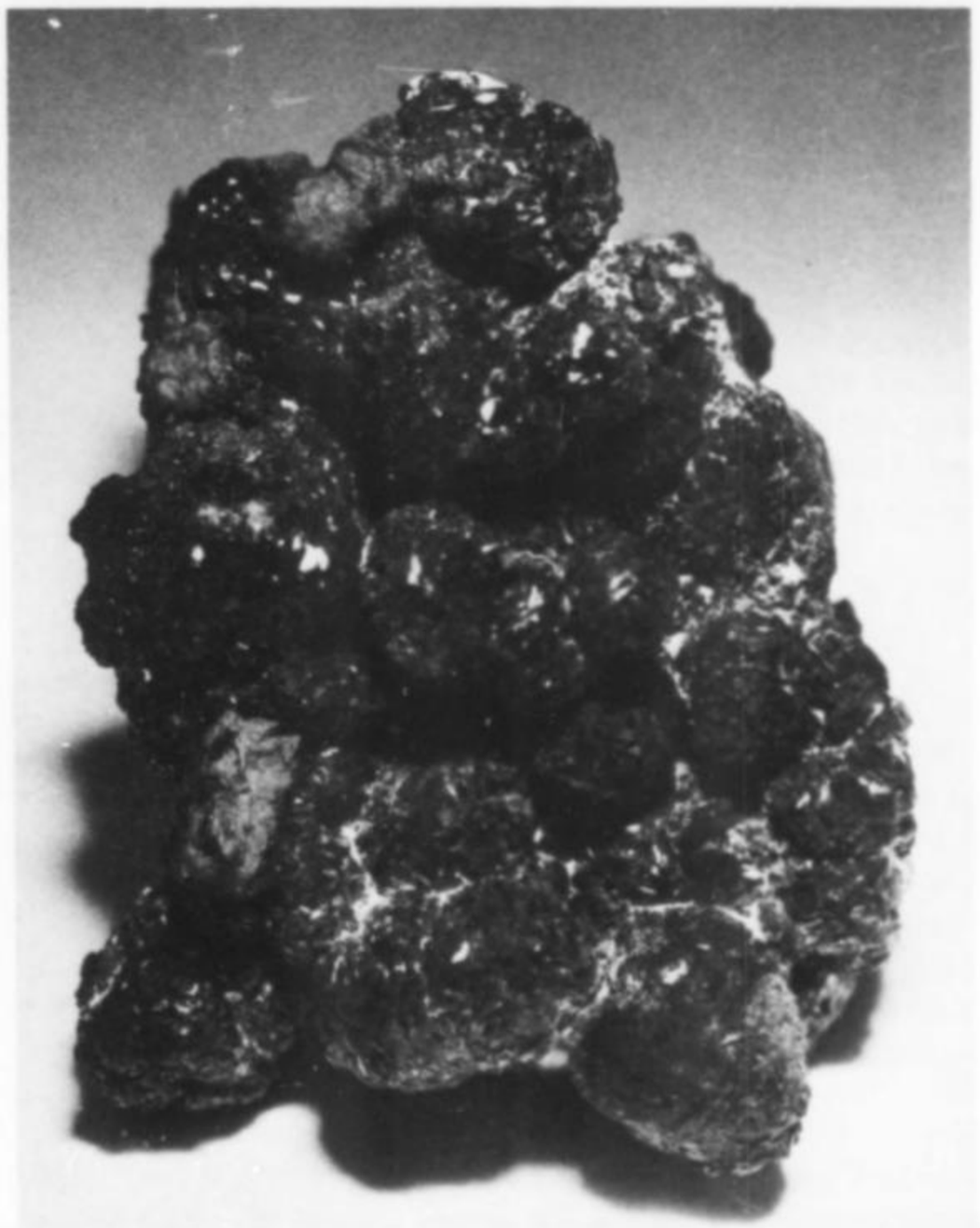
CALIFORNIA FEDERATION SHOW 1981

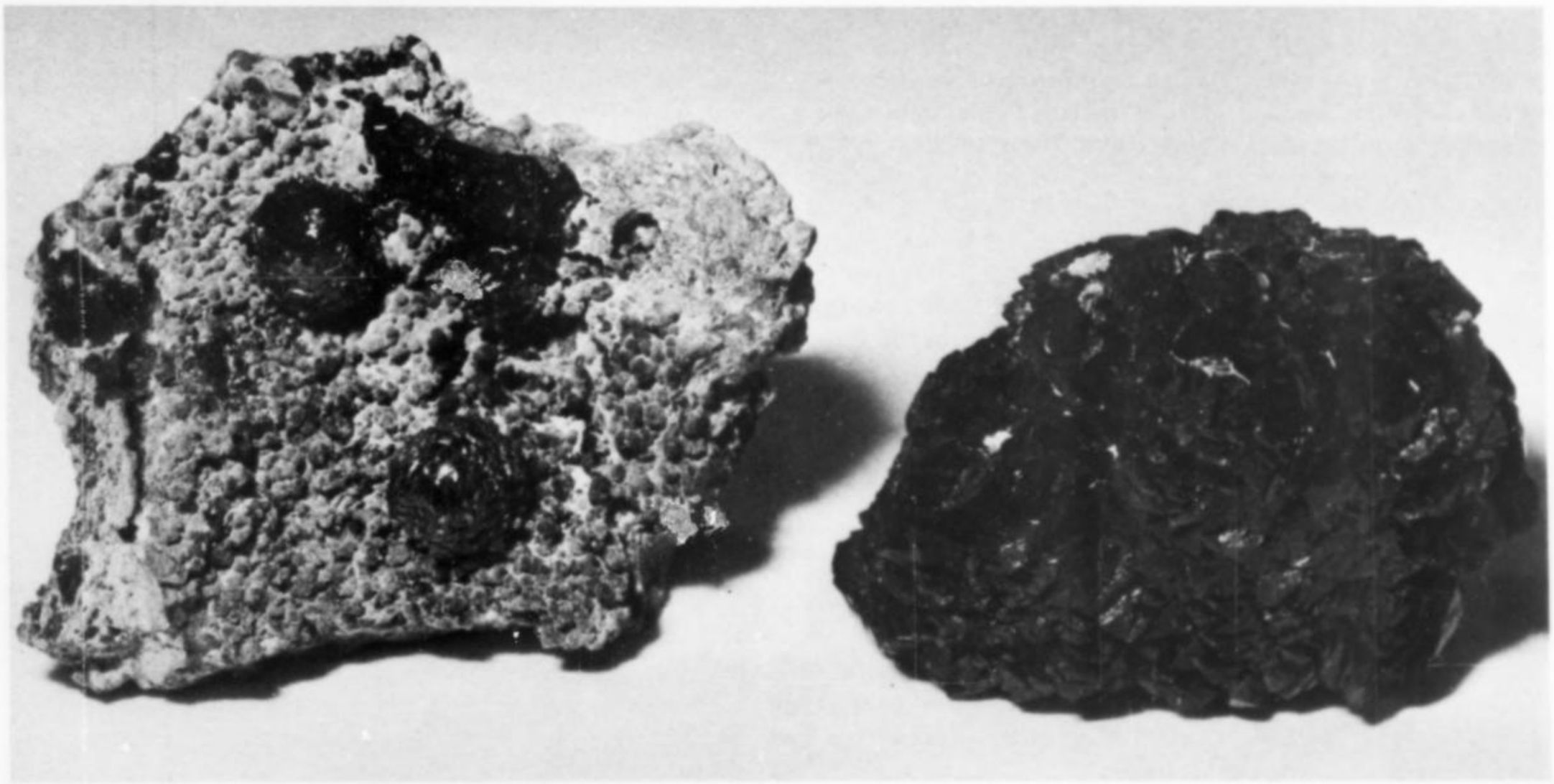
The annual California Federation Show was held in Anaheim this year, just a stone's throw from Disneyland (for those who became bored with minerals), in the large and modern Anaheim Convention Center. The show featured many fine showcase displays, as we have come to expect, and also some relatively new mineral discoveries.

Azurite collectors got to see some specimens from a large (several hundred pieces) new strike in Utah. The locality, named the Blue Grotto prospect, was discovered as an unmined outcrop by a group of collectors; it's situated in Lisbon Valley, near La Sal, in San Juan County. Reportedly the azurite occurred in a kaolinite-filled vein which pocketed repeatedly and which was lined with fine azurite roses, crystal crusts and balls. About 100 feet of the vein were mined, and the collectors involved feel there's nothing left; the tunnel has been caved. Tony Jones of *California Rock and Mineral Supply* (859 Evening Cyn. Rd., Brea, CA 92621) had several flats of the specimens in the wholesale section of the show, and kindly allowed some to be photographed for this column. Other dealers carrying this material include *Bitner's* (in Phoenix), John Seibel (P.O. Box 95, Tehachapi, CA 93561), Curt Van Scriver (6632 Cerulean Ave., Garden Grove, CA 92645), *Artrox* (12496 Montana, El Paso, TX 79935), Marshall Sussman (1217 Michigan Ave., Evanston, IL 60202), and Wayne Thompson (1723 E. Winter Dr., Phoenix, AZ 85020).

Figure 1. **Spherical groups of azurite crystals, the left specimen on matrix about 3 inches across, from the Blue Grotto prospect, La Sal, San Juan County, Utah. Tony Jones specimens.**

Figure 2. **Azurite group, almost 3 inches tall, from the Blue Grotto prospect, La Sal, San Juan County, Utah. Tony Jones specimens.**





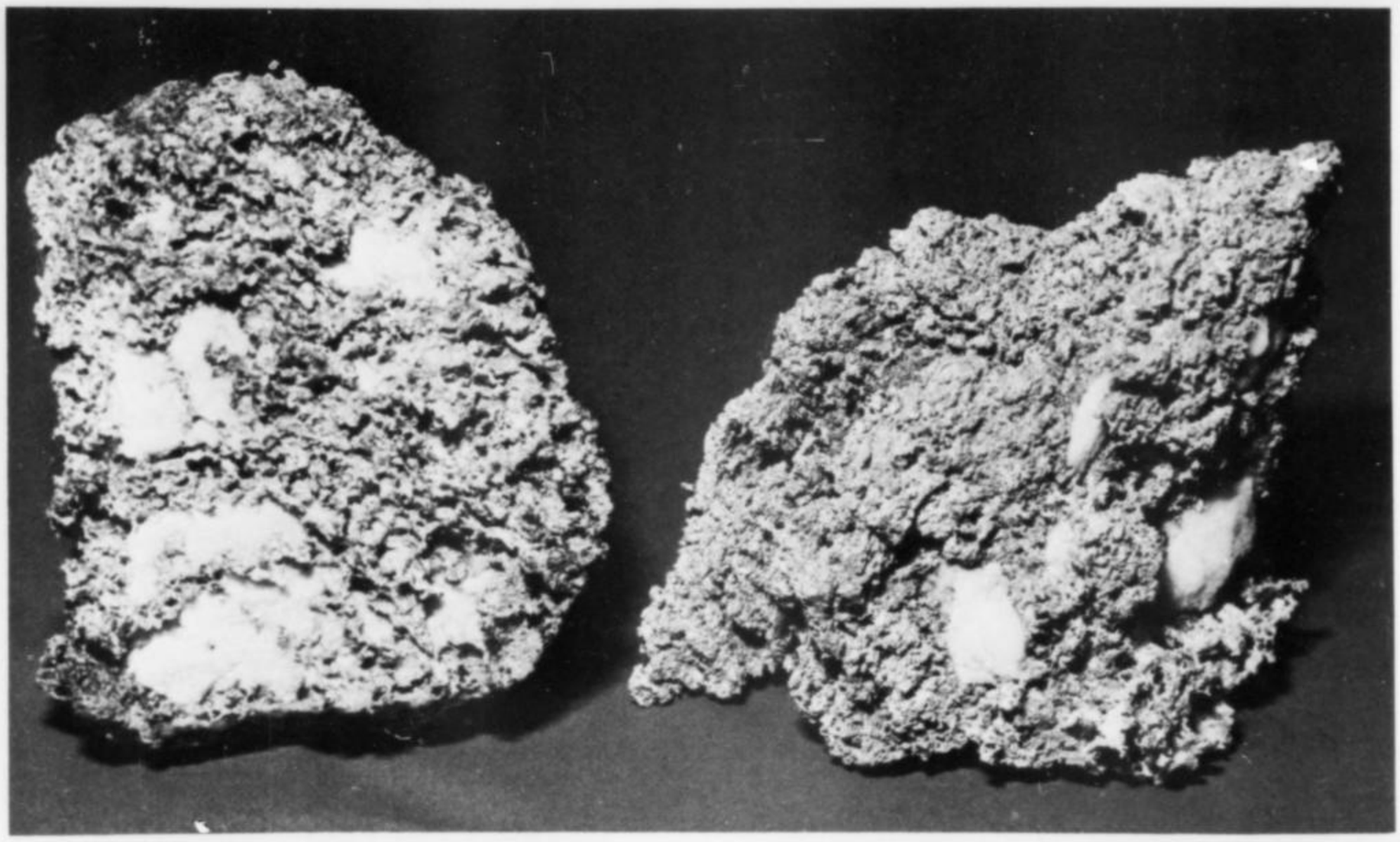


Figure 3. **Sponge gold in white quartz from the Sixteen-to-one mine, Allegheny, California. The specimens are about 4 inches in size. Tom Palmer specimens.**

Gold specimens form a mineral collecting category unto themselves, as most collectors know. The pricing structure is complex, and varies from little above bullion value for equant nuggets, somewhat higher for "artistic" or flattish nuggets, higher still for "sponge" gold, even higher for nice leaf gold and wire gold, and sometimes unbelievably high for fine crystal gold, which is the rarest and most attractive habit. And there are peculiarities regarding the way in which specimens reach the market. Relatively few specimens sold are recent finds; typically they have been saved in a shoebox or safe deposit box until the owner needed money. Furthermore, good gold localities are among the most closely guarded secrets in mineral collecting, for several obvious reasons, and one can rarely be 100 percent confident about a specific locality designation. Quite commonly all one receives with a specimen is the county name. In any case, collecting gold specimens is an interesting and challenging specialty, and one regularly blessed by new lots of specimens on the market these days. Tom Palmer (*Crystal Cavern Minerals*), for example, had about a dozen very nice specimens of sponge gold, cabinet size to small miniatures, from the Sixteen-to-one mine, near Allegheny, California. They have been partially etched out of enclosing quartz, and are fine examples of the habit. Gold from other localities could be seen at the *Kristalle* booth (Wayne and Dona Leicht), and constitutes one of their major specialties. Wayne gave a lecture during the show, showing slides of gorgeous specimens and entertaining the audience with many tales of searching out gold collections to buy.

Coincidence favored the Bunker Hill mine article elsewhere in this issue by providing a sizeable new strike of very fine pyromorphite from that locality in time to be reported here. Most specimens have crystals ¼ inch or larger, and a few thumbnail specimens sported crystals to an inch in size. This, combined with the appeal-

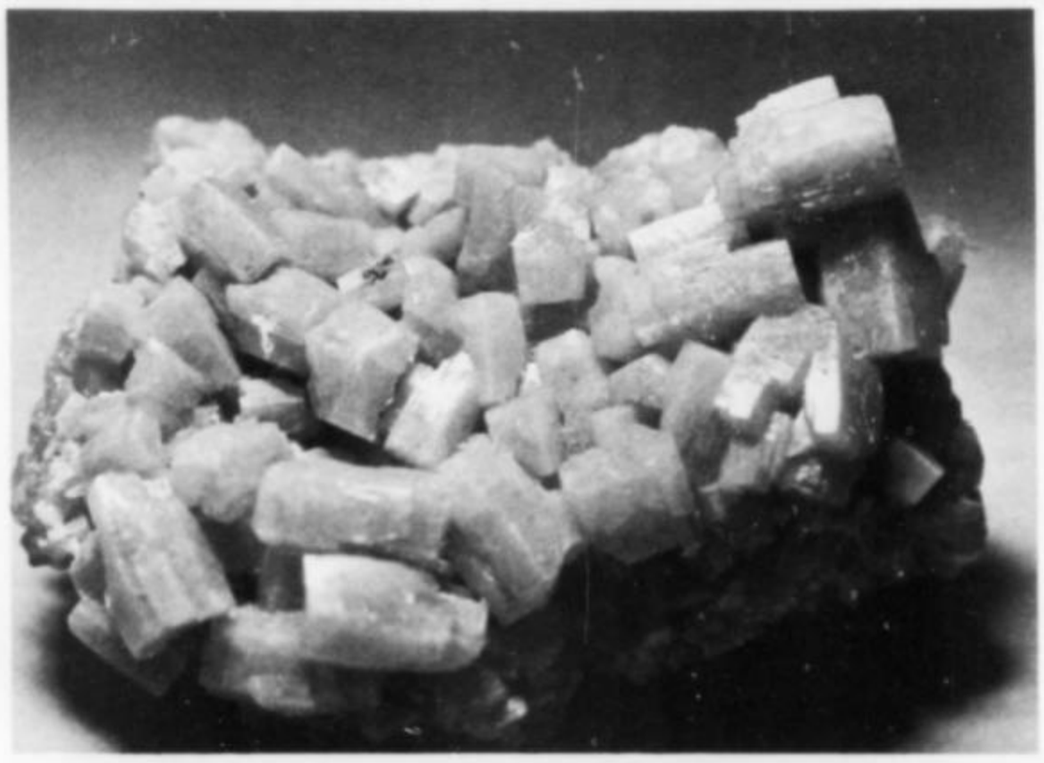


Figure 4. **Greenish yellow pyromorphite crystals to more than ¼ inch from the Bunker Hill mine, Couer d'Alene district, Idaho. Curt Van Scriver specimen.**

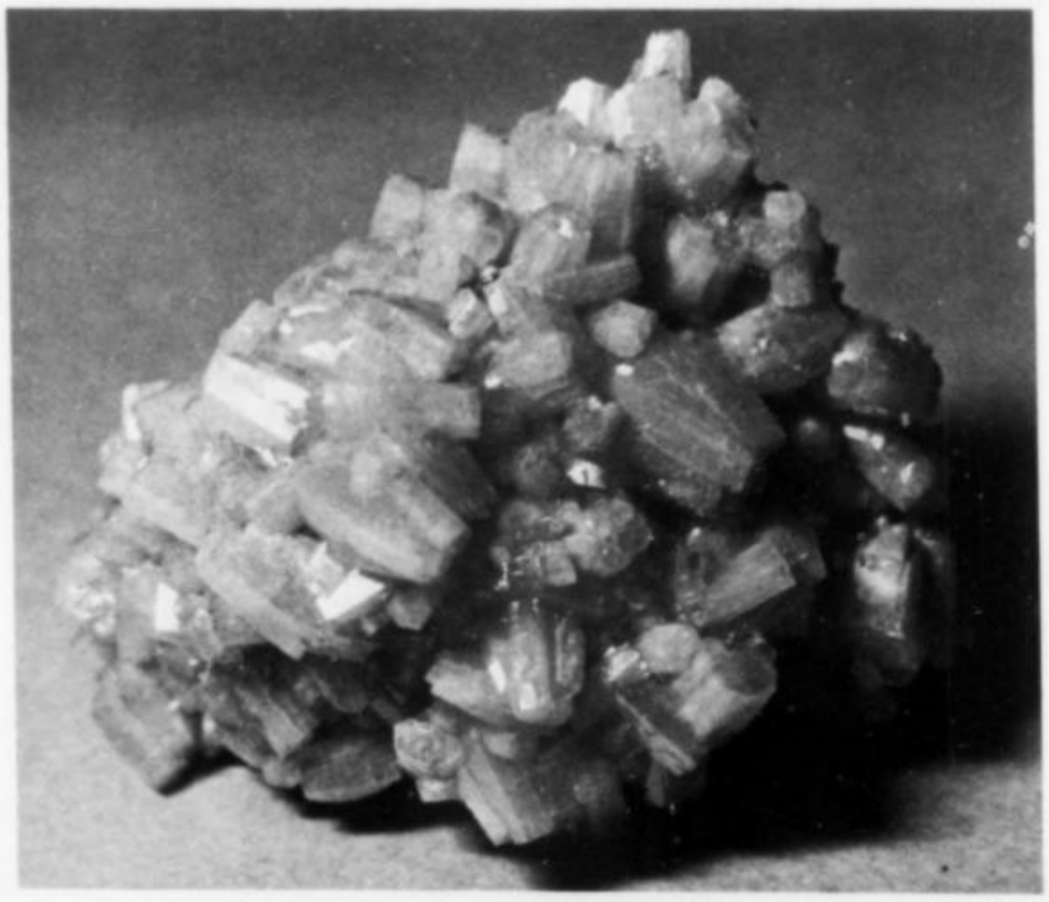


Figure 5. **Greenish yellow pyromorphite crystals to more than ¼ inch from the Bunker Hill mine, Couer d'Alene district, Idaho. Curt Van Scriver specimen.**

ingly clean, bright, greenish yellow color suffices to make these North America's finest examples of the species. Several flats of specimens were found in the 090-23-21 stope, floor 9 (9th level), in the Deadwood-Jersey vein of the Bunker Hill mine, which is located in the famous Couer d'Alene district, near Kellogg, Shoshone County, Idaho. Reportedly some fine specimens of cerussite and anglesite were found as well. Specimens were distributed among several dealers and collectors including Curt Van Scriver, Kevin Davey (89 Stanley Street, Wagga, 2650 New South Wales, Australia), Geary Murdock (628 Whittier St., Idaho Falls, Idaho 83401), Bill Berridge and Harvey Gordon, and Gardner Miller.

Curt Van Scriver has been lucky lately . . . his name keeps coming up in relation to new finds. On a recent trip to Mexico he visited a dealer in Santa Eulalia and saw some peculiar specimens in a case. Other dealers had passed them up, apparently, assuming them to be rather ordinary purple gypsum crystals. Sharp-eyed Curt and Kevin Davy bought most of them (Artrox also purchased some) and ended up with what are easily the largest and best creedite crystals ever found, some crystals exceeding an inch in size. The luster is somewhat frosty on many crystals, and the color is a delicate lavender, but the most remarkably feature is the large and well formed habit of the crystals; collectors are accustomed to seeing creedite in crusts of sharp points less than ¼ inch or so in size. According to one dealer, the miners are on strike in Santa Eulalia, and so have increased their surreptitious collecting to help make ends meet. (Perhaps there is something good to be said for strikes after all.)

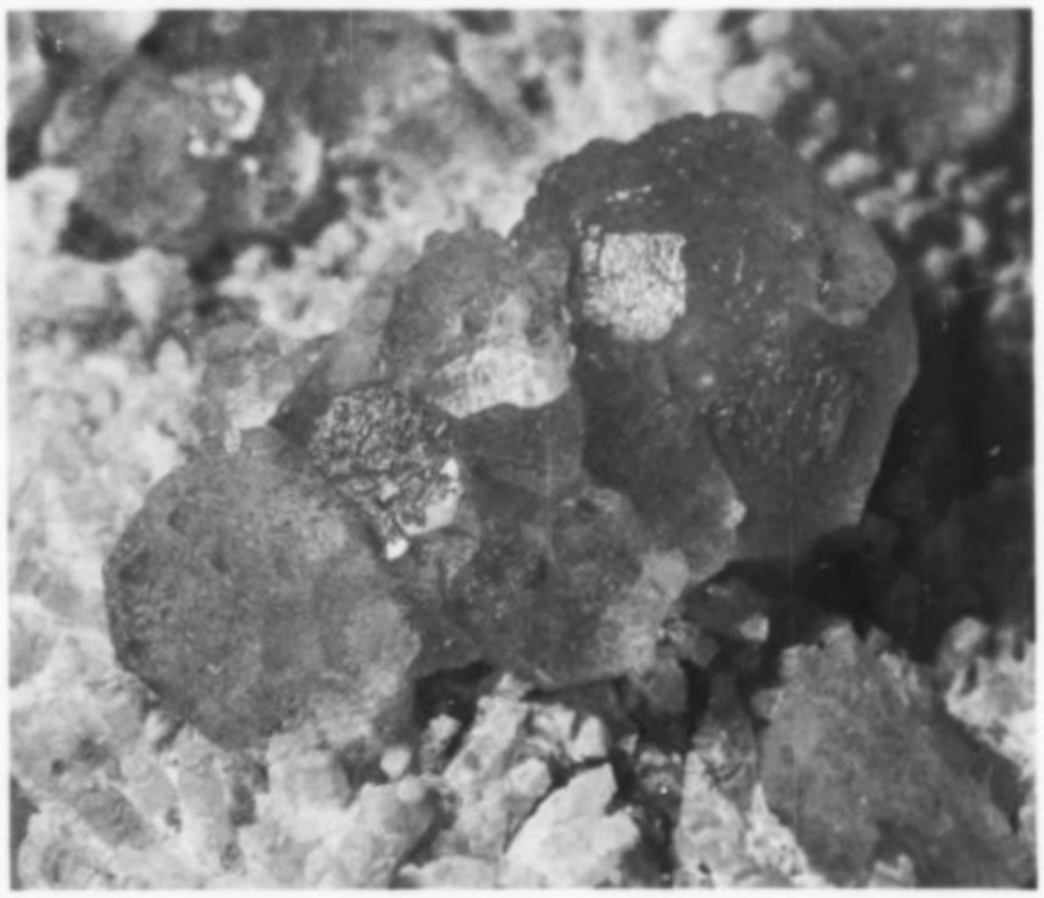
from famous localities and others from unpronounceable and unfamiliar places. These are all from an exchange made with a famous Russian mineralogical museum, and probably represent a one-time opportunity for locality specialists. Also available were some very fine specimens from China, including Cinnabar from Kweichow province, azurite from Guandong province, and stibnite from Hunan province. Write for their list.

When in Southern California one should always visit the Los Angeles County Museum of Natural History. Their display of gold specimens alone is worth the trip, and many hundreds of other fine specimens are there to stir the soul. Visitors from July 4 to September 6 were fortunate enough to also be able to see the temporary exhibit, "Sweat of the sun, tears of the moon: gold and emerald treasures of Colombia." After two years in the planning stage, this exhibit was finally unveiled with nearly all of the world's major emerald crystals brought together (including some that have never before been out of a Colombian bank vault since their discovery), and more than 600 gold artifacts. All of the emeralds are from the Colombian mines at Muzo and Chivor; the largest crystal, belonging to the Banco de la Republica, weighs in at 1796 carats . . . nearly a pound! The beautiful color catalog, available for $10 at the museum and also by mail (plus $1.50 for postage, 60¢ tax for California residents) is the next best thing to being there. (Museum Book Shop, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007. Phone orders accepted: 213-744-3434.)

W.E.W.

Figure 6. **Pale lavender creedite crystals, the largest measuring 1 inch, from Santa Eulalia, Chihuahua, Mexico. Curt Van Scriver specimens.**

Figure 7. **Pale green fluorite crystals to ⅝ inch from Deer Trail mine, Piute County, Utah. Mark and Jeanette Rogers specimen.**



Mark and Jeanette Rogers had a number of specimens from a new find of flourite in Deer Trail mine, Mount Baldy mining district, Tusher Mountains, Piute County, Utah. The crystals are a delicate pale green, and form combinations of the cube and dodecahedron (cubododecahedrons?). Crystals to nearly an inch on a matrix of milky quartz crystals were available in miniature to museum size. (The locality was first given as Sevier County, Utah.)

A large discovery (hundreds of crystals) of red and green elbaite was made at a locality in Minas Gerais, Brazil, reported as Marilac. Despite numerous inquiries I was unable to learn anything more about the locality or who is mining it or even to confirm the locality name. But the crystals are beautiful and abundant. Artrox had more than a hundred (none on matrix), some to 3 inches in size, in either flat or multi-faceted terminations, some as multiple crystals in groups or parallel growths. Perhaps more information will emerge later on this discovery.

Mineralogical Research had for sale a large number of Russian specimens of a kind almost never seen on the market . . . some

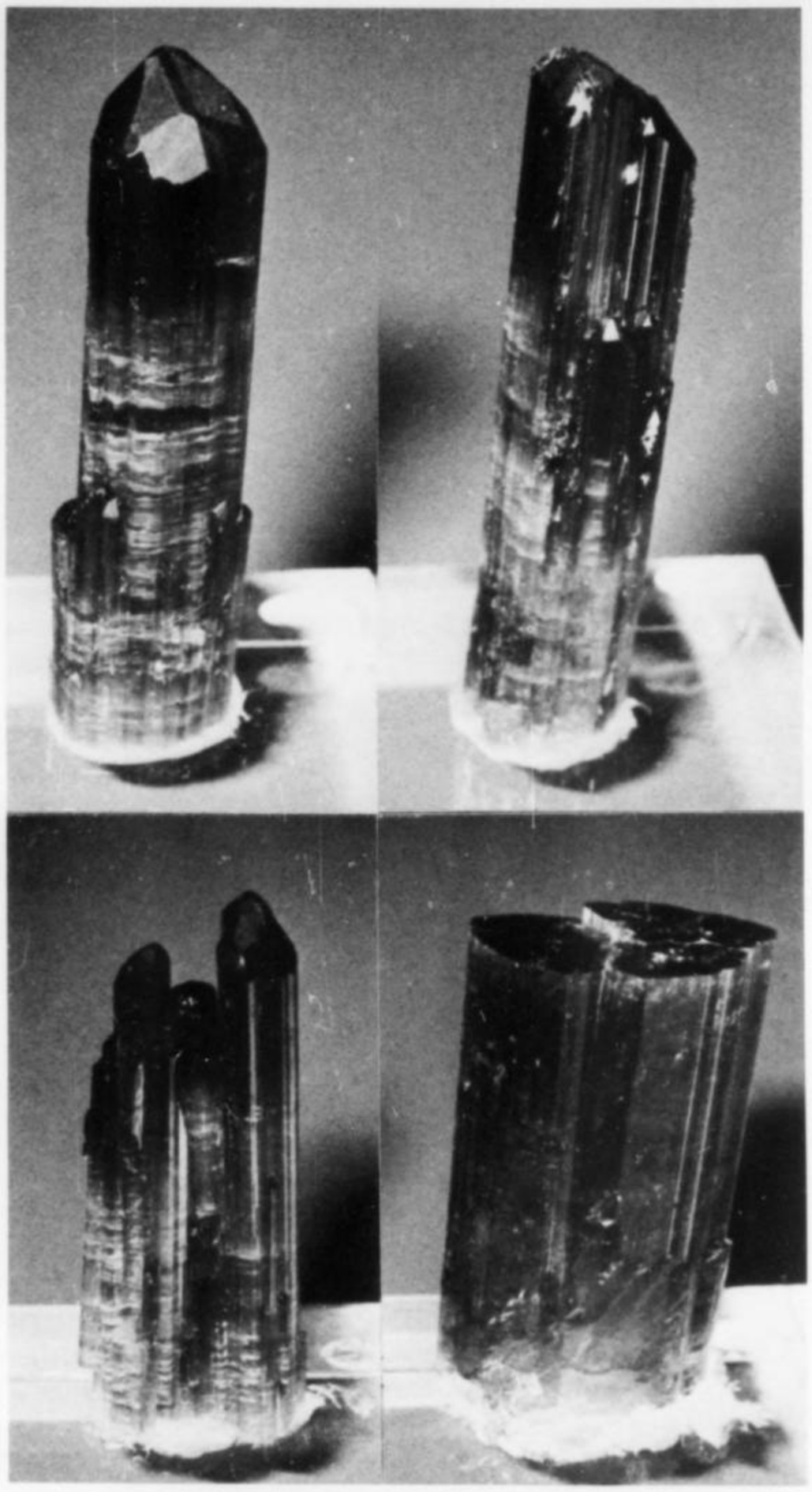


Figure 8. **Red and green elbaite crystals to 3 inches from Marilac, Minas Gerais, Brazil. Artrox specimens.**

ROCHESTER SYMPOSIUM 1981

The 1981 Rochester Mineralogical Symposium, held on April 23–26 at the Hilton Inn on the Campus, Rochester, New York, was one of the most successful and enlightening learning experiences in their 8-year history. The theme of the symposium this year was "Early American mining and mineral localities."

Beginning with a Thursday evening presentation by Ron Bentley entitled "The life and times of Henry A. Ward," the symposium continued the next morning with an in-depth delivery of "History and mineralogy of the Amelia mine, Boleo, Baja California Sur, Mexico" by Ed Swoboda. Other lectures covered "Early mineral localities of New Jersey" by Charles Key, "The development of the Harvard mineralogical collection" by Carl Francis, "Early gold mining in California" by Sharon Cisneros, and "Early Pennsylvania mineral localities" by Paul Desautels. Saturday's morning program covered "What's new in minerals and localities," a panel discussion moderated by Bill Pinch, with several of the speakers taking part, as well as audience participation and exchange of information on new finds, new collecting areas, new minerals recently described, and current status of many older areas of interest to mineral collectors. Special topics of discussion were the new azurite roses and stibnite crystal specimens coming out of the People's Republic of China, veszelyite from the Black Pine mine, Philipsburg, Montana, new finds made as Tsumeb, Namibia (including fantastic azurite, germanium minerals, mimetite, and the current status of the operation of the Tsumeb mine), pink fluorite from Peru, and the new species ojuelaite from Mapimi, Durango, Mexico, to name only a few. The Saturday lectures continued with a sketch covering "Mineral collecting in Arizona before 1900" by Richard Bideaux, Paul Desautels on "Early American mineral collections in the Smithsonian," and the evening auction—one of the high points of the symposium.

In order to support the RAS Symposium, donations are solicited and an auction is held each year to secure funds for assistance in covering expenses. The auction, then, is well attended and this year nearly 70 separate items were donated. The variety of goodies generously donated ranged from mineral specimens to old mineralogical books and publications (some quite rare and valuable), maps, posters, and various other items of related interest including some very worthwhile cut gemstones. The auction was extremely successful this year, and Bill Pinch, one of the co-chairmen of the symposium and its well known auctioneer, reported the symposium will continue with their high standards of topic selection and exceptional programs presented by such expert speakers as were mentioned earlier.

The Sunday morning speakers were George Robinson and Steve Chamberlain covering a very detailed presentation on "Early mineral localities of New York," followed by a panel discussion led by Bill Pinch on "Classic American localities," again with audience participation and many of the guest speakers present to offer information.

Many notable displays were set up for viewing during the course of the symposium. Special exhibits containing mineral specimens from some of the older Eastern U.S. localities included superb selections from now depleted historical areas such as Texas, Lancaster County, Pennsylvania, and the Wheatley mine at Phoenixville, Pennsylvania. Contemporary and old specimens were exhibited from many New York state localities, and there was a special exhibit of many fine old specimens from the Cornwall and Cumbria mining districts in England.

One floor of the Hilton Inn is reserved for mineral dealers and, as at the Tucson and Detroit shows, one can pursue mineral purchases with the 20 or so mineral dealers present until on into the wee hours of the morning if desired. Many Eastern U.S. and Canadian mineral dealers, as well as dealers from as far away as California and Arizona, with minerals from worldwide localities, were on hand with excellent selections. Two items will be refreshing for the serious mineral collectors—no lapidary dealers present, and no selling is allowed during the lectures. This latter stipulation allows the dealers to attend the lectures too, and preserves the basic high level of reputation this symposium has among both amateurs and professional mineralogists.

The RAS Symposium continues to be a valuable meeting place, and presents an excellent opportunity to get together at this time of the year to discuss minerals, old localities, and new developments of interest to all. If you have not attended the symposium in the past, you should plan on it for April 1982. Contact Georgianna Apolant (41 Eastbourne Road, Rochester, NY 14617) for details. If you attended the 1981 symposium, we know you'll be back! With such an impressive amount of information available, the chance to meet with friends, and the opportunity to learn—all of this activity going on in one location—you can't afford to miss it. See you in Rochester in 1982!

Sharon Cisneros

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Letters

BALD KNOB MEMORIES

Dear sir,

I particularly enjoyed the recent (May–June) issue of the *Record*. The article on the manganese minerals of Bald Knob, North Carolina, brought back memories of our visit there in the early 1950's. We were trying to locate some galaxite which we, not surprisingly, associated with the town of Galax, Virginia. That's where we went, asking all manner of people about the existence of a manganese deposit in the township. Finally an elderly resident, to whom we had been sent by the sheriff, told us that following the Civil War the state boundaries of Virginia and North Carolina had been slightly changed, and the town of Sparta, near the mine, became part of North Carolina. We soon found the locality, after meeting the owner of the property in a drug store in Sparta. We didn't find any galaxite but we did find many of the other minerals.

Curt G. Segeler
Brooklyn, New York

THE PINK FLUORITE COVER

Dear sir,

The metallic luster and general morphology of the crystals upon which the fluorite octahedra are so jauntily perched lead me to suspect that the crystals are actually galena, and not sphalerite [as the cover caption states].

Ed Huskinson, Jr.
Denver, CO

Dear sir,

Beautiful cover on the May–June issue. Never seen such cubic sphalerite before. Sure does bear a striking resemblance to galena.

Jack A. Crowley
Newark, CA

Dear sir,

The cover of the May–June issue is outstanding. The pink fluorite shown is a real beauty. [However,] the prominent cubic form of the crystals would be far more characteristic of galena. Is it really cubic sphalerite, or galena? Or perhaps a mixture of both? I realize that it is difficult to identify minerals from photographs, but since the *Record* is relied upon by most collectors as "the authority" I would appreciate clarification.

Gene L. LaBerge
Oshkosh, WI

Dear sir,

I am sure I will not be the first or only person to suggest that the fluorite (on the May–June cover) must be on galena, not sphalerite. There may be some sphalerite present, but the galena is the obvious mineral, possibly with some pyrite.

Paul W. Zimmer
Rhinelander, WI

Ahem. Just wanted to make sure you're paying attention. Actually the cubic crystals are pyrite, but with a coating of some grayish metallic mineral, possibly sphalerite. Near the top-center of the specimen are some small crystals which may also be sphalerite or perhaps tetrahedrite. (But no galena.) The piece, incidentally, is now in the Smithsonian collection. *Ed.*

Dear sir,

You did a nice job on the cover with the Peruvian fluorite. I cannot, however, take full credit for the piece as I had lots of help from my friend Curt Van Scriver (of Van Scriver's Minerals in Garden Grove, California) who accompanied me to Peru when we obtained this piece and a few others in December of 1980. I would also like to thank Mr. Rock Currier of Jewel Tunnel Imports for his enthusiasm and frugality, without which we may not have been able to obtain the few fine specimens we did.

Tony Jones
California Rock & Mineral
Duarte, CA

THE RUBELLITE COVER

Dear sir,

I was absolutely appalled to see the *hand* on the March–April cover, which is in the photo either because of the tourmaline ring being worn, or to support the specimen. I did not realize that the *Record* had changed its format to that of an artsy-craftsy magazine. I strongly believe that if such an aspect is introduced into the *Record*, the original intent of the magazine has been violated.

Bob Stewart
Canon City, CO

Let me assure you that the hand was present neither to show off the ring nor to support the specimen. It was there solely for scale. We felt that the specimen was so superb and so unbelievably large that most people would assume it was thumbnail or miniature size without bothering to check the cover caption. With the hand beside it, the specimen's size is immediately and strikingly apparent to everyone. *Ed.*

BOLIVIA CRACKS DOWN

Dear sir,

For the last few years I have been obtaining some fine minerals from Bolivia. These have included pink apatite, crystallized faustite, fine arsenopyrite crystals, wolframite with Japan-law quartz twins, superb vivianite crystals on a matrix of childrenite, and some really incredible plates, up to 9 inches across, of dark blue crystallized vauxite which transcend anything found before.

Since the last governmental change in Bolivia, my partner there, a Bolivian national, has been unable to procure any more specimens. He writes:

"In an effort to diminish the excessive theft of minerals (in excess of $20 million per year) the Bolivian government has issued a Supreme Decree which makes the illegal transport of minerals a very serious offense. All of the Comibol (nationally owned) mines are under marshall law. Theft of minerals is met with confiscation of *all* personal property, and the suspension of civil rights."

Richard A. Kosnar
Golden, CO

MINYULITE FROM AUSTRALIA

Dear sir,

As a result of Bill Henderson's excellent column in the March–April issue, most readers are now aware of minyulite crystals from South Australia. Until recently, the mineral had been fairly rare at St. John's phosphate quarry, which is situated about 6 km east of Kapunda and was first opened in 1903. The quarry cuts a large marble and limestone bed, the marble commonly carrying blue apatite crystals to 2 cm.

I have been collecting at St. John's for about nine years, often feeling lucky if I came home with one reasonable wavellite specimen after a day of work. This changed about two years ago when wavellite and crandallite became more common there. Around Christmas of 1979, Barry Porter of Berri found a small boulder containing minyulite crystals. (I had found minyulite at Moculta five years earlier, and at Tom's quarry in 1978, where it was associated with fluellite crystals.) The St. John's minyulite differed from the other occurrences in that the crystals were found free-standing. Despite subsequent searches at the quarry, however, minyulite proved very elusive.

In November of 1980 the contractor operating St. John's quarry informed me that he had encountered a zone of wavellite, so a couple of days later I drove the 60 km to St. John's to investigate. The zone is quite large,

and proved to be a minyulite zone. It was lenticular in shape, about 30 m wide, 15 m deep, and probably 6 m long in an east-west direction. Minyulite was found in vugs within veins dipping north.

In less than two hours I picked up over 100 specimens varying in size from 2 by 2 cm to 10 by 20 cm, most of them superb. Since this zone was found I have been leading clubs in to collect every two weeks or so, and anticipate two or three more trips will be possible before the zone is mined away. Many hundreds of really good specimens have been taken out, some of which have gone to dealers in the States. Though I am not in favor of fossickers [= *rockhounds. Ed.*] selling specimens (it is illegal in South Australia), I don't really condemn it because it is often the only way most collectors can obtain some specimens.

Another mineral of interest is fluellite, which, as I said, I found at Tom's quarry, a short distance from St. John's. Recently found crystals differ from previous finds in being pinkish to reddish, or colorless and transparent with pink to red zoning. Also from Tom's quarry have come specimens of orange and apricot-colored wavellite, two previously unknown colors for wavellite; these are very rare at Tom's, with probably no more than 100 small specimens being found.

Vince Peisley
23 Dorset Street
Brahma Lodge, South Australia 5109

LUNING, NEVADA

Dear sir,

Regarding the article on magnesioaxinite (*Mineralogical Record,* Vol. 11, page 13, 1980), I'm puzzled about the connection between the magnesioaxinite and the artinite "near Luning, Nevada."

The locality, Luning, is a small town with a population of about 50 people. The nearest larger towns are Hawthorne, 25 miles west; Mina, 9 miles southeasterly; and (within the last 40 years) Gabbs, 30 miles northeast. In one sense, then, "near Luning" includes several hundred square miles and numerous mines and mineral localities. Luning lies on the edge of a large playa (Soda Spring Valley). For miles in each direction, there is only surface alluvium (the nearest surface bedrock is about 2 miles to the southwest). Hence, bedrock mineral localities are not too close to Luning.

Regarding the axinite group, John Melhase's 1935 article on axinite (*The Mineralogist,* Vol. 3, No. 7, page 4, first paragraph) refers to a "black hill." This "black hill" is north 18 degrees west (azimuth 342) and about 6.5 miles from Luning. The roads cited by Melhase are now largely changed. The "black hill" is a stock of granodiorite immediately rising from the southerly alluvium pediment. In the granodiorite, several prospect workings show narrow quartz veins associated with fibrous schorl and platy hematite but no axinite. However, northerly from the stock area there are some east-west series of contact metamorphic minerals along the dolomitic limestone. Nearly 30 years ago, by tracing float, I found one axinite group occurrence about ½ mile northwest from the "black hill." It had been covered up and I had no pick and shovel at hand to dig it up. I never returned. I don't know if that is the subject of magnesioaxinite "near Luning" or not.

Regarding the artinite and associated brucite, Melhase further wrote (*op. cit.*) "There is a very large deposit of brucite in Section 36 of Township 12 North, Range 36 East, about 30 miles northeast of Luning that may also be visited while in this locality." Shortly thereafter crude brucite was shipped by truck to Luning and transferred by rail to Maple Grove, Ohio, for steel refractories and to Oakland, California, for epsome salt. About 500,000 tons of crude brucite was shipped until 1950 when it was largely supplanted by dead-burn magnesite. In 1946 Dr. Hurlbut (*American Mineralogist,* **31**, 365) wrote "In the fall of 1942 Mr. Alan B. Shaw brought to the Department of Mineralogy at Harvard University a suite of specimens collected from the then recent workings of Basic Magnesium Inc. at Luning, Nevada. Most of these were brucite similar to that mined and shipped for calcining to MgO. In addition to the massive brucite there were several specimens of vein material. Mineralogically, the vein proved to be made up of hydromagnesite, brucite and artinite."

In 1937 Basic Refractories, Inc. controlled the brucite deposits and shortly thereafter a large part of the magnesite deposits in and adjacent to Sec 36, T12N, R36E (see Melhase, *op. cit.*). In 1941–44, Basic Magnesium, Inc. (a government-owned operation) temporarily took over, including the lands, to convert magnesite to magnesium metal for the war effort. In 1942, the brand new town of Gabbs was largely unknown so it was common to refer to the mines as *Basic Magnesium, Inc. at (or near) Luning!* And, at that time, one could collect specimens at the brucite stockpiles at Luning! For a more general article on brucite, etc., see Victor E. Kral (Mineral Resources of Nye County, Nevada, Vol. XLV, No. 3, pages 104–108, January 1951).

In view of the foregoing, it is my opinion that a more accurate description of the locality of the brucite, artinite and hydromagnesite would be:

Sec 36, T12N, R36E
Brucite Upper Pit
2 miles east of Gabbs
Nye County, Nevada

In addition to the listed references, I have also drawn upon my own experience when I was a geologist for Basic Refractories, Inc. at Gabbs in 1950–56. I'm sorry that I did not elaborate on the artinite locality years ago.

Hatfield Goudey
San Mateo, CA

THEFT AT WRIGHT'S

Dear sir,

In March of 1981, at the Phoenix Gem and Mineral Show, the following minerals were stolen from Wright's Rock Shop.

(1) A Moroccan azurite, 3 by 3 by 2½ inches, with excellent crystals and color.

(2) An apophyllite on stilbite from India, with good green apophyllite and white stilbite, 3 by 2 inches.

(3) One Pakistan aquamarine, a very transparent, 1 by 3 inch crystal.

We are offering a $1000 reward for recovery of the specimens, and an additional $1000 reward if a conviction of the guilty party results. We have two witnesses who saw the probable thief near the specimens at about the time of the theft. If you have any information concerning this theft please call 501-767-4800 collect, or the Phoenix Police Department, or write directly to Wright's Rock Shop.

Chris Wright
Wright's Rock Shop
Route 4, Box 462
Hot Springs, Arkansas 71901

BROKEN HILL, ZAMBIA

Dear sir,

The article on Broken Hill, Zambia (Vol. 11, p. 339) by Norebaart and Korowski brought back memories of my own collecting days there. I visited the No. 2 open pit many times until eventually being shown off by the mine police, but my visits were rewarded by collecting excellent specimens of tarbuttite and zincian libethenite. I also found specimens of phosphophyllite, barite, apatite, and hydrozincite, none of which were mentioned in the article. The phosphophyllite specimens, consisting of minute crystals liberally coating tarbuttite, were identified for me by the Geological Survey in Lusaka. In addition to the minerals already mentioned, other minerals which have been found at Broken Hill include clausthalite, zincite and veszelyite, although only the latter is mentioned by Dana.

C. M. Leppington
"Jaythorpe," Wreay
Carlisle, Cumbria, England

EXCHANGES

I have many fine, small to medium cabinet-size minerals (all well crystallized) from Quebec and Ontario which I wish to trade. These include apatite, diopside, biotite, hornblende and fluor-richterite. I am looking for only well crystallized cabinet specimens (suitable for the advanced collector), preferably of uncommon to rare species. All serious inquiries welcome.

Curt McKee Selby
122 7th Avenue
Brunswick, Maryland 21716

ERRATA

Dear sir,

Regarding the *Microminerals* column by Bill Henderson in the March–April issue, dealing with Australian minerals, I wish to make an important correction.

The article refers to Jim Johnson as Curator of Minerals at the South Australian Museum, when actually he is an Honorary Associate. We are certainly proud to have Mr. Johnson, a leading authority on South Australian minerals, associated with us. However, the implication was that the South Australian Museum itself is officially engaged in exchanging microminerals, when in fact Museum Board policy forbids it. Therefore, any exchange of specimens or correspondence with Mr. Johnson is strictly for his own private research and does not involve the museum.

John K. Ling, Director
South Australian Museum, Adelaide

[Regarding the new batch of Silver from the New Nevada mine, Batopilas district, Mexico, mentioned in the May-June 1981 "What's New in Minerals?" column] you state that Tony Otero and other dealers acquired some of these specimens through Artrox. In 1976 I did acquire some specimens from that mine through John Whitmire [of Artrox]. However, while I have some very fine specimens from the new batch, I did not acquire them from Artrox; I have my own source.

Tony Otero
Magdalena, New Mexico

In our article on mineral fakes in the July-August 1981 issue, the emerald in Figure 15 is credited to the Miriam and Julius Zweibel collection. This was an error; it is actually an American Museum of Natural History specimen and was never owned by the Zweibels.

Pete J. Dunn
Washington, D.C.

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Any article of potential interest to amateur mineralogists and mineral collectors will be considered for publication. Articles on *famous mineral localities* and collector-oriented *descriptive mineralogy* are particularly welcome.

Authors of papers at the professional level may refer to guidelines published by the *American Mineralogist* regarding any questions or conventions not discussed below.

(1) When beginning work on an article, write to the editor informing him of your chosen topic. This topic will then be reserved for you, and you need not worry about someone else submitting an article on the same topic before you have completed your work. Your reservation of the topic will be valid for six months.

(2) All manuscripts must be typed and double-spaced, on 8½ x 11-inch paper. Do not use script type or all-caps style.

(3) Figure captions should be typed together (rather than individually on figures) to make typesetting easier.

(4) Photographs are eagerly solicited with articles. Photos must be approximately 5 x 7-inch **glossy black and white prints.** (Check with the editor before submitting color photography.) Submit photos in individual, numbered envelopes; do not place glue, tape, or writing on either the front or back of photos.

Every mineral photo should be accompanied by the following information in the caption:

(a) Species ***name*** and ***locality***
(b) Specimen or crystal ***size*** (not magnification power)
(c) Specimen ***color***
(d) Specimen ***owner***

Other optional data that may be in the caption include the credit for the photographer, crystallographic details, and the specimen's history.

NOTE: *If authors have difficulty obtaining photos of specimens, the editorial board may be able to supply photos as needed. An article should be written and approved by the editor before photographs can be solicited from the editorial board.*

(5) Locality articles published in the *Record* generally have similar structure, and include the following sections:

(a) ***Introduction*** (discusses the significance of the locality to collectors, its precise location, and other details)

(b) ***History*** (discovery and mining or collecting history, including mention of particularly significant specimens, veins or pockets, the history of ownership, and the current collecting status.)

(c) ***Geology*** (a brief overview of the important geologic features of the setting and the deposit, especially as applies to the origin of the deposit.)

(d) ***Minerals*** (a discussion of each species found there, with emphasis on those favored by collectors. Best specimens, rarity, important discoveries, typical characteristics, descriptive mineralogy.)

(e) ***Discussion*** (theories on the origin of the deposit, paragenesis, mineralogical peculiarities, etc. All speculation should be reserved for this section; other sections should be strictly factual.)

(f) ***Acknowledgments***

(g) ***References*** (All articles should be thoroughly referenced.)

Locality articles generally benefit by having a **locality map** or two, possibly a general **geology map,** a photo of the locality, and photos of good specimens of as many minerals as possible.

(6) References: All references must follow *Record* format:

(a) Author(s) name(s) all in capitals, initials following each name.

(b) Year of publication in parentheses.

(c) Title of the article, first letter only capitalized except for proper nouns and foreign language titles, followed by a period.

(d) Journal title completely spelled out (no abbreviations), and underlined, followed by a comma.

(e) Volume number with a wavey underline, comma, page numbers, period.

An example of correct reference form is as follows:

LAIRD, J., and ALBEE, A. L. (1972) Chemical composition and physical, optical and structural properties of benitoite, neptunite and joaquinite. American Mineralogist, 57, 85-102.

(7) Numerical tables. Camera-ready numerical tables are requested where such tables are absolutely necessary; numerical tables are discouraged where the data can be presented in summarized form within the text. Tables of X-ray data will not be accepted unless markedly different from existing data, or entirely new.

(8) Authors should give their complete mailing address, including zip code, under the article title.

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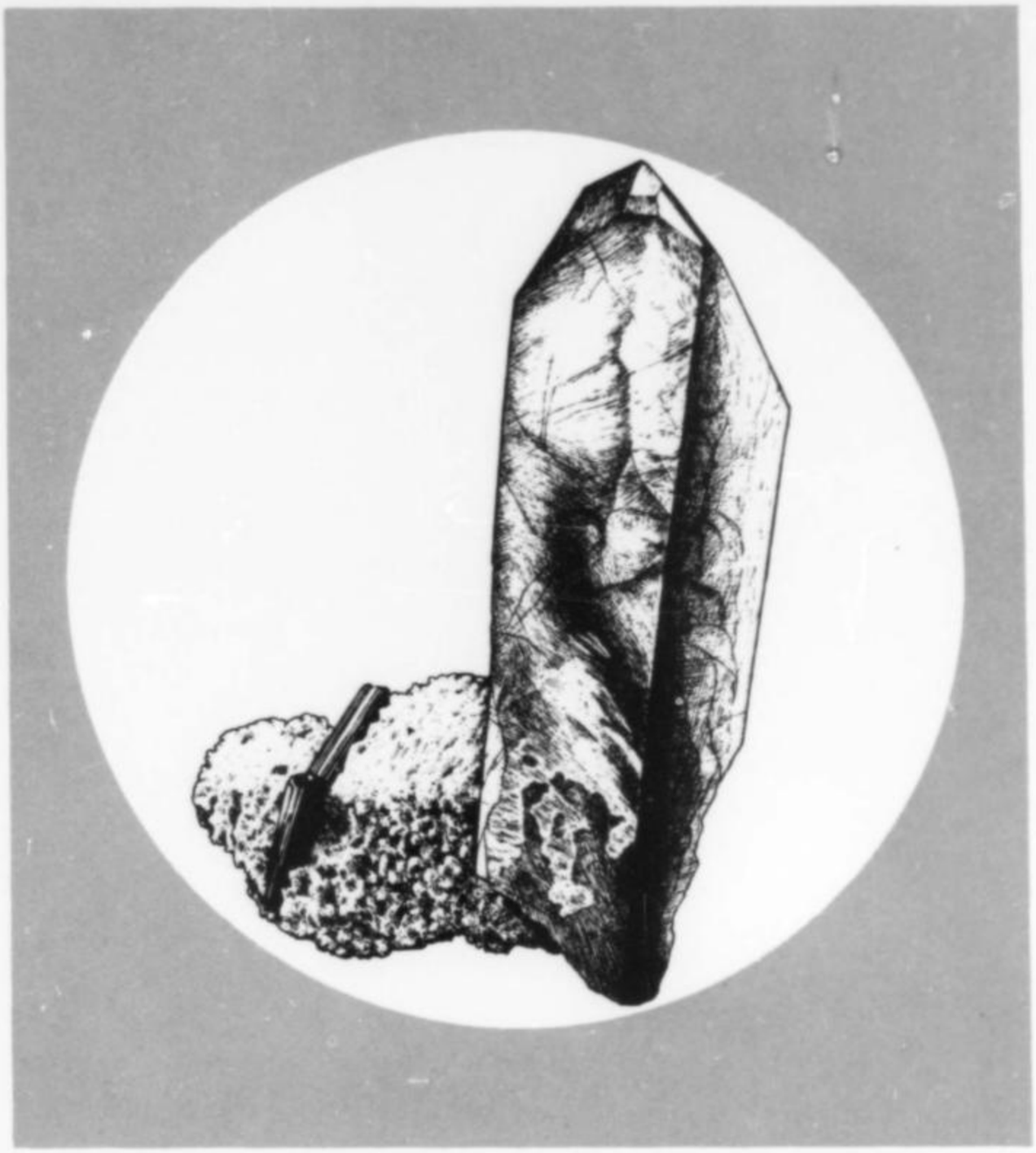

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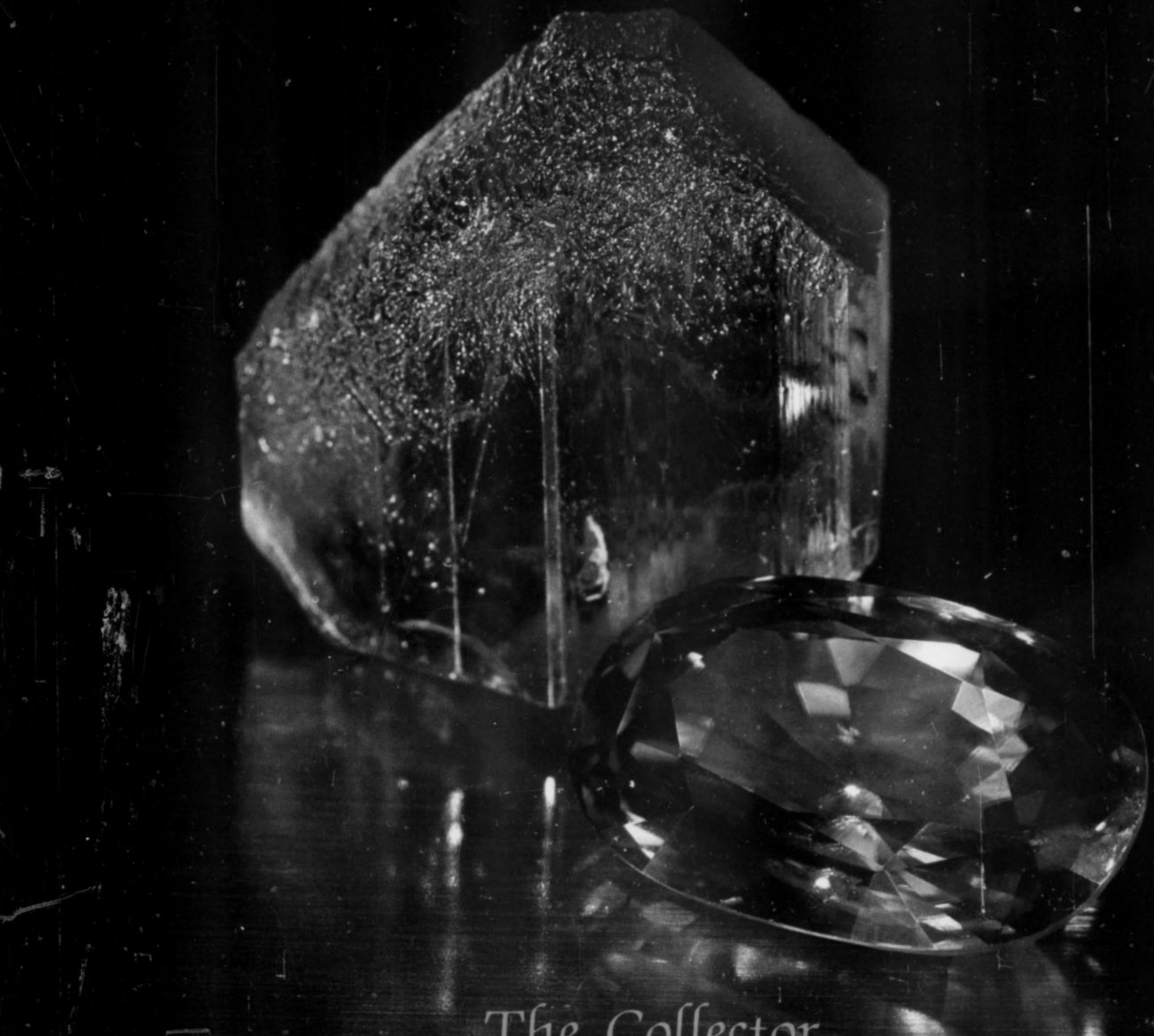

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