THE MINERALOGICAL RECORD

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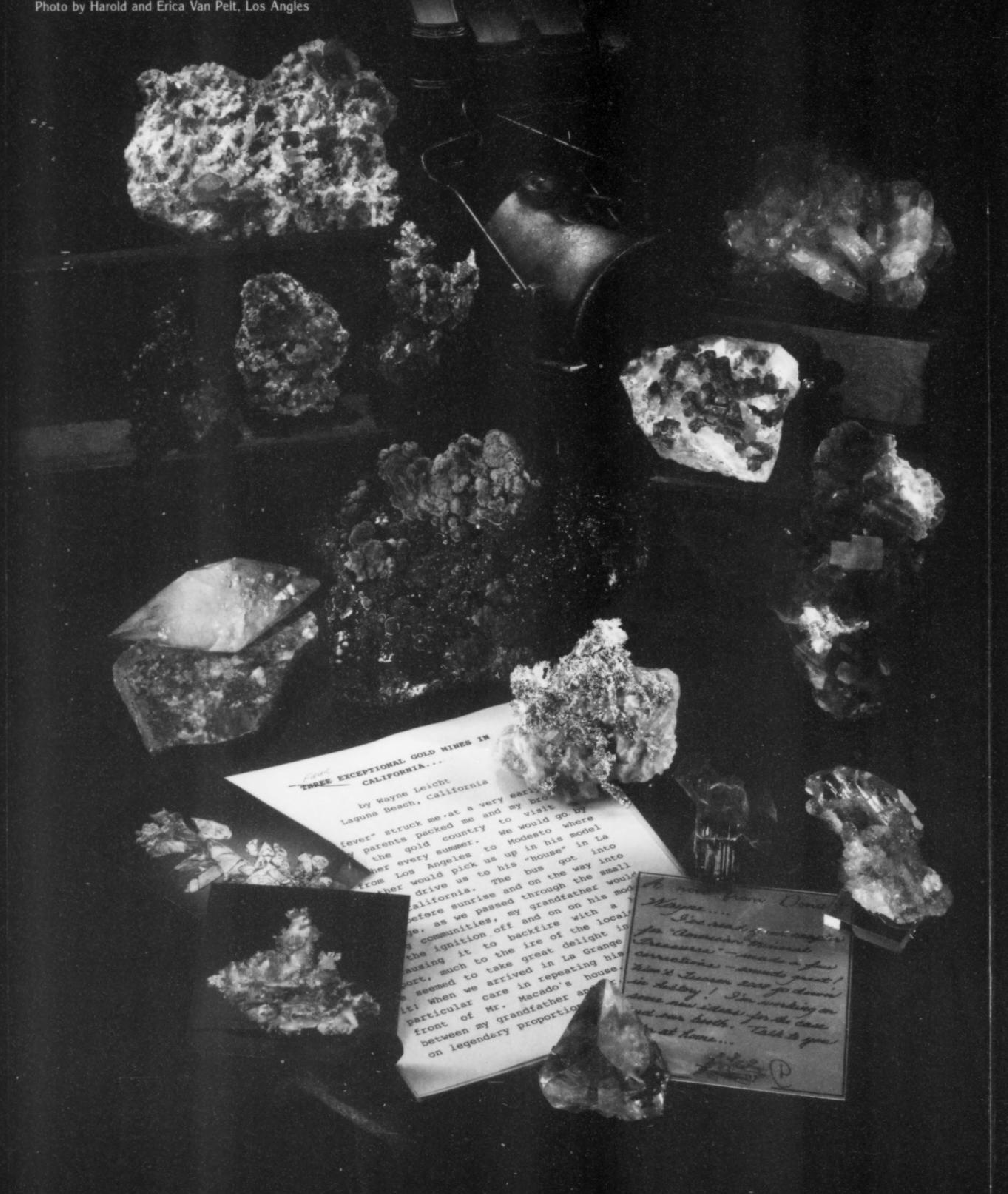
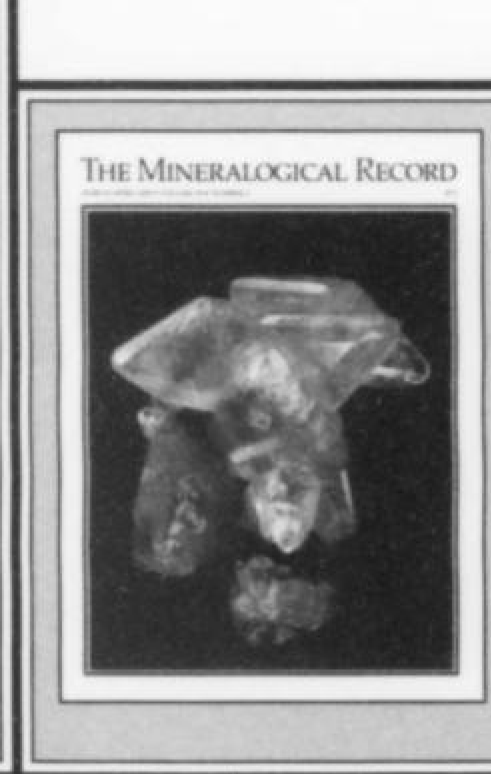


THE MINERALOGICAL RECORD

March–April 2008 Volume Thirty-nine, Number Two

Articles

Columns



COVER: CALCITE (Co-rich) crystal cluster, 3.5 cm, from the Mashamba West mine, Katanga, Republic of the Congo. Rob Lavinsky (The Arkenstone) specimen, ex Gilbert Gauthier collection; photo by Jeff Scovil. For more on this locality see the article by Lhoest *et al.* in vol. 22, no. 1 (1991).

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*Continued on p. 162

notes from the EDITORS

New *Glossary* is Out!

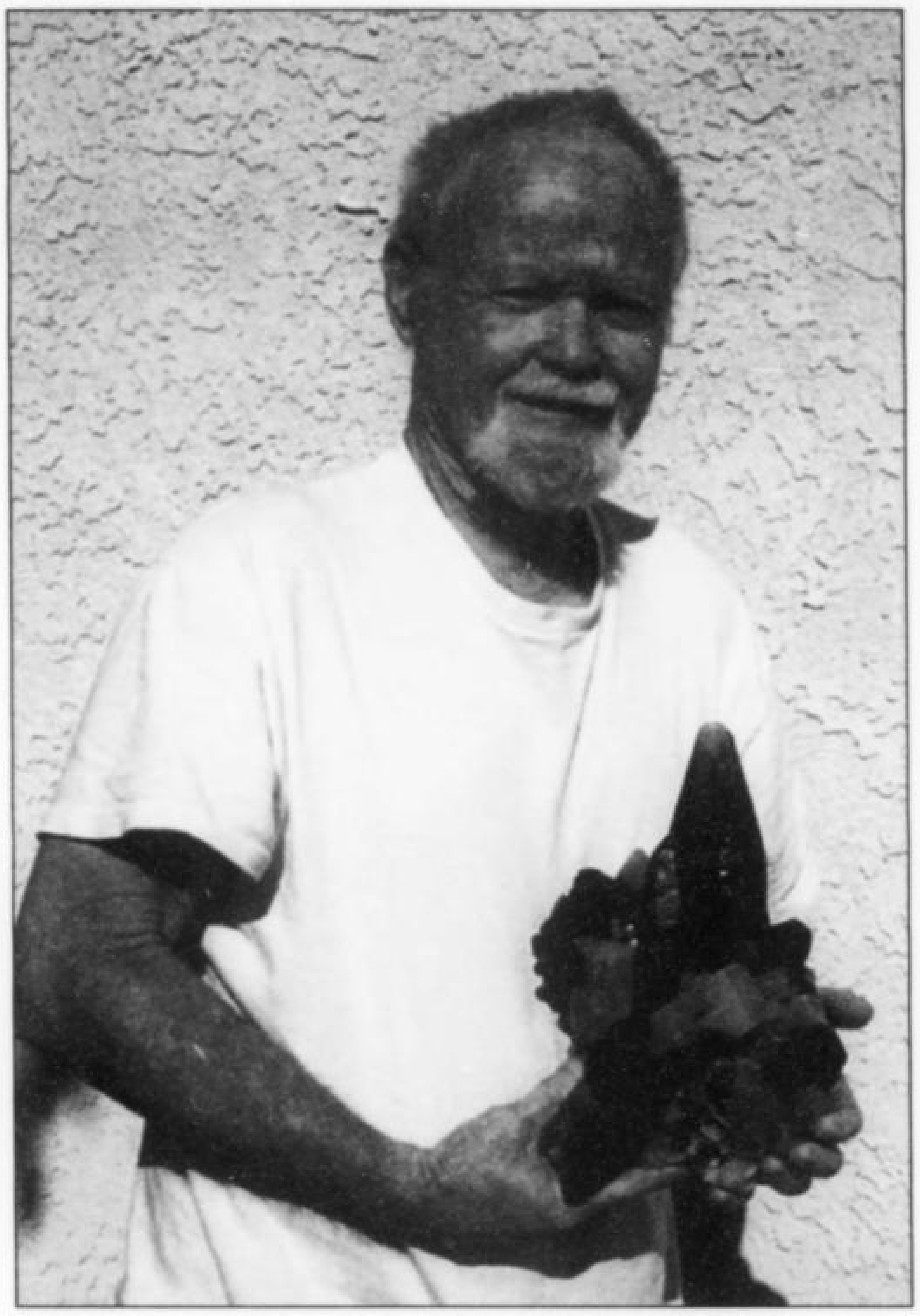
The 10th edition of Fleischer's venerable *Glossary of Mineral Species* for 2008 made its debut at the Tucson Show last month and was very well received. Malcolm E. Back, coauthor of the 9th edition with the late Joseph A. Mandarino, has taken over senior authorship of this installment in the series, and has dedicated the book to Joe. Because of all the added species, plus an 80-page section on Mineral Groups, this new edition has been printed in a larger 6 × 9-inch page size (so as not to become too thick for the wire binding), and contains 346 pages (vs. 309 for the previous edition). And yet it is priced at just $26, only $2 more than the previous edition! This book is one of the real bargains in the mineral world, and the extended section listing all of the minerals in each of the many mineral groups is not only very interesting and useful, but is also available nowhere else (even on the Internet). Considering all the changes in nomenclature over the last four years, no collector or mineralogist can afford to be without this handy reference. Order directly from the Mineralogical Record and help your favorite mineral magazine, too! You can order a copy online via the Bookstore section of our website at www.MineralogicalRecord.com (which will automatically calculate the postage for you), or by email to our Circulation Manager, Mary Lynn Michela, at minrec@aol.com.

Died, Al Ordway, 72

Albert C. Ordway, consummate California field collector, was born in Los Angeles, California on August 28, 1935, the son of Marie and Albert J. Ordway. He lived in Bloomington, California for 25 years, until his retirement, at which time he and his wife moved to Hesperia, California north of San Bernardino.

Al was a nice guy and respected by all. He worked for 30 years as a transportation engineer for the California Highway Department before retiring in 1995 to become a mineral dealer. But you could tell his heart was really not in it because he still spent most of his spare time in the field. I think he did a few mineral shows for the opportunity to meet other collectors and to socialize more than to make money.

To say he was a field collector sells him short. He was a demon field collector. All the best field men in Southern California reckoned him a formidable competitor. You knew if you went out collecting with Al that you were going to have to work really hard and be real lucky if you were going to find better specimens than he did. He always had the knack of finding the best places to dig, and I mean all the time. How did he manage to do that? None of us ever found out, but we knew part of the answer was that he worked at it really hard and smart.



Albert C. Ordway (1935–2007)

Al first got interested in minerals during a school field trip to the Los Angeles County Museum. He served in the Army from 1954 to 1957 and later attended Pasadena City College on the GI Bill. During his studies at PCC he became a confirmed mineral nut while studying Geology under Stanton Hill and becoming a member of the Dana Club. He joined the Mineralogical Society of Southern California in 1959/60 and often exhibited specimens from his collection in their annual shows. He won the Gus Meister Trophy in 2000 and the Hyman Savanar Trophy in 2005 for a morganite-and-quartz specimen from the Cryo-Genie mine in San Diego County, California.

Al's main interest was always pegmatites, and he may have dug in more of the pegmatites in San Diego and Riverside Counties than any other collector. Early on he was one of Josephine Scripps' surrogate diggers. Josie could not dig much herself, but she had money and made it possible for certain young collectors to dig in various pegmatites in Southern California and Baja California. Al worked the La Verde pegmatite near La Huerta in Baja and dug what may be the largest danburite crystals yet found in a pegmatite. Josie also had the claim on the Blue Chihuahua pegmatite in Riverside County and Al got some very nice hydroxyl-herderites from there. For a short time Al leased the Katerina Pegmatite and dug some kunzite there. This sparked a brief interest in faceting, though it didn't last long. In later years he mentored and collected with Jon Page and they found some fine specimens of hydroxyl-herderite at the Green Cloud mine in Chihuahua Valley in San Diego County. Al also collected in Tasmania, and at the epidote locality at Prince of Wales Island in Alaska. Topaz Mountain in Utah and the barites of the Book Cliffs near Grand Junction were also favorites. Al and his wife Betty were regulars at the annual Tucson and Trona shows. At Trona he would even stoop to collecting crystals of hanksite and halite yet one more time.

In the summer of 1980 Bob Bartsch staked some claims on pegmatites near Crystal Creek, near Lake George, Colorado. Al asked for and received permission to dig on Bob's claims. He found and dug with hand tools a fabulous pocket of amazonite and quartz crystals. A couple of years later Bob and I rented a bulldozer with backhoe and systematically mined the claims. Although we recovered more than a thousand pounds of specimens, we didn't hit a pocket as good at the one Al found.

Al was also a superb craftsman when it came to cleaning and repairing specimens. He reassembled amazonite pieces from that pocket into some world-class specimens, one of which ended up in the Sorbonne museum in Paris and on the cover of a poster. Al came back that year to peck around on the claim and carefully go through a pile of rejected pocket material in hopes of adding a fragment or two to some amazonite specimens he was reconstructing. This was typical of his thoroughness. Jon Page remarked:

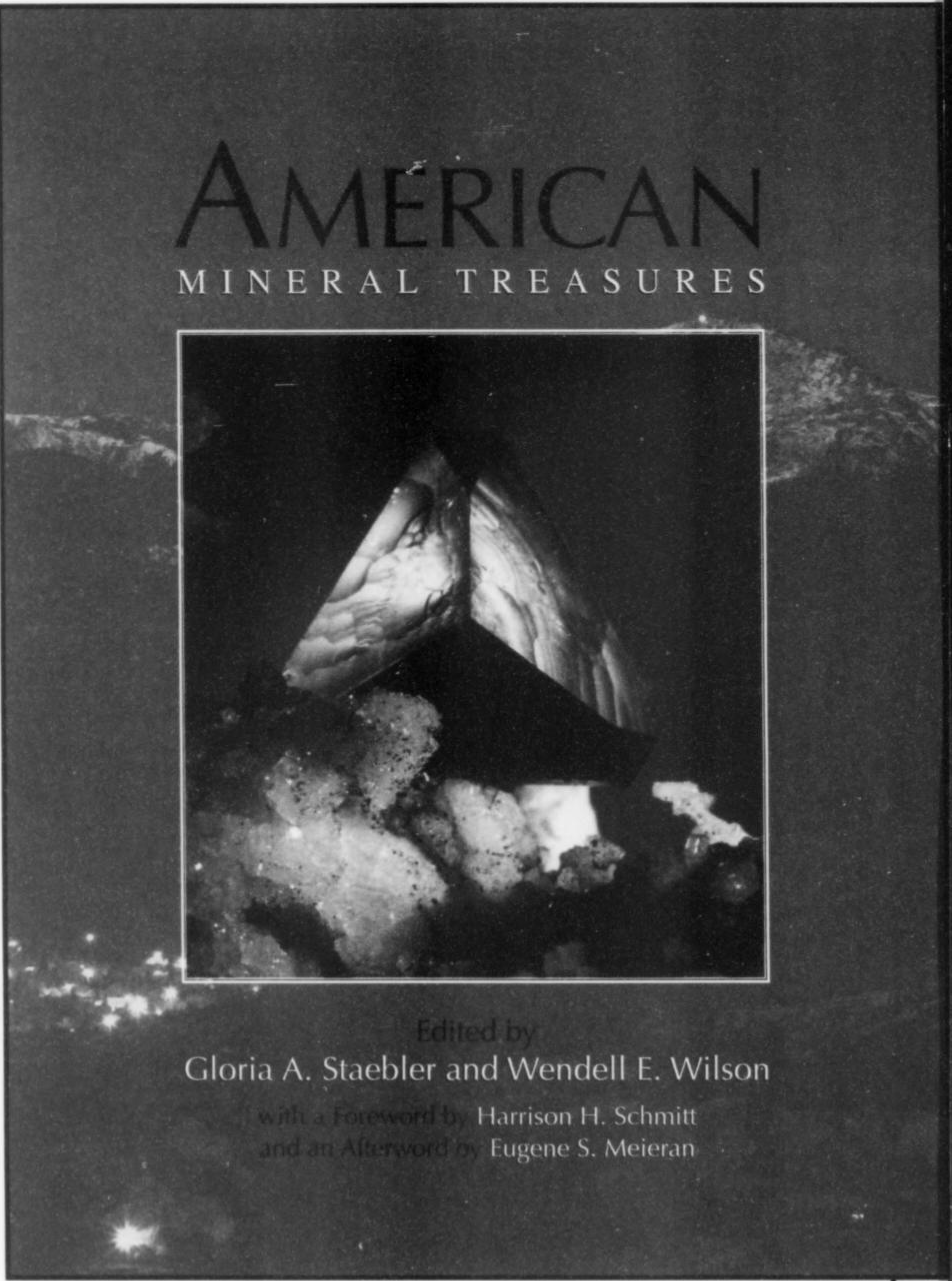
> I have plenty of stories (about Al), but the most noteworthy point about Al was his undying devotion to one more prospecting mission, even when we both felt we would never go back to that last place! He would always call and say he found some micromineral in his pack that needed another look.

One of the blue-cap tourmalines from the Tourmaline Queen mine that he worked his magic on was purchased by a well-known wealthy collector who mounted it in a giant sterling silver "work of art." This disturbed Al greatly, and it is said that he wrote the collector an indignant letter about his use of his fine specimen for such a purpose. You had to love the guy. Al also wrote various articles for publication over the years (including some "Mineral Stories" and an article on the Jensen quarry for the *Mineralogical Record*).

Al and his wife Elizabeth (Betty) were happily married for 48 years and had three children, seven grandchildren and a growing number of great-grandchildren.

Al Ordway died of a heart attack on September 29, 2007, while digging rocks at Soda Lake near Taft, California. He was trying to find crystals of blödite, one of the few minerals in the Southwest that had managed to elude him during his life as a mineral collector. We all said it was a fitting end, and we think he would have wanted it no other way. His friend Jon Page reminisced that Al would usually end a discourse about a locality or mineral with "That's all," and Jon would always respond "That's AL!"

Rock H. Currier



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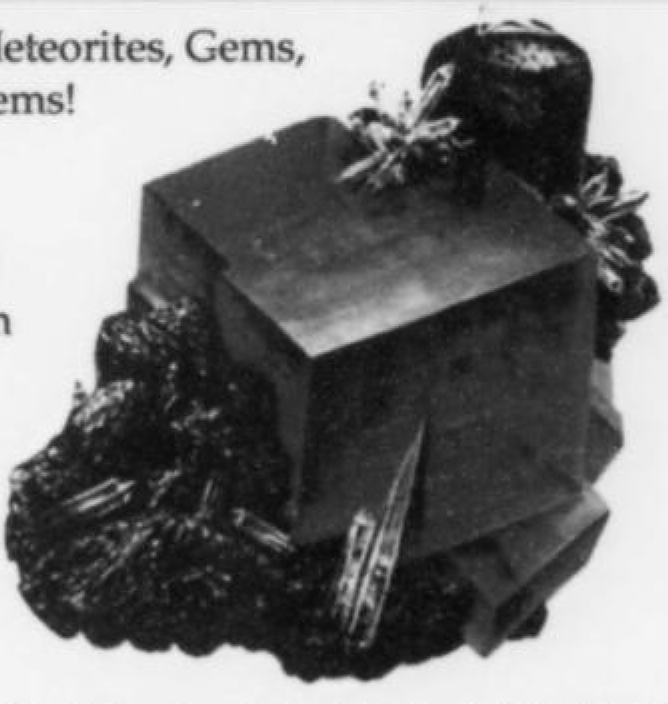

Rhodochrosite - Colorado   Frederick Wilda©

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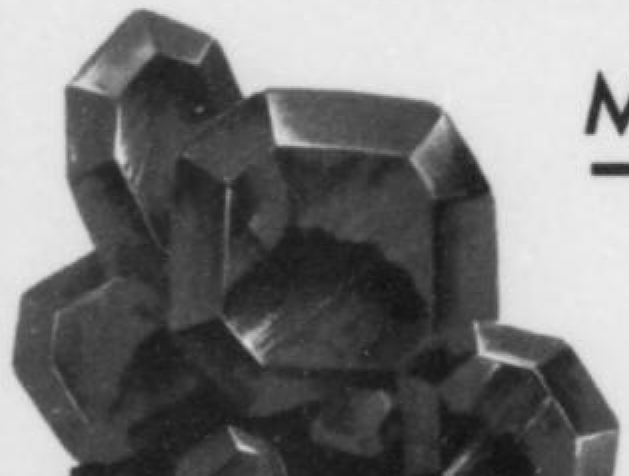

Wulfenite -- Red Cloud mine, AZ
Frederick C. Wilda ©

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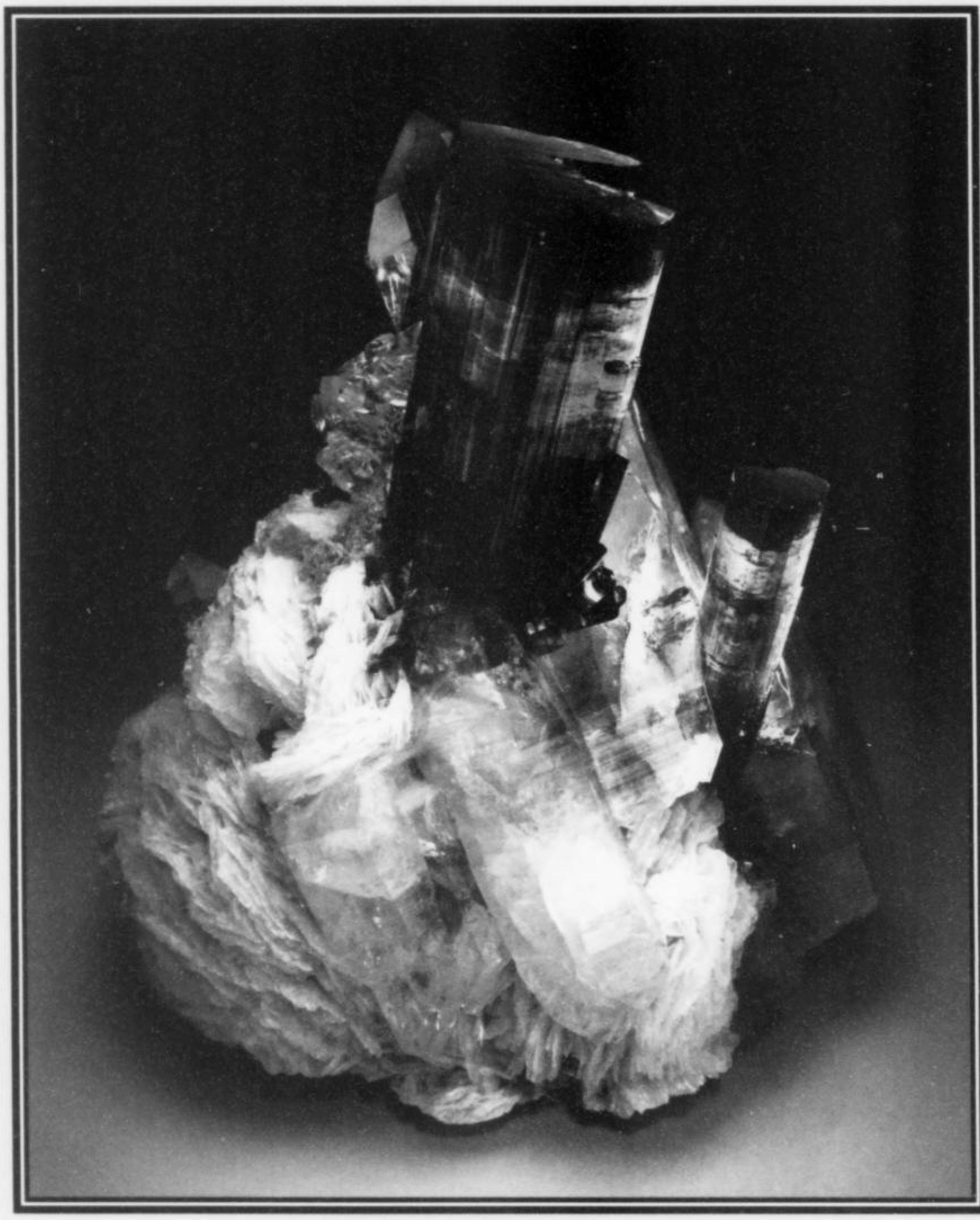

THE FIRST ROCK TRIMMERS FOR MINERAL COLLECTORS

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The earliest mechanical rock trimmer designed for use specifically by mineral collectors was invented around 1875 by New Jersey mining engineer and mineral collector Frederick A. Canfield and marketed by the newly opened mineral dealership of Albert E. Foote in Philadelphia.

The first mechanical rock trimmer for trimming mineral specimens was invented by Frederick A. Canfield (1849–1926) of Dover, New Jersey around 1875. Canfield, one of America's leading mineral collectors of the early 20th century, was born April 7, 1849, at the Canfield homestead (called *Ferromonte*) in Randolph, near Dover, New Jersey. His father was a mine superintendant, and had inherited the mineral collection of his uncle, Mahlon Dickerson (1770–1853), so young Frederick had an early exposure to minerals. He attended private schools in Mendham and Chester, New Jersey and later the Newton Collegiate Institute. After graduating from Rutgers College in 1870 he went on to earn a degree in Mining Engineering from the Columbia School of Mines in 1873.

Shortly after graduation he invented his trimmer, possibly inspired by the laborious trimming of rocks and mineral specimens that had been part of his studies at the school. The trimmer was introduced at Columbia in November 1875 and was an instant success. Prof. Thomas Egleston (1832–1900), founder of the school of mines, wrote an article for the mining journal *Iron Age* in June 1876, extolling its virtues. "Since the introduction of this machine in November last," he wrote, "the hammers and chisels of the School of Mines have been consigned to a drawer, as there is rarely occasion to use them, and we no longer fear to trim a specimen of any size, no matter how hard the rock or how delicate the crystals."

Canfield's trimmer came to the attention of Philadelphia mineral collector Albert E. Foote (1846–1895), probably via the *Iron Age* article. Foote, who soon thereafter became one of America's most famous early mineral dealers, was born on February 4, 1846, in Hamilton, Madison County, New York. He graduated from Courtland Academy in Homer, New York, where he first became interested in mineralogy through the influence of Dr. Caleb Green, and began collecting minerals in 1862. He was a student of Prof. Walcott Gibbs at Cambridge and Prof. Hoffmann in Berlin. Foote obtained his medical degree in 1867 from Michigan State University in Ann Arbor. In 1870, after teaching for three years at Ann

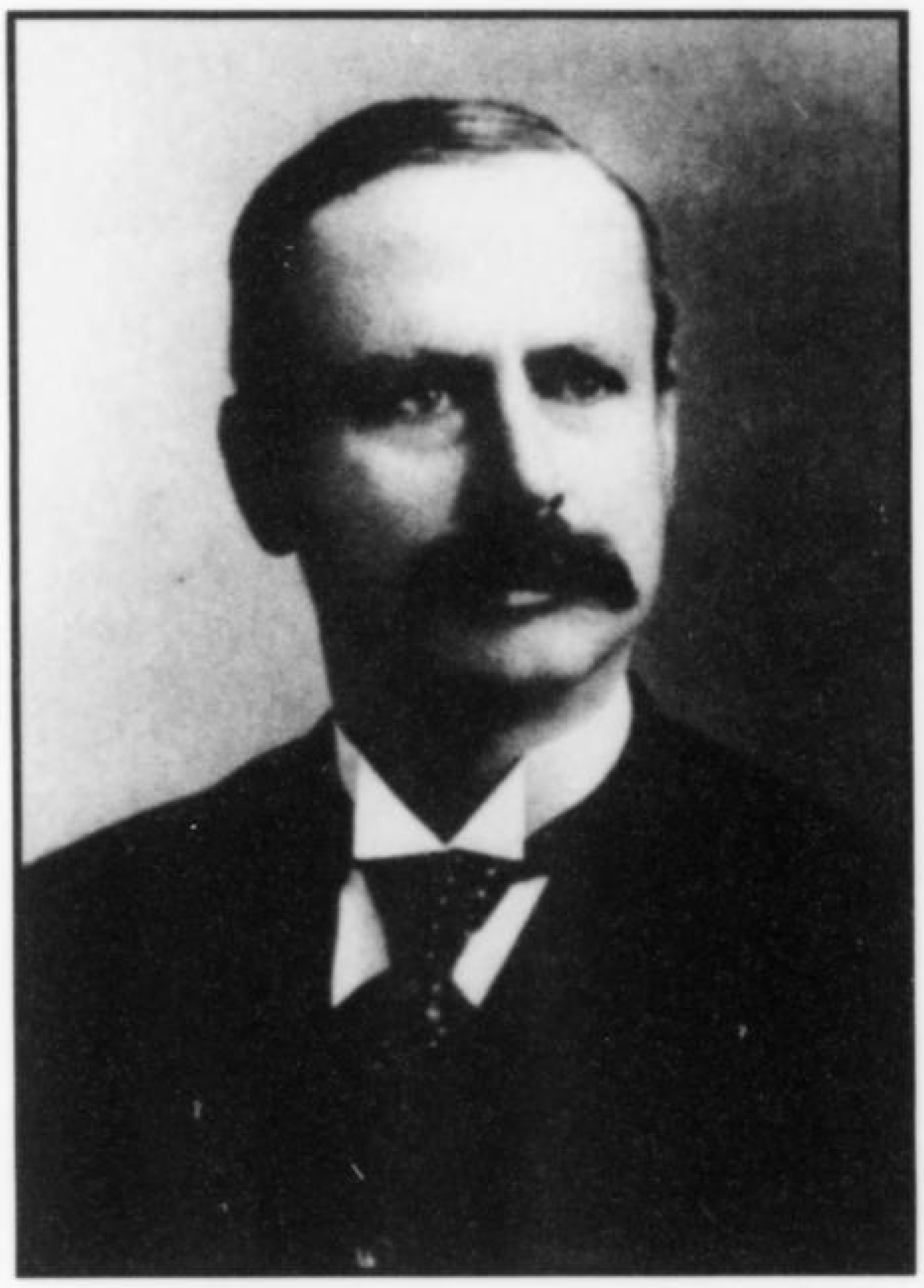
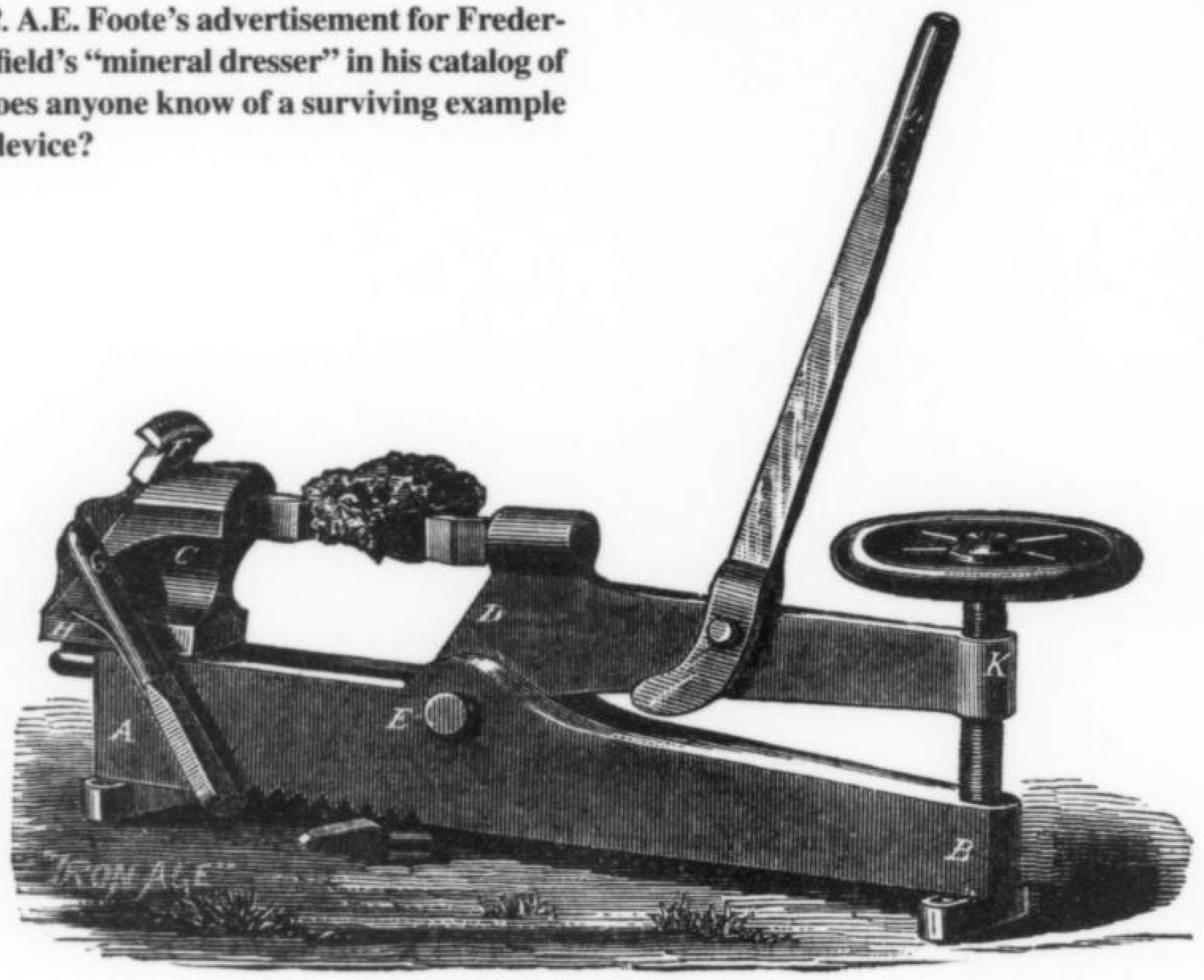


Figure 1. **Frederick A. Canfield (1849–1926).**

Figure 2. **A.E. Foote's advertisement for Frederick Canfield's "mineral dresser" in his catalog of 1876. Does anyone know of a surviving example of this device?**



Canfield Mineral Dresser.

We supply this invaluable machine, capable of making a clear cut through two inches or more of the hardest rock, for $25.00. The following description, by PROF. T. EGLESTON, PH. D., taken from the "Iron Age," of June 8th, 1876, will explain the machine fully:

"The mineral dresser, invented by Mr. F. A. Canfield, Dover, N. J., is composed of a bed plate A B made of cast iron, which is planed and sloted at one end to receive a movable head C, and is slightly tapered at the other to allow of greater motion of the head D round the pin E. The head C is made of cast iron, and is planed to fit the slot in the bed plate. On its side there is a projection fitted with a half circular hole for receiving the clamp G, which holds it in place when adjusted. The head D is made entirely of wrought iron. It is bulged slightly at one extremity to secure the steel screw K, which is moved by a hand wheel, and has a very slow motion.

The heads C and D are bored out, tapering to secure the cutting chisels, which may be made of any shape so that the action of the machine may be made to be either that of a chisel or that of the shears. To use the machine the sliding head C is freed. This is done by removing the steel wedge F, which holds the steel clamp G in position. This clamp fits into notches in the under side of the bed plate and into the circular slot in the back of the head C, and is kept from falling by the brass spring H. The specimen to be operated upon is placed between the two chisels, the screw K having been previously run down so that the chisel of the head D is slightly above that of the head C. The chisels are then turned at any angle so as to suit the specimen, and the movable head run up against the specimen. The clamp G is then secured by the wedge F. As the specimen is not tight between the chisels, it is held in the hand while the head C is being fastened. The screw K is then slowly turned; this causes the chisel of the head D to advance slightly. The two cutting surfaces being exactly opposite each other, the hardest rock will soon yield under the pressure, and it will almost invariably be cut off square. If one hand is kept on the specimen when the cutting takes place, it will be found that there is a slight jar at the moment the specimen is cut, but not sufficient to detach the most delicate crystals. Specimens containing very fragile crystals on both sides of a very hard rock have been cut in two, thus giving two specimens, when a single stroke of the hammer would have destroyed most of the crystals on both sides of the specimen. Since the introduction of this machine in November last, the hammers and chisels of the School of Mines have been consigned to a drawer, as there is rarely occasion to use them, and we no longer fear to trim a specimen of any size, no matter how hard the rock or how delicate the crystals.

When the machine is to be used on soft rocks or in trimming fossils, it is provided with a lever arm L, which straddles the long arm of the head D, and is fastened by means of a pin, which can be easily removed when the arm is not wanted. To use it the screw K is turned up so that the long arm of the head D rests on the bed plate, the head C is then adjusted, and by a series of quick movements toward the specimen, the instrument is made to detach the rock. By changing the form of the chisel the two cutting surfaces may be made to act like shears, so as to cut specimens of shale exactly without breaking them. This instrument is invaluable to collectors of minerals and fossils, as it allows of the greatest precision in preparing specimens for the cabinet, since it is no longer necessary to dress a large quantity of surperfluous rock for the sake of preserving a few crystals on it. To suit the varying shapes of specimens, chisels of any shape or size can be made to fit the heads. It has been found, however, that three shapes are all that is necessary. The chisel shape with a bevel edge like the drawing, the pyramid and the shear. It is sometimes desirable to vary the length of the cutting edges, but, generally, one inch is found to be sufficient for all ordinary cases. The expense of the instrument is not large, and it will earn its cost to a collector in a very few weeks."

Arbor, he took a position as Assistant Professor of Chemistry and Mineralogy at Iowa State Agricultural College, and was promoted to Full Professor in 1871.

Foote had developed an intense interest in mineral collecting, and had collected minerals from the Michigan copper mines (1868), from Magnet Cove in Arkansas (in 1875), and from the Minnesota iron range, ostensibly for teaching purposes—but he built up a much larger stock than necessary for classroom use. He displayed his fine personal collection in New York in 1873 and at the St. Louis Exposition in 1875, where he was awarded a medal. In 1875 he moved to Philadelphia and set up practice there as a physician, mineralogist, and seller of medical and other scientific books. He placed a handsome exhibit of minerals in the 1876 Centennial Exposition in Philadelphia, and had to rent cheap quarters nearby to store his surplus specimens; visitors to the exhibition wanted to purchase specimens, so he took them to his temporary quarters, and thus his mineral business was born.

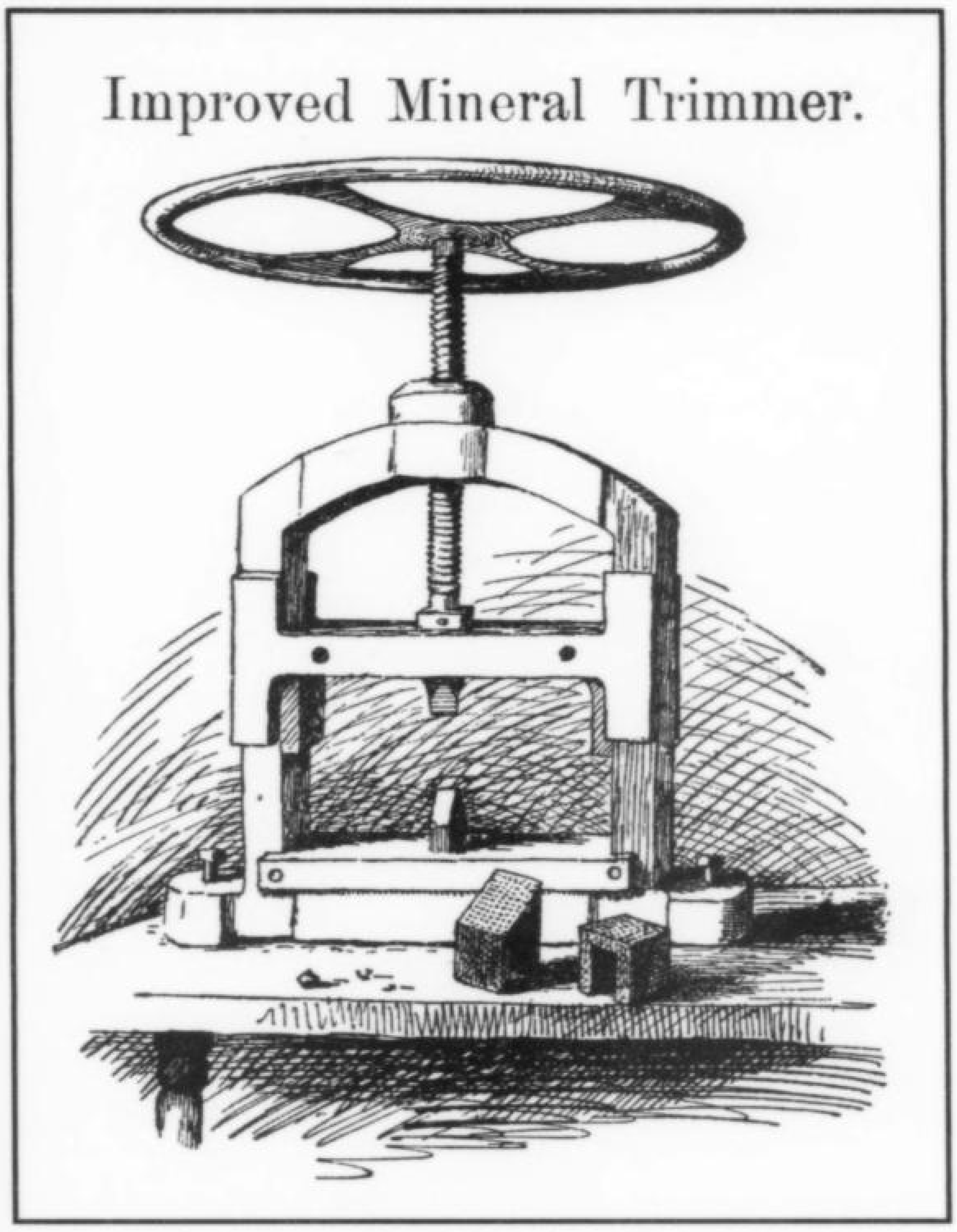


Figure 3. **George English's "Improved Mineral Trimmer." In his 1894 catalog he states that "We have used one of these trimmers steadily in our establishment for five years, and it is today as good as new."**

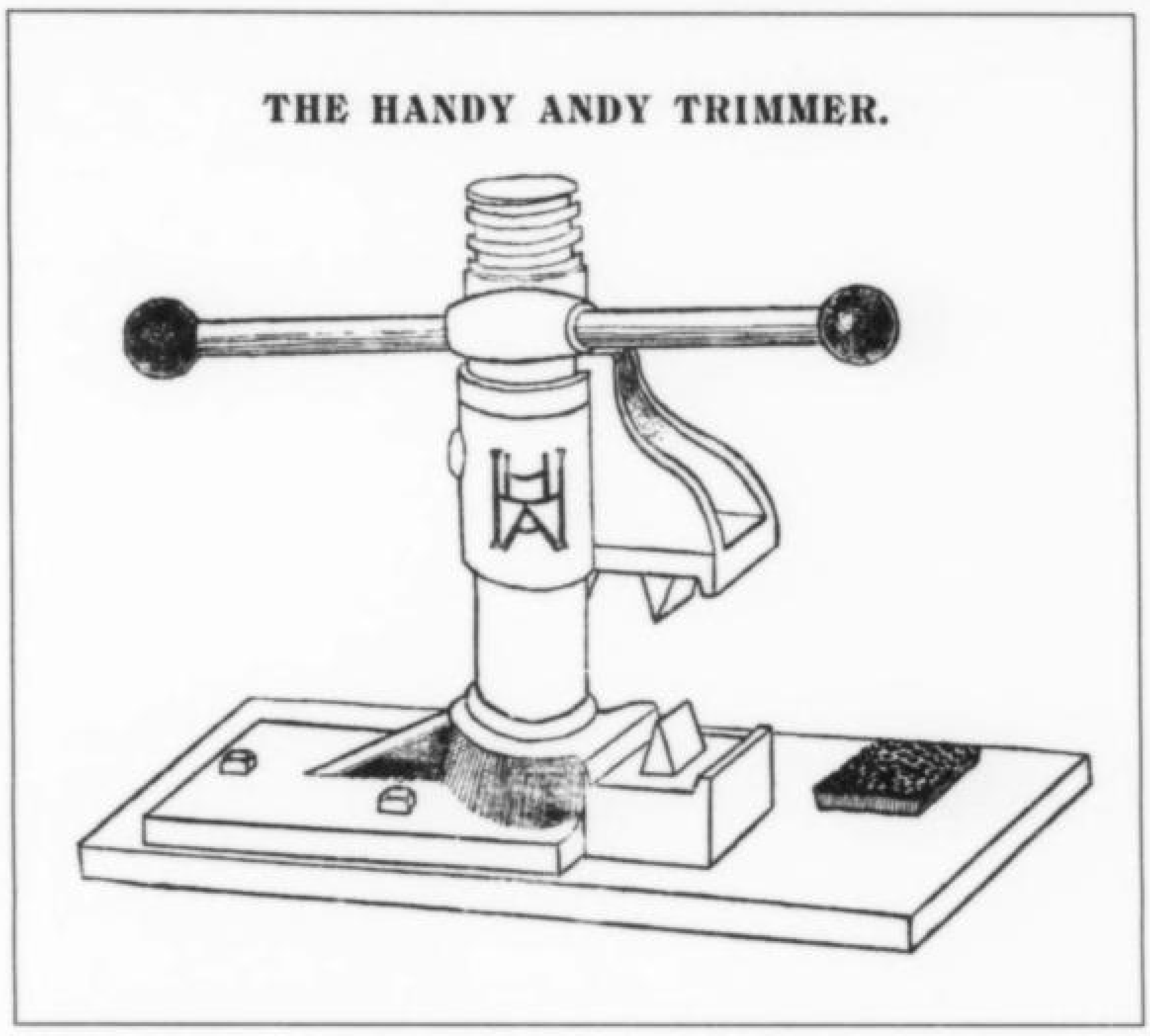


Figure 4. **Roy Hopping's "Handy Andy Trimmer" (1899).**

In 1876, to help launch his new business, Foote issued his first mineral catalog; it ran to 50 pages, and included Canfield's trimmer (Fig. 2), priced at $25. He continued to offer it in subsequent catalogs and bulletins at least through 1884 and probably later. Around 1889, New York mineral dealer George L. English (1864–1944) developed a trimming device of heftier, simpler design, which he called his "Improved Mineral Trimmer" (Fig. 4). He offered it for $35 in his 1894 catalog,, though he also offered the "Canfield Mineral Dresser" for $25. Another New York mineral dealer, Roy Hopping (1872–1930) offered a third and less expensive design of rock trimmer which he called the "Handy Andy Trimmer," for $15 in his 1899 catalog; he also offered George English's "Improved Mineral Trimmer."

Like his father, Frederick Canfield became involved in iron mining, primarily in New Jersey, Virginia and North Carolina. From 1885 to 1887 he worked at the Cerro de Potosí mines in Bolivia, where he also collected minerals and discovered a new species later named *canfieldite* in his honor. He also visited iron mines in Brazil in 1890. He collected both scientifically and aesthetically, and eventually accumulated 9,100 specimens, including 1,474 from Franklin, New Jersey.

Like his great-uncle Mahlon Dickerson, Canfield never married, and lived most of his life alone on his family's estate, managing the Dickerson Suckasunny Mining Company. His latter years in particular were devoted almost entirely to building his mineral collection. He served as Vice President of the Mineralogical Society of America during the year 1922–1923, was a member of the Board of Managers of the Geological Survey of New Jersey for 17 years, and was also interested in history and genealogy. He died on July 3, 1926 (apparently of skin cancer); his only living relatives at the time of his death were two second cousins. Canfield bequeathed his entire mineral collection, plus a $50,000 endowment for its support and enlargement, to the Smithsonian Institution; under conditions of the will, the Smithsonian may not disperse any of his specimens.

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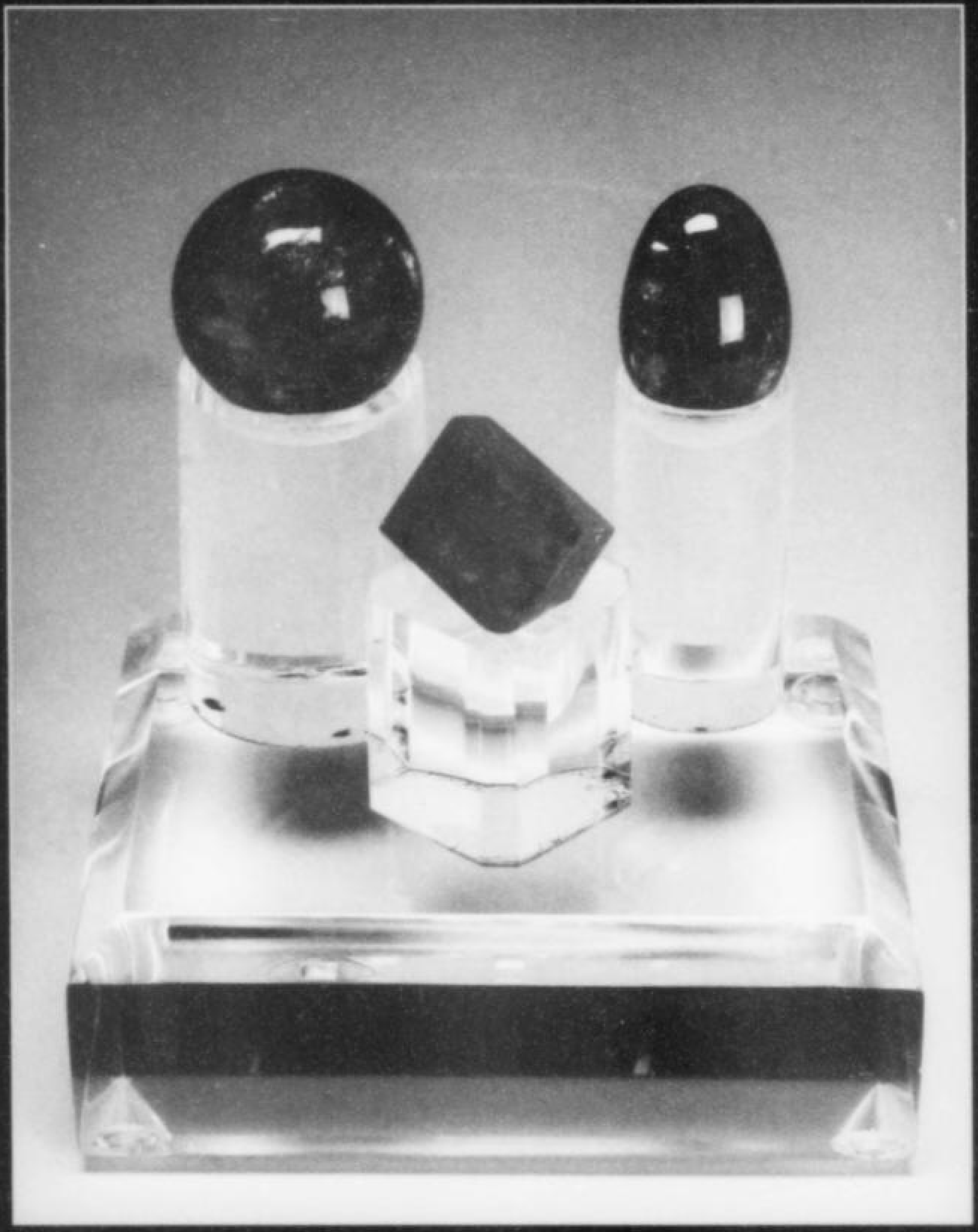

THE PALOMO MINE
HUANCAVELICA DEPARTMENT, PERU

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Since 2000 the Palomo mine has sparingly produced excellent and distinctive specimens of realgar—the author of this article brought a fine lot of realgar specimens to the 2007 Tucson Show. Since mining formally ended in 2000, a few remaining miners have concentrated on recovering specimens, and good examples of other sulfides including seligmannite, and also gypsum, have been brought out.

INTRODUCTION

The Palomo (or El Palomo) mine is situated in a dry valley at the considerable altitude of almost 5000 meters above sea level, between the much more famous Julcani and San Genaro mining districts in Huancavelica Department, Peru. A property of the San Genaro Mining Company, the Palomo mine belongs metallogenically to the Huachocolpa ore district (Samame-Boggio, 1985). The last active mining took place between 1995 and 2000, when the Palomo mine was leased by the Buenaventura Company. Now the mine is closed, and only an entrance portal and the remains of a few buildings are in evidence at the site. However, during the last few years the mine has given up mineral specimens to a few independent miners who are mining strictly for specimens. The number of species known from the Palomo mine is not impressive, but some specimens are among the best to have come from Peru in recent times, and the new realgar specimens are among the more interesting examples of the species.

GEOLOGY

The Palomo mine area is composed entirely of volcanic rocks: andesitic lavas, pyroclastic rocks, tuffs and breccias. All of the mineralized veins are found within these rocks. In the depths lies an intrusive diorite stock which is probably genetically related to the mineralization.

Three vein systems are known in the mine. The main system (the Palomo 1, Palomo 2 and Palomo 3 veins) strikes north-south; the second (the La Suerte and 7-A veins) strikes northeast-southwest; the third (the Palomo 6 and 6-A veins) strikes northwest-southeast. The mineralization is characterized by banded vein fillings of rhodochrosite with calcite, barite and quartz occurring as common gangue minerals. The main sulfide minerals are pyrite, galena, sphalerite and chalcopyrite, and much less commonly tetrahedrite and silver sulfosalts (pyrargyrite, proustite and polybasite). Realgar, orpiment and stibnite are common in the outer parts of the deposit. The mine was closed mainly because of problems with water flow, and all of the workings below the main gallery are now flooded. Nevertheless, economically significant ore reserves are known to exist at depth, with the silver content increasing downward.

MINERALS

Only minerals represented in recently found specimens are described here; it is probable that no significant specimens of silver minerals, rhodochrosite, calcite or barite have survived from the period of active mining.

Chalcopyrite $CuFeS_2$

In 2006 a small number of specimens containing chalcopyrite crystals was found. The largest specimen shows a crystal 3 cm across on drusy quartz but, unfortunately, the crystal has an unattractive gray matte surface because small tetrahedrite crystals are epitactically overgrown on it. One broken chalcopyrite crystal shows the typical metallic-golden color inside.

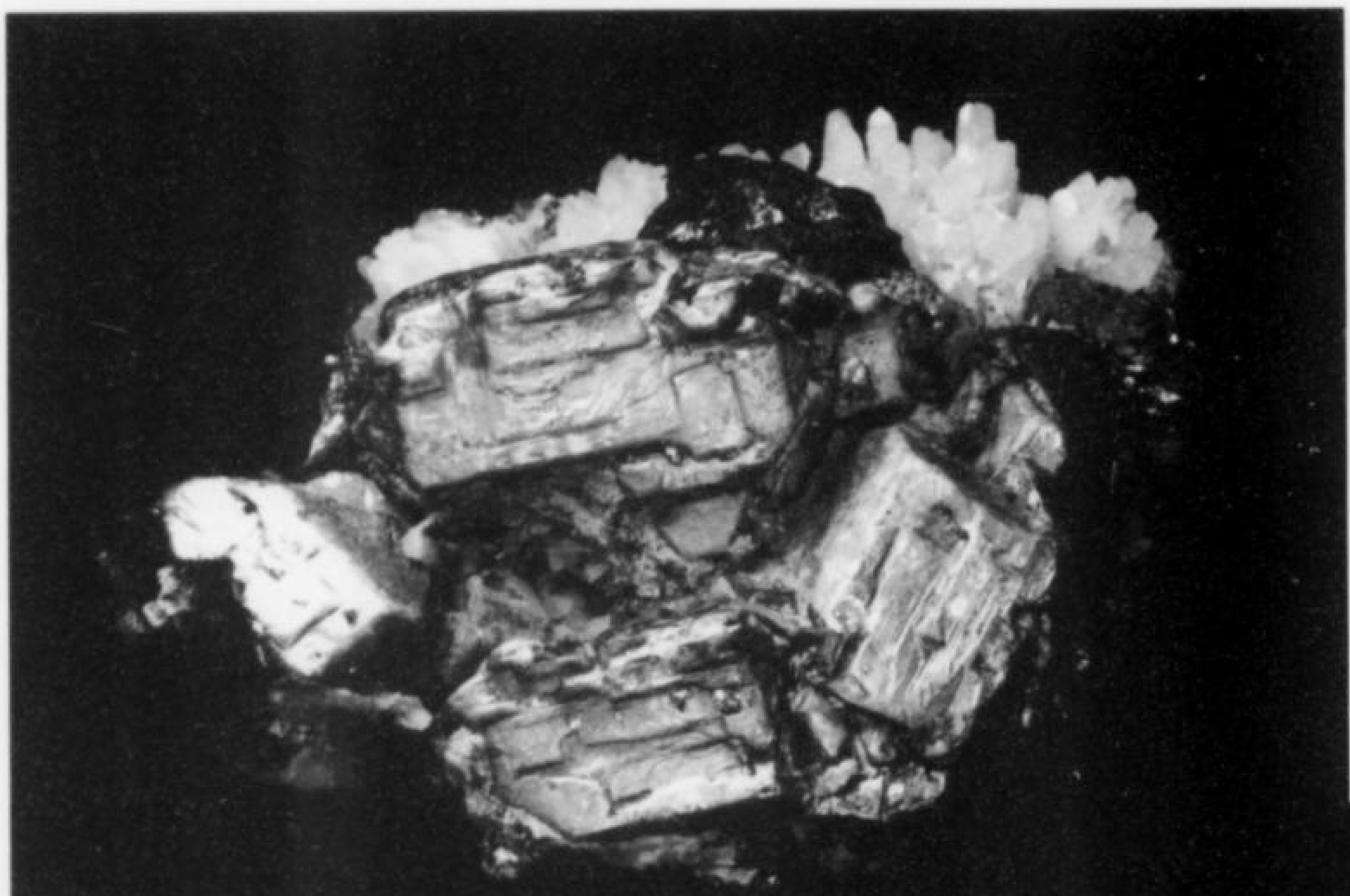


Figure 1. **Galena crystals with quartz and sphalerite, 10 cm, from the Palomo mine. Jaroslav Hyršl specimen and photo.**

Figure 2. **Chalcopyrite on quartz, 7 cm, from the Palomo mine. Jaroslav Hyršl specimen and photo.**

Cinnabar HgS

A red crust of botryoidal cinnabar was identified on several specimens of quartz found in 2003.

Galena PbS

Massive granular galena is quite common in the mine, and a few unusual crystal specimens were found at the end of 2006. These show cuboctahedral galena crystals up to 2 cm, with heavily tarnished surfaces. Because of the iridescent colors of these surfaces, Peruvian dealers call galena of this type "pecho paloma" (breast of dove). Some spinel-law-twinned, flattened, untarnished galena crystals to 4 cm with rounded edges have also been found. Some of them are covered by tiny seligmannite crystals, yellow orpiment and powdery orange pararealgar.

Gypsum $CaSO_4 \cdot 2H_2O$

Large gypsum crystals, similar to old specimens from Raura, were found in the Palomo mine at the end of 2003, in the vein which produced the stibnite specimens (see below). Some of these specimens show transparent, colorless, long-prismatic crystals of gypsum to about 25 cm (completely transparent gypsum crystals occur only rarely in the mine), and one dealer says that prisms more than 50 cm long were recently found and broken into smaller pieces for easier transport. Another occurrence in the mine yielded gypsum crystals to about 10 cm (transparent inside but with corroded, milky surfaces) covering matrix. One 13-cm gypsum crystal is naturally curved into an S-shape. The most beautiful gypsum specimens of the Palomo mine, like no other specimens found anywhere in Peru, are gypsum cleavages containing clusters of stibnite crystals. Still rarer, and very attractive, are a few gypsum crystals, found in 2004, containing very thin, phantom-like veils colored bright yellow or orange; commonly both colors appear in the same crystal. The inclusions are difficult to identify, but their hues are like those of native sulfur and orpiment. One crystal, found in 2006, includes small but sharp crystals of red realgar.

Orpiment As_2S_3

Some of the realgar specimens found in 2003 carry yellow crusts of orpiment. Nice orpiment specimens found in January 2006 show botryoidal yellow encrustations on quartz "peppered" by tiny orange crystals of a younger orpiment generation. The best orpiment specimens so far found in the mine emerged at the end of 2006; these

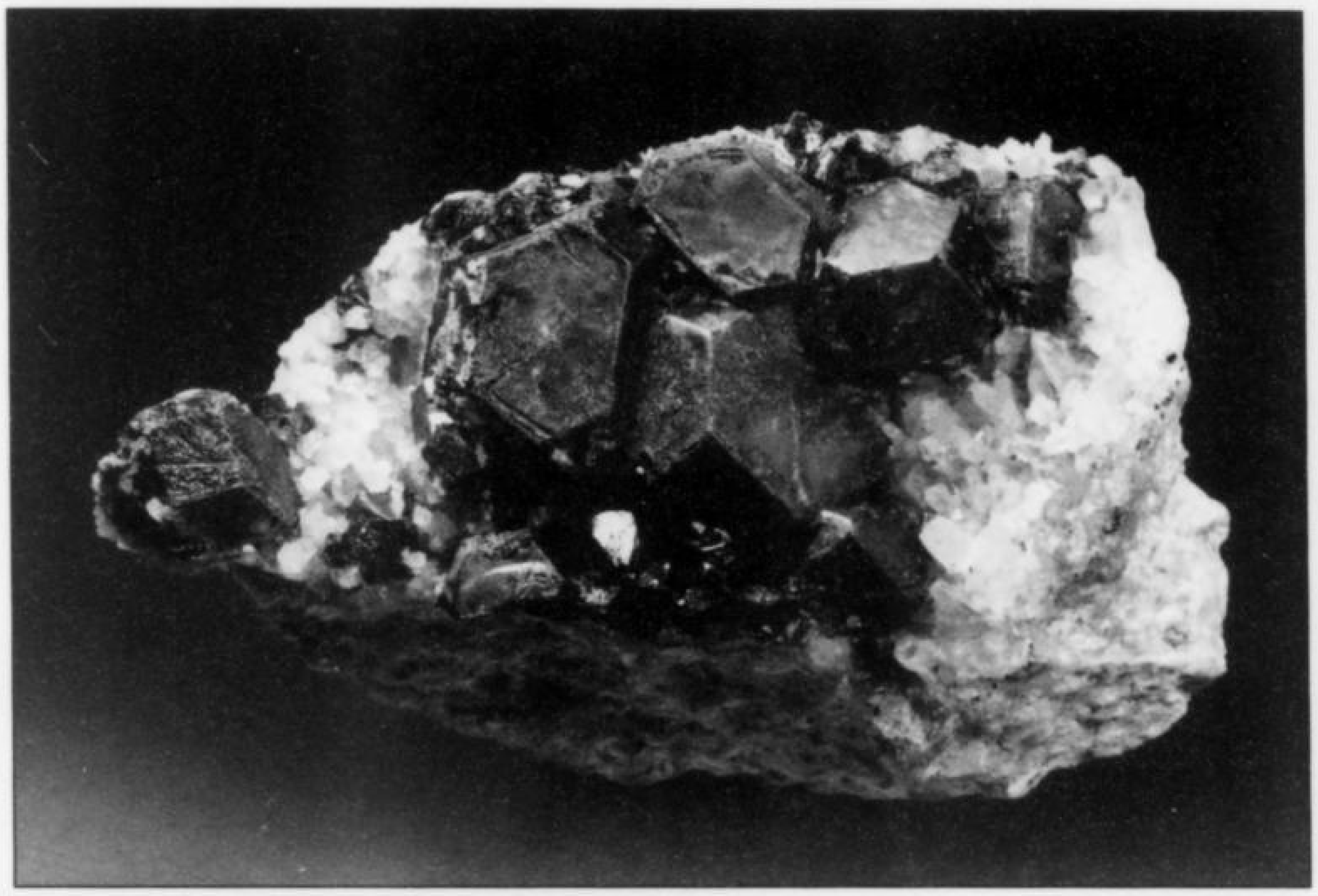


Figure 3. **Iridescent galena with quartz, 8 cm, from the Palomo mine. Jaroslav Hyršl specimen and photo.**

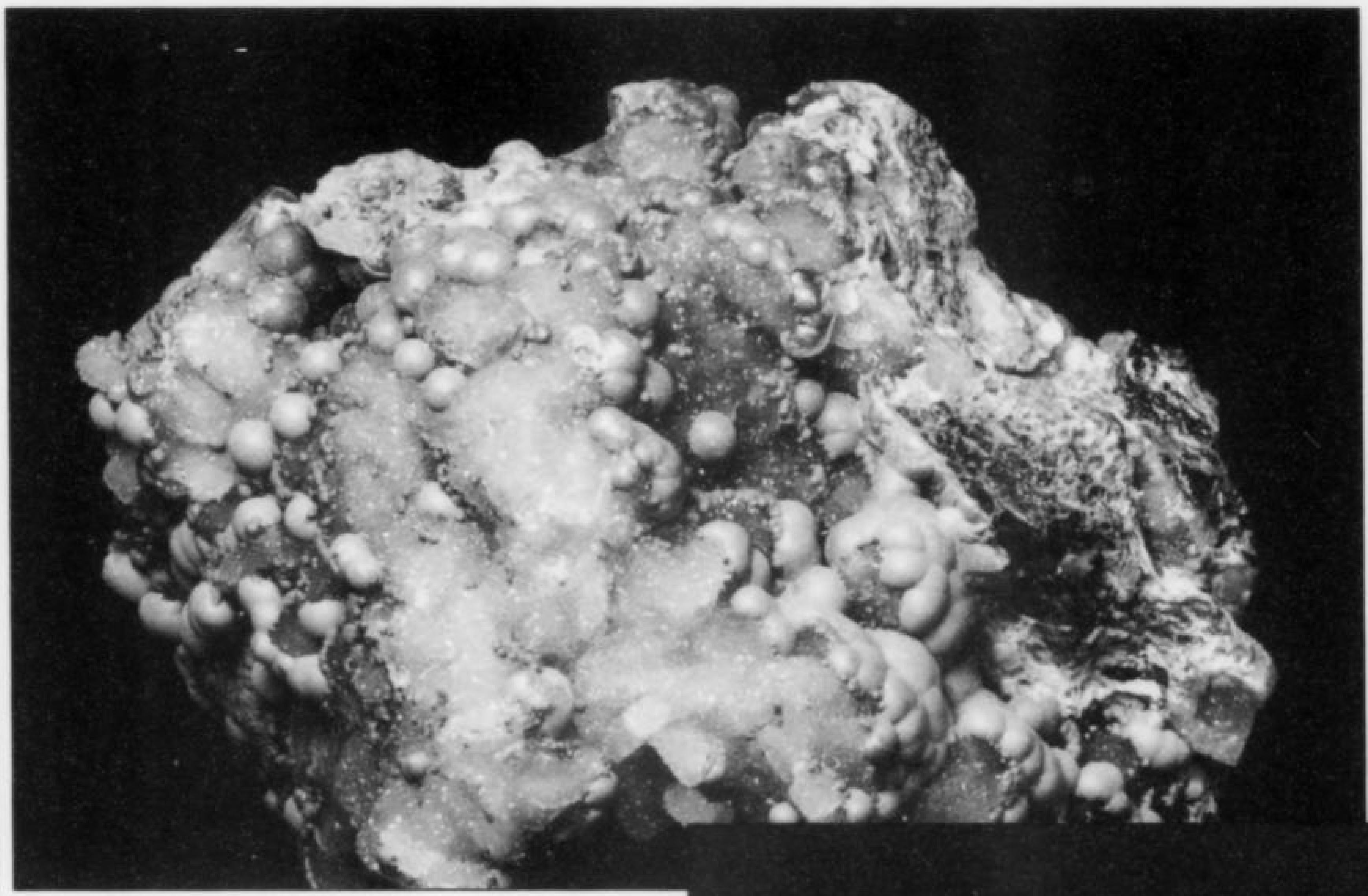


Figure 4. **Botryoidal orpiment, 8 cm, from the Palomo mine. Jaroslav Hyršl specimen and photo.**

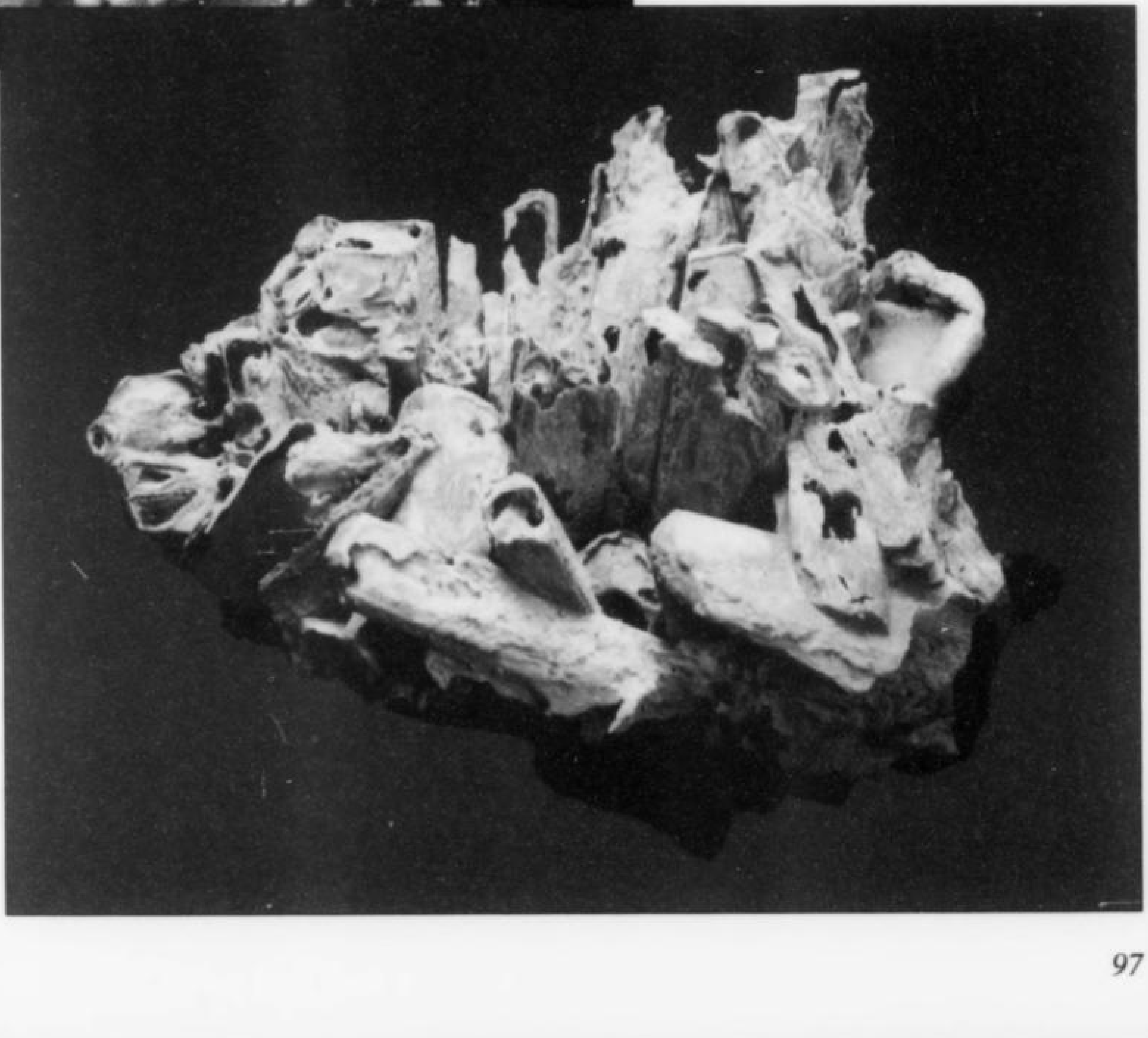


Figure 5. **Orpiment pseudomorphs after realgar crystals, 6 cm, from the Palomo mine. Jaroslav Hyršl specimen and photo.**

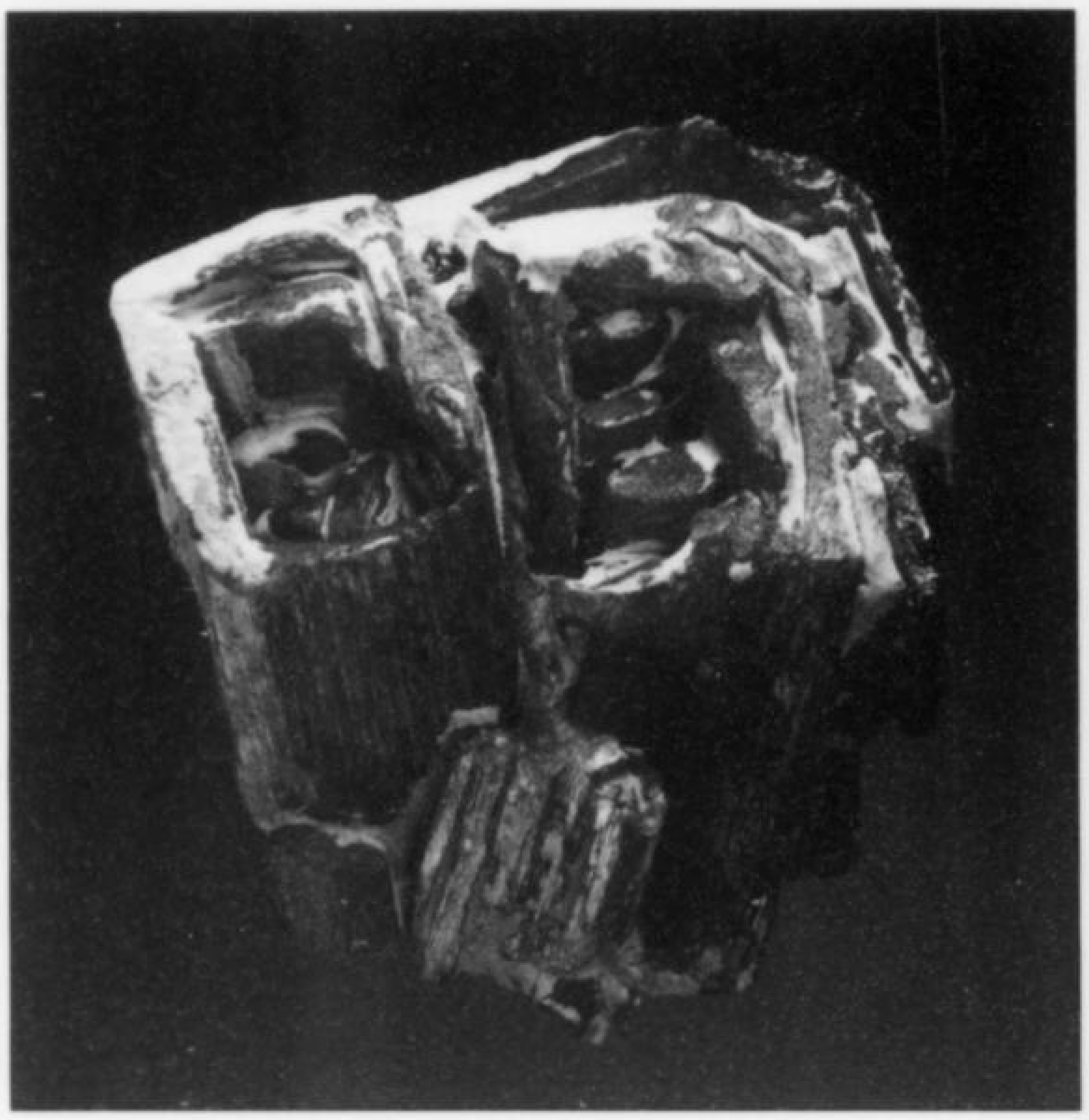


Figure 6. **Skeletal realgar with orpiment, 6 cm, from the Palomo mine. Jaroslav Hyršl specimen and photo.**

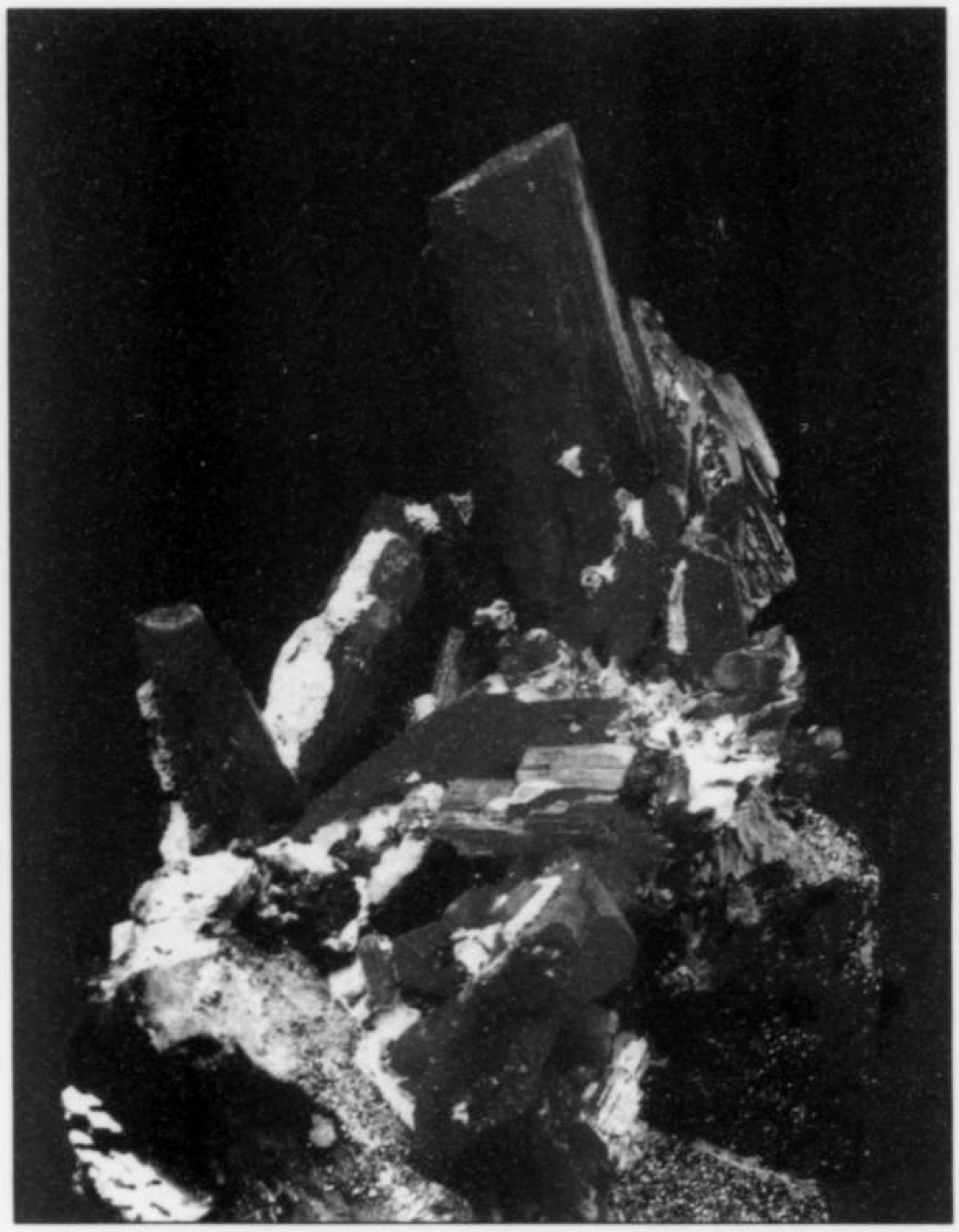


Figure 7. **Realgar crystals with orpiment on galena crystals with seligmannite, 7.5 cm, from the Palomo mine. Jaroslav Hyršl specimen and photo.**

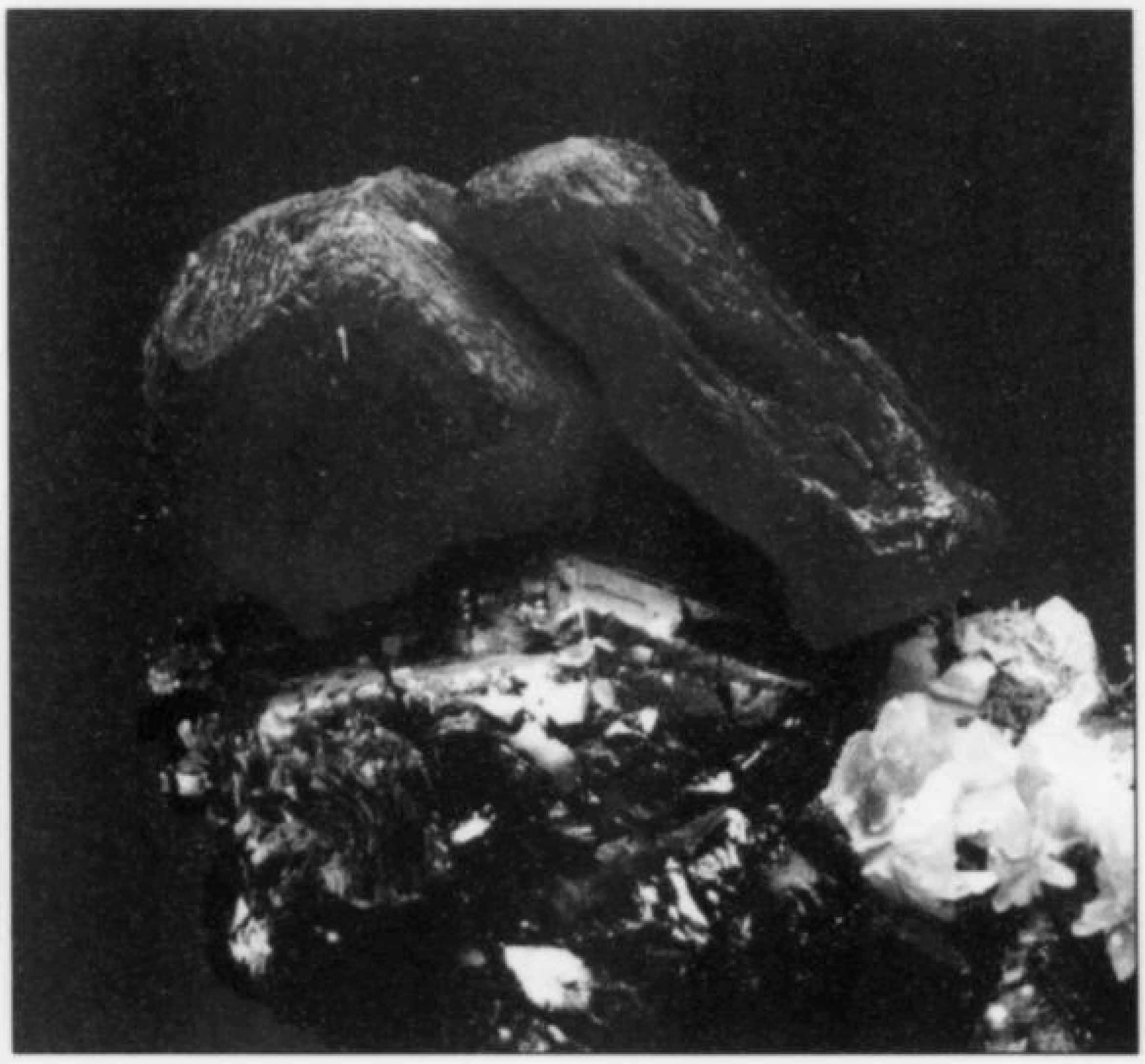
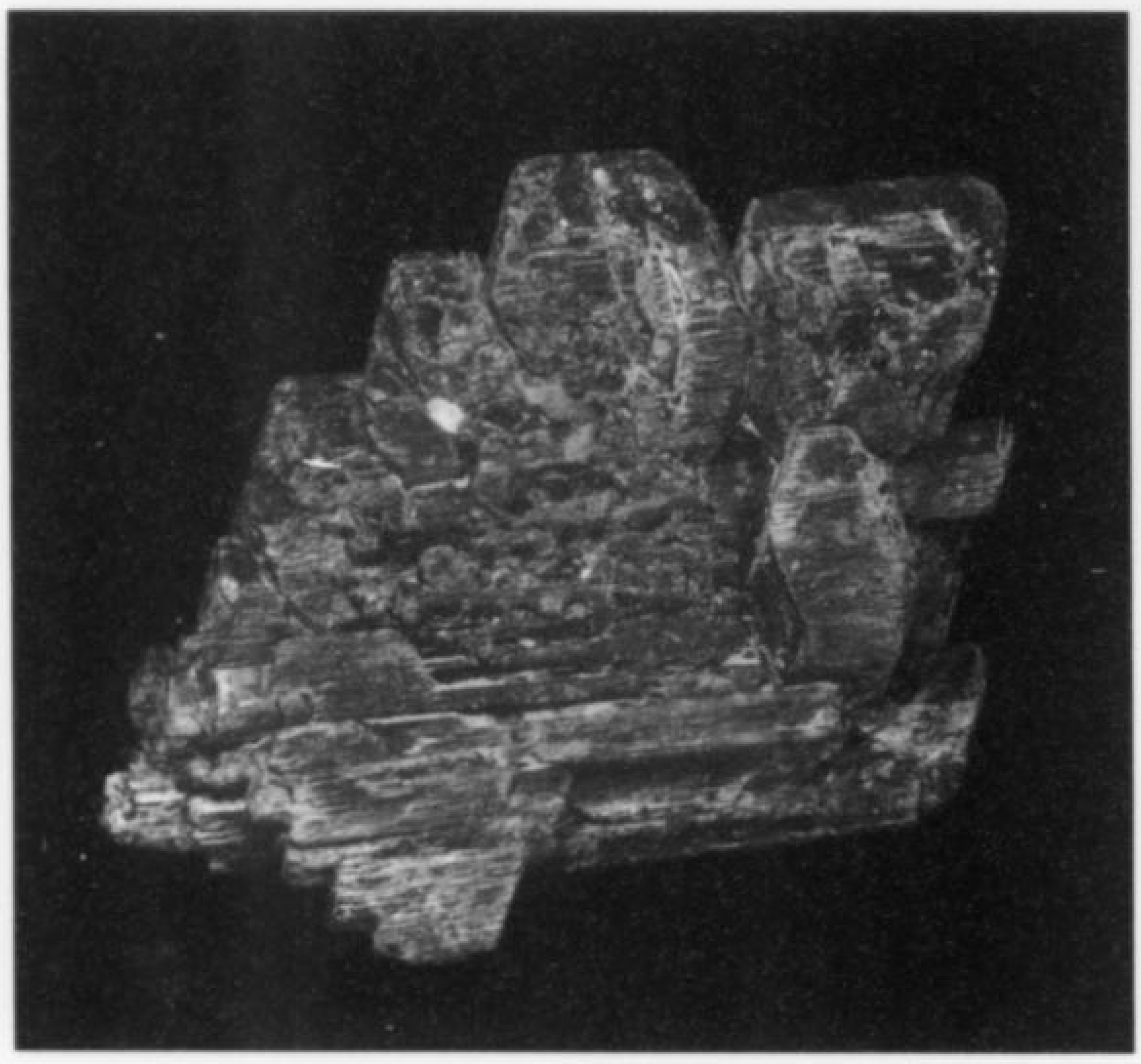


Figure 8. **Realgar on sphalerite, 5.5 cm, from the Palomo mine. Jaroslav Hyršl specimen and photo.**

Figure 9. **Flattened realgar crystal, 4.8 cm, from the Palomo mine. Jaroslav Hyršl specimen and photo.**



combine botryoidal yellow aggregates and fan-like aggregates of yellow-orange orpiment cleavages to about 5 cm.

Orpiment pseudomorphs after realgar are a specialty of the Palomo mine. The first specimens were found in spring 2006, but the best ones came with the best realgar crystals at the end of 2006. Some of the pseudomorphs are complete replacements of realgar by orpiment, while others are partial, showing relict realgar inside. The complete pseudomorphs are usually hollow and very fragile, in sizes up to 4 cm.

Pararealgar AsS

Orange, crystallographically parallel zones seen in some loose realgar crystals found in 2000 consist of pararealgar.

Pyrite FeS_2

Tarnished pyritohedral crystals of pyrite to 1 cm with beautiful iridescence appeared at the end of 2006, together with iridiscent galena crystals (see under galena).

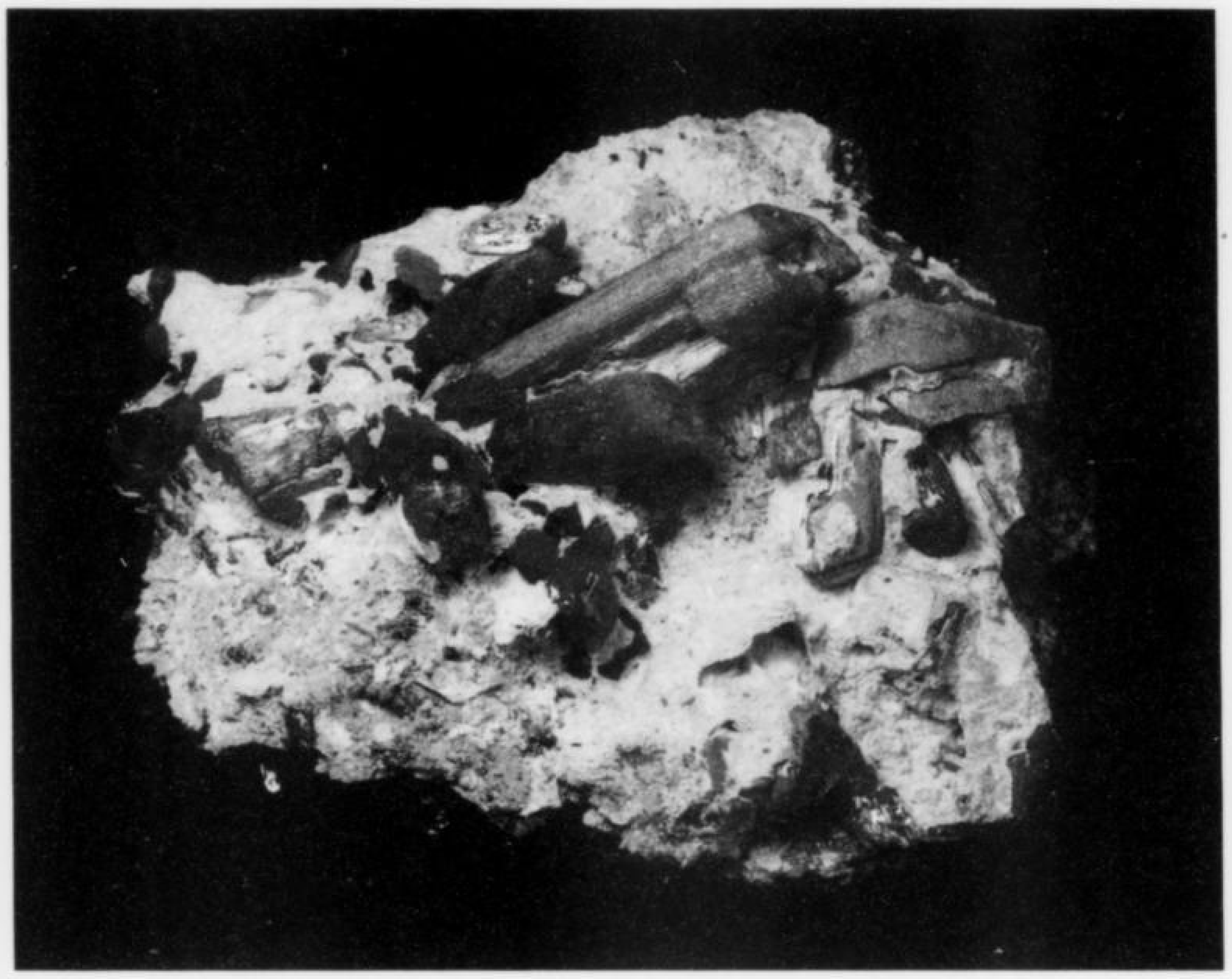


Figure 10. **Realgar and orpiment, 8 cm, from the Palomo mine. Jaroslav Hyršl specimen and photo.**

Quartz SiO_2

Hundreds of specimens showing thin, platy pseudomorphs of quartz after barite were found in 2006. The pseudocrystals measure between 1 and 2 cm, exceptionally reaching 10 cm. A banded, agate-like inner structure is evident on some of the larger broken plates. A few of the pseudocrystals are covered by thin stibnite needles or by orpiment or realgar crystals.

Realgar As_4S_4

Loose realgar crystals to 2 cm from the Palomo mine first appeared in 2000. Some of the crystals are partially altered to orange pararealgar, which forms crystallographically continuous zones. A few specimens showing lustrous realgar crystals to 1 cm with tetrahedrite, galena and sphalerite were found in 2003.

At the end of 2006, the Palomo mine produced quite a large number of specimens (probably a few hundred) showing what are by far the best Peruvian realgar crystals ever discovered. Most of the crystals are columnar, their sizes ranging to almost 5 cm long and 1 cm thick. Platy crystals, also to 5 cm, are very rare. Most of the realgar crystals are slightly rounded, but a few with sharp edges were also found; some crystals are skeletal. Unfortunately, realgar is extremely fragile and virtually all specimens show at least a little damage.

During the last few years hundreds of faked specimens with glued realgar grains have been offered in Lima, the larger ones for very high prices. They are said to be from the more famous Julcani or San Genaro mining districts, but probably the realgar crystals and the matrix alike come from the Palomo mine. These specimens are quite easy to recognize, because the realgar on them is always strongly rounded and drops of glue can be seen with a loupe.

Seligmannite $PbCuAsS_3$

Tiny, brightly lustrous prismatic crystals up to nearly 1 mm seen rarely covering sphalerite or galena surfaces have been identified as seligmannite by Anthony R. Kampf (personal communication, 2007). Some of the seligmannite crystals form small star-like groups, probably because of twinning. They are associated with younger realgar crystals and orpiment.

Sphalerite ZnS

Complex brownish black sphalerite crystals up to 3 cm were found with realgar and orpiment. Rarely they are covered by small tetrahedrite crystals. Sphalerite from the Palomo mine also forms lustrous botryoidal chocolate-brown aggregates composed of microcrystals.

Stibnite Sb_2S_3

In 2003 the mine produced strange stibnite specimens, which local dealers call "cactus." Columnar stibnite crystals are completely covered by tiny, later-generation crystals which grow perpendicularly on the earlier crystals. Individual crystals reach 2 cm, and the druses reach 10 cm wide. Stibnite druses of the same type embedded in transparent gypsum have been found regularly since 2004. The same mine has also produced druses of hemispherical aggregates, each hemisphere formed by radiating acicular crystals of stibnite.

Tetrahedrite $Cu_6Cu_4(Fe,Zn)_2(Sb,As)_4S_{13}$

One specimen found at the end of 2006 shows two spherical aggregates, each composed of dozens of tetrahedral crystals to 1 cm; the larger sphere is 3 cm in diameter. Similar tetrahedrite crystals have been found as overgrowths on chalcopyrite and sphalerite crystals; realgar and orpiment pseudomorphs after realgar are overgrown on the tetrahedrite.

ACKNOWLEDGMENT

Thanks to ing. Julio Meza for information about the geology and history of the mine.

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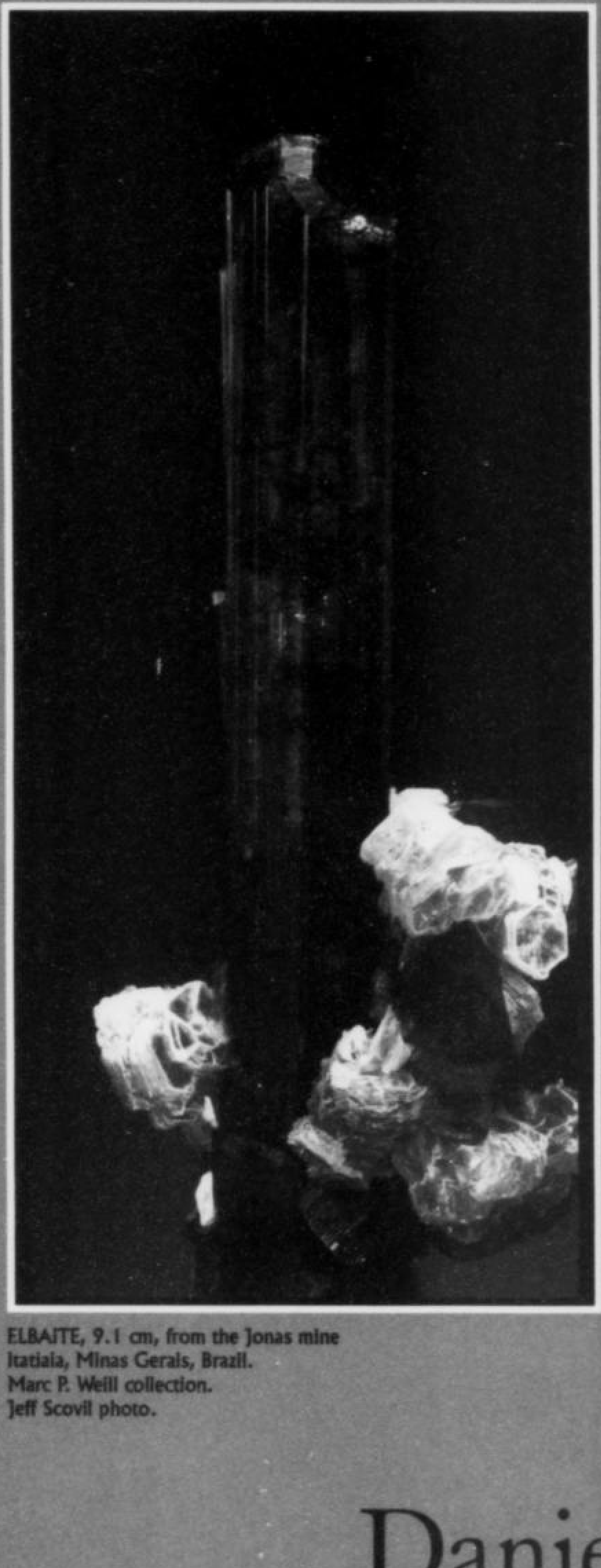
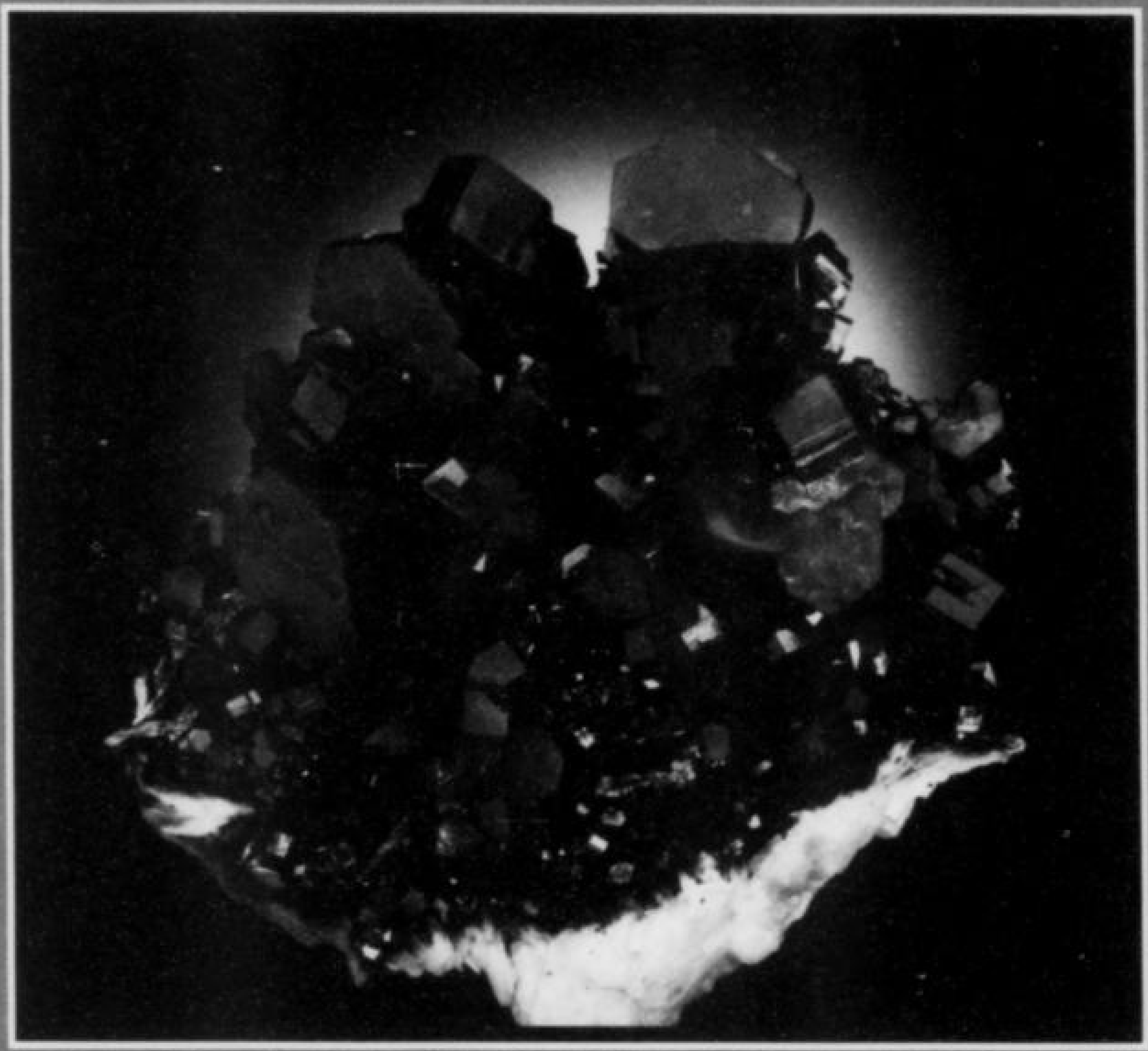
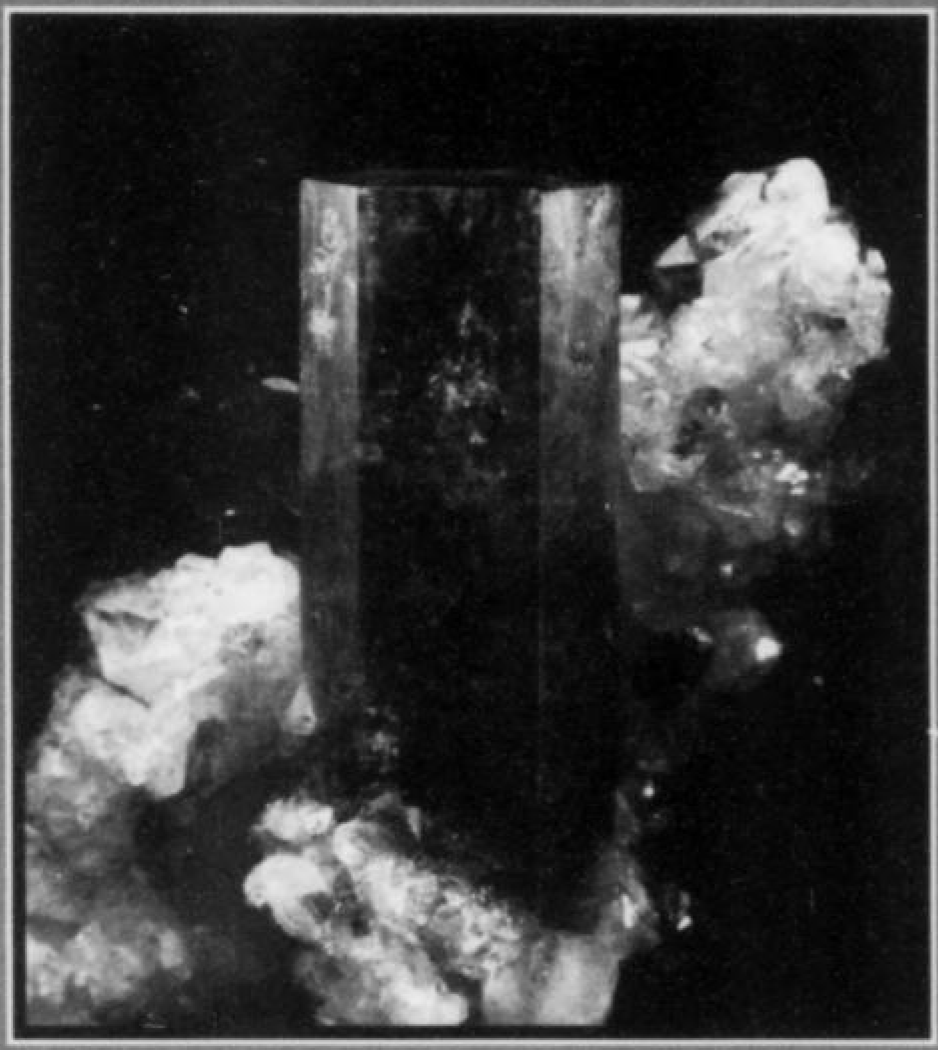


ELBAITE, 9.1 cm, from the Jonas mine
Itatiaia, Minas Gerais, Brazil.
Marc P. Weill collection.
Jeff Scovil photo.



VANADINITE on
Barite, 9.6 cm, from
Mibladen, Morocco.
Marc P. Weill collection.
Jeff Scovil photo.



EMERALD Crystal,
5 cm, from the
Cosquez mine,
Muzo, Colombia.
Marc P. Weill collection.
Jeff Scovil photo.

Daniel Trinchillo

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Michigan

QUARTZ crystals, 4 cm, from Goose Lake, Marquette County, Michigan.
Collected from a surface outcrop of silicified Kona Dolomite in 2006
by Shawn M. Carlson, Mark J. Elder and Matthew K. Heilman.
Once a productive U.S. quartz locality, the Goose Lake occurrence
was later abandoned and the locality lost until its rediscovery in 2004
by Matthew K. Heilman, a student at Northern Michigan University.

From the Shawn M. Carlson Collection

Pseudomorphs from Peru

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Pseudomorphs, crystals that have been replaced by another species while retaining their original shape, have been found in remarkable variety in the mines and mineral deposits of Peru. They provide evidence of changing chemical and physical conditions within ore deposits, and also make fascinating specimens.

INTRODUCTION

Pseudomorphs (replaced crystals) and perimorphs (molds of dissolved crystals) are a rare but very interesting part of the mineral kingdom. They are scientifically important, some of them are aesthetic, and they are very popular among mineral collectors. This article summarizes occurrences of pseudomorphs and perimorphs in Peru, much as a previous study by Hyršl and Petrov (1998) summarized Bolivian pseudomorphs. Most of the cited examples were acquired by the author during regular trips to Peru since 1995, and later analyzed by X-ray diffraction.

The classification of pseudomorphs is very difficult, because in many cases the original mineral cannot be verified. For this reason, they are listed here according to the chemical composition of the replacing mineral. For more detailed description of the localities in Peru see Crowley *et al.* (1997) and Hyršl and Rosales (2003, 2005).

SULFIDES

Acanthite after Silver

The Uchucchacua mine has produced excellent specimens of silver minerals, especially in 2001. Black acanthite pseudomorphs after thick native silver wires to about 1 cm long rise from calcite druses, together with small crystals of acanthite paramorphous after argentite.

Arsenopyrite after Pyrrhotite

The Huanzala mine has occasionally produced nice pseudomorphs of arsenopyrite after thin, platy pyrrhotite crystals.

Chalcopyrite/Pyrite/Stannite (?) after Chalcopyrite

The Animon mine (also called the Alimon mine, in the Huaron district) has yielded Peru's most beautiful chalcopyrite specimens. In 2001 it produced strange pseudomorphs of a mixture of sulfide species after chalcopyrite. These are yellow rounded crystals to 2 cm with dull luster, on thin quartz needles with black sphalerite. X-ray diffraction analysis indicates that the replacing substance is a mixture of chalcopyrite, pyrite and a mineral close to stannite.

Galena after Apatite

Galena is an unstable mineral in the mines of Quiruvilca; Crowley *et al.* (1997) mention that pseudomorphs of sphalerite, tetrahedrite and even gratonite after galena are known from the locality. However, in a specimen collected in December 2002, a mixture of galena and calcite forms a pseudomorph after three parallel hexagonal crystals (with prism and pinacoid faces), to 1 + 3 cm, of an unknown mineral on a pink manganocalcite crystal. The shape would suggest that apatite was most probably the original mineral. Galena forms tiny rounded crystals, and calcite forms gray, distorted rhombohedrons of saddle-like shape to about 1 mm. Three bournonite crystals to 4 mm are seen as floaters in the galena-calcite mixture.

Galena after Barite

Pink platy barite crystals have been found quite commonly in the Jesus vein of the Julcani mine since 2004. The crystals reach about 5 cm long and are comonly found covered by younger siderite and galena. Several specimens, almost certainly from the Jesus vein, show original platy barite crystals covered by fine-grained galena and by later-generation beige-colored siderite. The barite was later

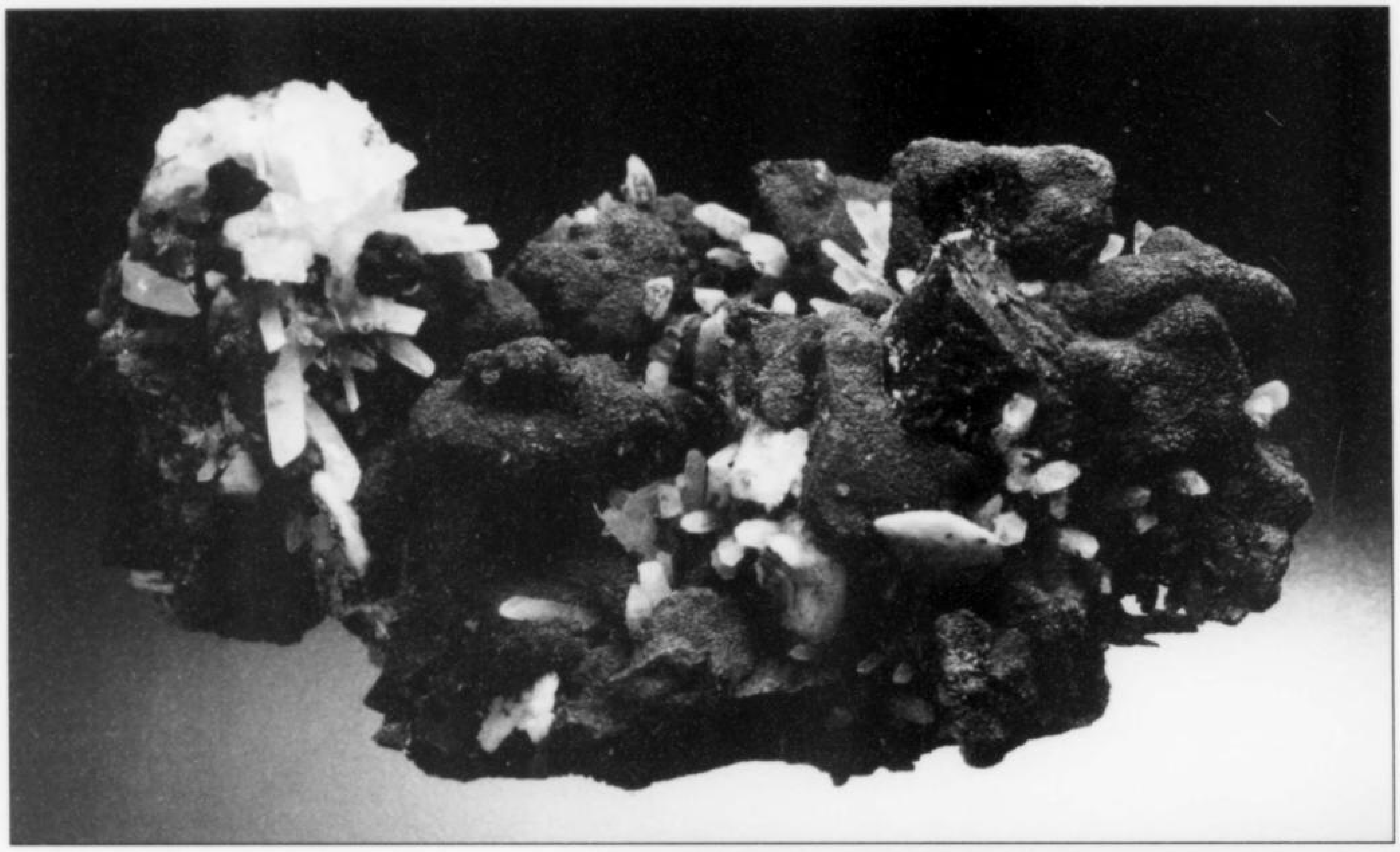

Figure 1. **Mixture of chalcopyrite, pyrite and stannite after chalcopyrite, 11 cm, from the Alimon mine. Jaroslav Hyršl collection and photo.**

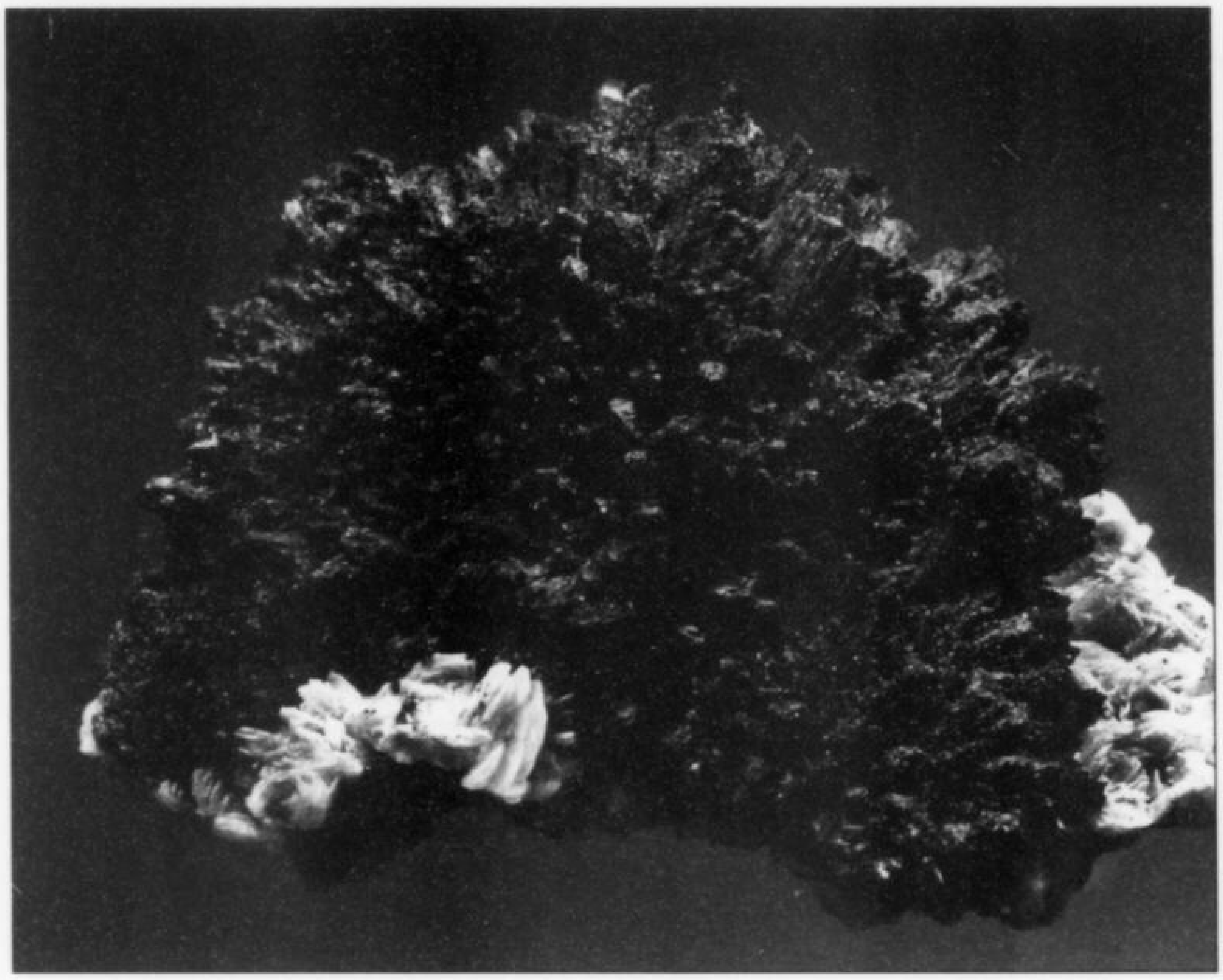

Figure 2. **Galena after stibnite, 12 cm, from the Julcani district. Jaroslav Hyršl collection and photo.**

replaced by galena. The youngest barite generation forms small, colorless, transparent crystals on the surface of the pseudomorph.

At least two interesting specimens of galena perimorphs after barite crystals were found at Quiruvilca in 2002. These are hollow, rectangular galena casts. The larger specimen, now in the collection of Rock Currier, measures 3 × 8 × 8 cm.

Galena after Stibnite

A very aesthetic pseudomorph which the author purchased in 2000 comes reportedly from the Julcani district, but Crowley *et al.* (1997) mention the same type from the Cuadalosa mine in the Castrovirreyna district. These two mining districts lie very close to each other, and it may be that the pseudomorphs in question come from both places. The studied specimen is a druse of fine-grained gray galena pseudomorphs after pointed stibnite crystals up to about 2 cm in length. Some of the pseudomorphs are hollow.

Pararealgar after Realgar

In 2000 the Palomo mine in Huancavelica Department produced nice single crystals of transparent red realgar up to about 2 cm. Most of the crystals have two symmetrical superficial zones of alteration to orange pararealgar (see the accompanying article in this issue).

Pyrite after Arsenopyrite

One of the pyrite after pyrrhotite pseudomorphs from Huanzala contains also an unusual pseudomorph of pyrite after elongated 1.5-cm arsenopyrite crystals.

Pyrite after Barite

Barite is common in the Julcani district, and commonly is replaced by galena and sphalerite. One specimen collected in 2005 shows platy pyrite pseudomorphs up to 1 cm after (most probably) barite.

Figure 3. **Pyrite after pyrrhotite, 8.5 cm, from the Huanzala mine. Jaroslav Hyršl collection and photo.**

Quartz perimorphs after barite have been noted commonly in the Pachapaqui mine since 2004. One specimen found in December 2005 has one side of the perimorph entirely composed of pyrite crystals (combining the cube and pyritohedron forms); the remaining sides of the perimorph are formed by a thin quartz layer.

Pyrite after Chalcopyrite

One of the most interesting Peruvian pseudomorphs came in 2001 from the Pachapaqui mine, a locality noted especially for producing many habits of calcite. Sharp pseudomorphs of fine-grained to coarse-grained pyrite after chalcopyrite are covered by brightly lustrous tetrahedrite crystals to 1 cm. The original chalcopyrite crystals were up to 5 cm, and in some specimens chalcopyrite is still present as grains in the centers of the pseudomorphs. Tetrahedrite has grown epitactically on the pseudomorph's surfaces as parallel crystals. The tetrahedrite covered the chalcopyrite first, and then chalcopyrite was replaced by pyrite.

Even more aesthetic, sharp pseudomorphs of pyrite after chalcopyrite to 4.5 cm came at the end of 2005 from the Casapalca district. The pseudomorphs are intergrown with quartz prisms, tennantite crystals to 1 cm, and black sphalerite crystals to 3 cm covered by tiny tennantite tetrahedrons. Rarely, pseudomorphs of tennantite after enargite rest on the tops of the pseudomorphs.

Pyrite after Enargite

Between 1984 and 1987, hollow cast pseudomorphs of pyrite after enargite up to 7 cm long were found at Quiruvilca (Crowley *et al.*, 1997).

Pyrite after Pyrrhotite

The Huanzala mine is probably the world's biggest producer of pyrite crystals. It has also yielded many interesting pseudomorphs of pyrite after platy hexagonal pyrrhotite crystals to more than 5 cm. Some of the pseudomorphs are hollow, and some are covered by small galena crystals.

Many specimens whose locality is given as the Huanzala mine may well be from the small Pucarrajo mine, which has a similar assemblage and is situated near the pass between the Huanzala and Pachapaqui mines. On studied specimens of pyrite pseudomorphs after pyrrhotite from the area, those from Pucarrajo are more columnar than the platy ones from Huanzala.

A specimen with unusually elongated fine-grained pyrite pseudomorphs after pyrrhotite comes reportedly from the Colquijirca mine near Cerro de Pasco. Of the several pseudocrystals, the largest is 4 cm long but only 1 cm in diameter.

I visited the San Cristobal mine in January 2006, and inside the mine I saw a wall 3 meters high and partially covered by galena crystals to 2 cm; a 1 square meter area of the wall was completely covered by pyrite pseudomorphs after pyrrhotite up to 1 cm, a few of these pseudocrystals reaching 2 cm across. Unfortunately, the rock was too hard to allow extraction of a good specimen.

Pyrite pseudomorphs after flat pyrrhotite crystals to 5 mm associated with small pyrite crystals were found at Uchucchacua in 2002.

Pyrite after Siderite

Casapalca has produced specimens showing pyrite cast pseudomorphs after a carbonate, most probably siderite. These are rhombohedrons to 2 cm, formed by 1.5-mm crusts of fine-grained pyrite overgrown by small quartz crystals; inside the casts are abundant small pyrite cubes.

Pyrite after Tetrahedrite

A few strange specimens were found in the Casapalca district in September 2001: rounded crystals covered by a thin, lustrous crust, analyzed as a tetrahedrite-tennantite mixture with a ratio close to 1:1. The underlying pseudocrystals consist of fine-grained pyrite and, to judge from their shape, they are probably pseudomorphs after tetrahedrite-tennantite or after chalcopyrite. The pseudomorphs, reaching about 1.5 cm in diameter, rest on druses of short-prismatic quartz crystals.

Sphalerite after Barite

Goodell (1974) shows a picture of a colloidal epimorph of sphalerite after flat barite crystals from the Julcani district; the specimen is 15 cm across. Another specimen, collected in the Jesus vein in Julcani in 2005, shows plates of fine-grained sphalerite covered by younger, pale brown siderite. A sphere of colloidal pyrite, typical for Julcani, is sitting on the top of the specimen.

Sphalerite and Arsenopyrite after Calcite

A few unusual pseudomorphs were found in the Carmen mine in the Casapalca district in the summer of 2005. They show hollow, pointed triangular shapes which very probably are molds after calcite scalenohedrons. The molds are composed of tiny black sphalerite crystals mixed with larger galena crystals up to 5 mm, coated by tin-white arsenopyrite crystals on their inner surfaces. The pseudomorphs reach 3 cm long and almost 2 cm wide, and are partially covered by younger, elongated, white calcite crystals. Probably the molds grew over the original calcite crystals from only one direction, because all are open on the same side.

Sphalerite after Galena

On a specimen probably found in the Julcani district, a black cube, 1.9 cm on edge, occurs with platy barite crystals and a younger calcite crust. The cube is composed of coarse-grained sphalerite and surely is a pseudomorph after galena.

Another specimen, collected in 2005 in the Animon mine, has several cubic pseudocrystals of brown sphalerite up to 1 cm on edge. One is broken and is seen to consist entirely of sphalerite, proving that the replacement is complete. The original mineral was almost surely galena, as fresh cubic crystals of pyrite are also present.

Sphalerite after Wurtzite (?)

A nice specimen which came from Huanzala in 2004 shows two types of pseudomorphs. In one of them, thick hexagonal-tabular crystals of sphalerite to 1 × 3 cm are covered by small galena crystals. In the other, pyrite appears as hexagonal-tabular pseudocrystals to 2 cm in diameter but only 3–5 mm thick; some of the pseudocrystals are slightly twisted and several are hollow. It seems clear that in the latter specimens pyrite has replaced pyrrhotite, but in the former specimens sphalerite must have replaced a different hexagonal or trigonal mineral. Wurtzite is a possibility, as Huanzala is the only Peruvian locality known for wurtzite crystals. In this case the original crystal would have been one of the world's finest wurtzites, had it survived unaltered.

Tetrahedrite after Bournonite

Pseudomorphs of tetrahedrite after columnar, striated bournonite crystals from the Julcani district are also interesting; they were collected around 1996. The pseudocrystals are up to about 1 cm long, and grow on white barite together with acicular crystals of bismuthinite.

Tennantite after Enargite

One of the most beautiful Peruvian pseudomorphs was found in the Julcani district in 1999, and specimens were quite abundant for a short time. They show tennantite replacing columnar enargite crystals, accompanied by white barite plates. The size of the pseudocrystals reaches at least 5 cm, but most of them are severely damaged. Many of the pseudocrystals are hollow, with enargite remaining in the centers of some of them as black cleavable grains. A few of the pseudocrystals, to about 1 cm long, are covered by tiny pyrite crystals. X-ray diffraction studies show that the replacing material has a tetrahedrite : tennantite ratio close to 1:1.

Figure 4. **Tennantite after enargite, 6 cm, from the Julcani district. Jaroslav Hyršl collection and photo.**

Pseudomorphs of tennantite after enargite were found also in the Casapalca district in November 2005. They are columnar and hollow, and reach 2 cm long. Some of the pseudocrystals rest on nice sharp pyrite pseudomorphs after chalcopyrite, intergrown with black sphalerite crystals.

Crowley *et al.* (1997) mention many pseudomorphs from Quiruvilca. The most abundant of these are probably partial to complete pseudomorphs of tetrahedrite after enargite, very similar to the more recent specimens from Julcani. According to Rock Currier, they were not analyzed, but it is reasonable to suppose that, like the Julcani specimens, they are tennantite and not tetrahedrite; moreover, enargite and tennantite contain the same elements.

The extremely important Cerro de Pasco silver deposit is still exploited by a huge open pit, but in recent years almost no mineral specimens from this locality have appeared on the market. Ward (1961) describes many types of pseudomorphic replacements from Cerro de Pasco, including tennantite, chalcopyrite, chalcocite and pyrite after enargite, as well as enargite and chalcocite after pyrite. Unfortunately, the author has seen no examples of any of these recently.

HALIDES

Paratacamite after Atacamite

The small Lily copper prospect, about 50 km east of Pisco, yielded beautiful specimens of atacamite, malachite, chrysocolla and gypsum around 1998–2000, as well as the world's best paratacamite in dark green cuboidal crystals to 1.5 cm. The best known Lily prospect specimen of atacamite included in gypsum appears on the cover of the *Mineralogical Record*, vol. 31, no. 3. A few pale green columnar aggregates to about 1 cm long were found to be paratacamite; these must be pseudomorphs after atacamite.

Fluorite after Calcite

Several attractive specimens found in the Huanzala mine in 2005 show thin purple fluorite crusts on calcite crystals. Most of the calcite has dissolved away, but in some cases the perimorphs are filled with recrystallized calcite crystals, proving that the perimorphs are natural, not products of artificial leaching.

CARBONATES

Calcite after Galena

One specimen found at the Huanzala mine shows a hollow

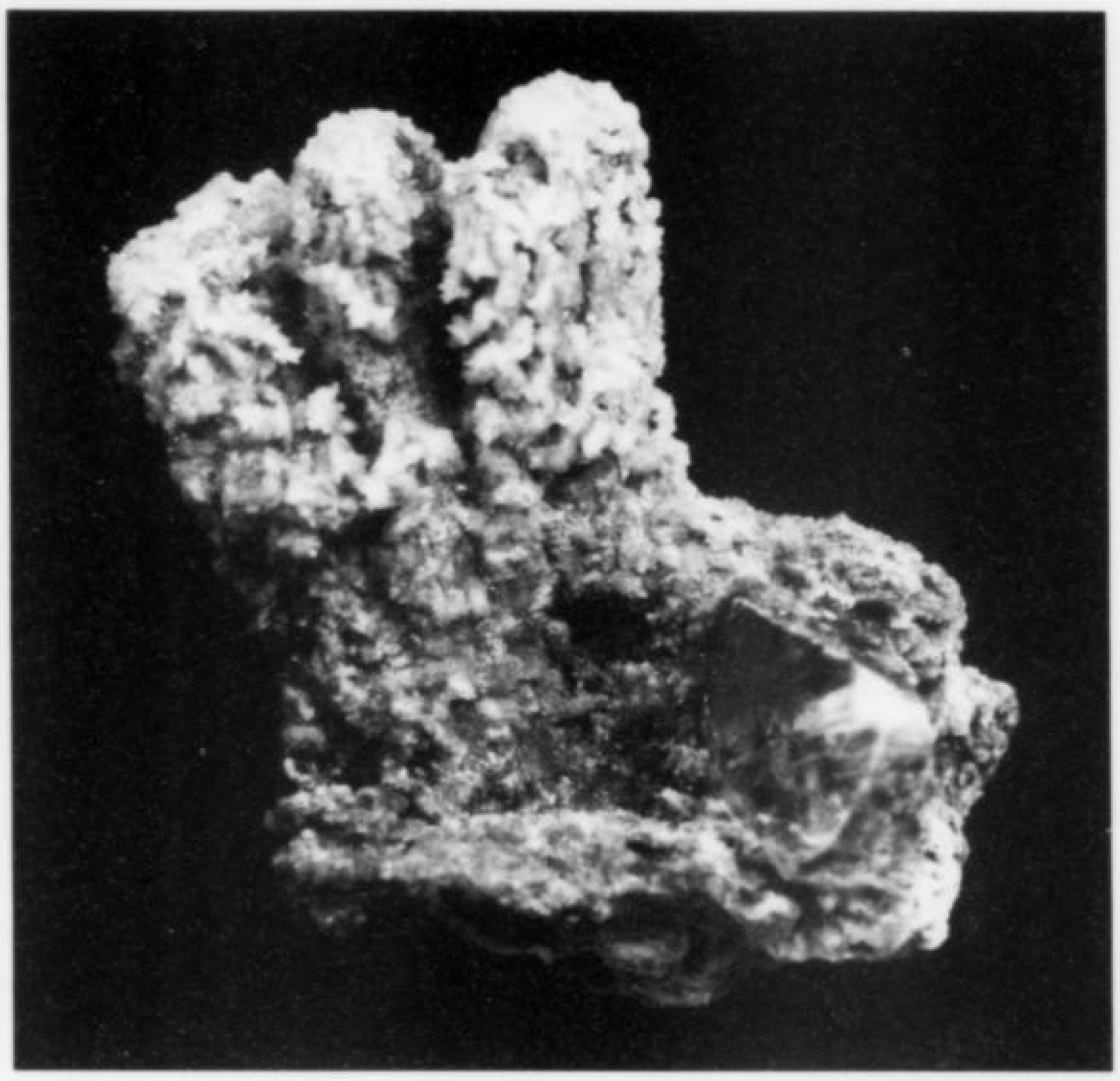

Figure 5. **Paratacamite after atacamite, 1.8 cm, from the Lily copper prospect. Jaroslav Hyršl collection and photo.**

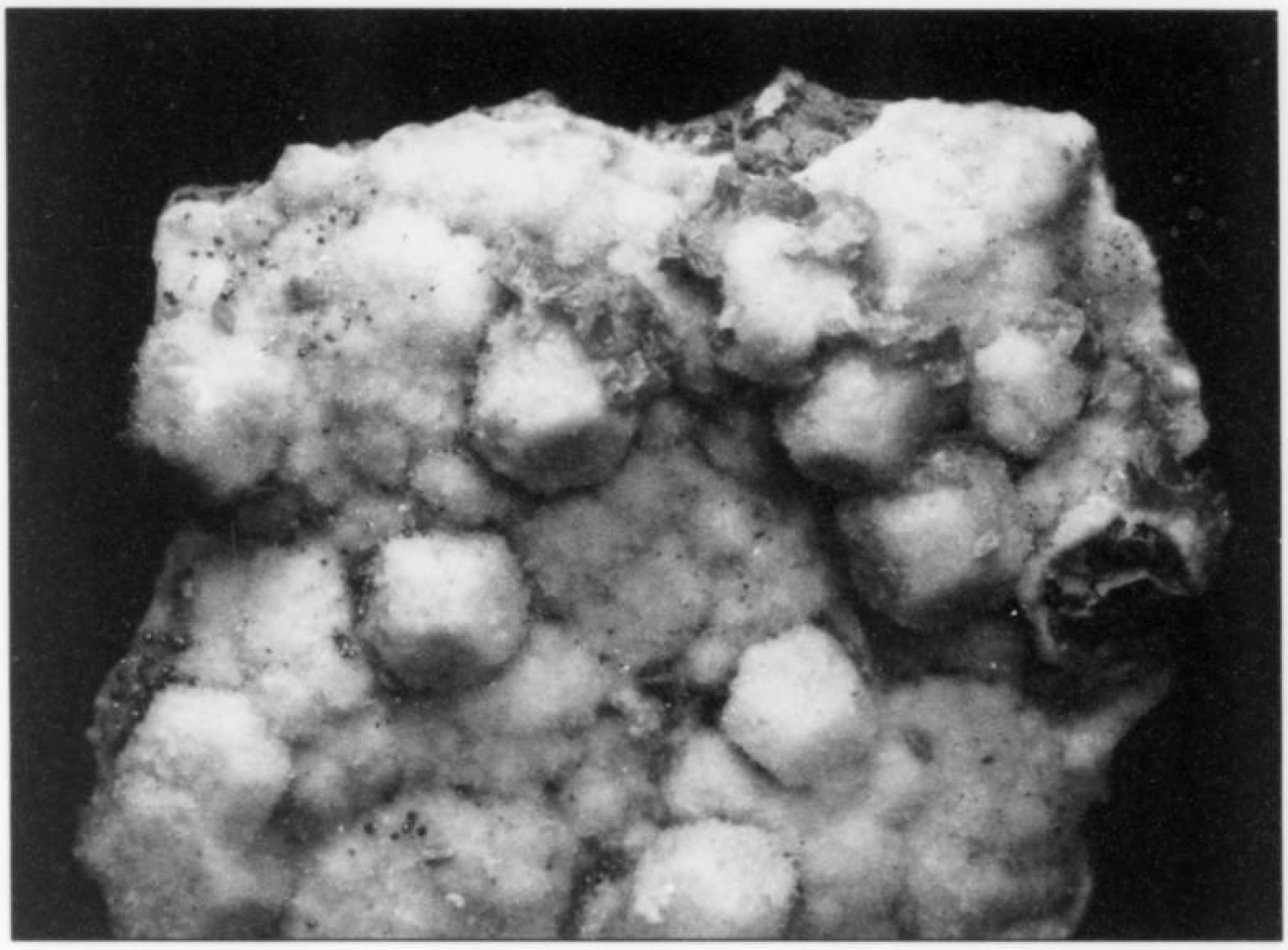

Figure 6. **Quartz perimorphs over rhodochrosite pseudomorphs after galena, 6.5 cm, from Morococha. Jaroslav Hyršl collection and photo.**

calcite perimorph about 1.5 cm across with patches of corroded galena on its inner surface. Most probably, therefore, the original mineral was galena.

Dolomite after Calcite

A specimen showing dolomite perimorphs after calcite rhombohedrons to 3 cm is most probably from the Huanzala mine. The dolomite crust is 2 mm thick and covered by colorless fluorite cubes measuring 2 to 10 mm.

Rhodochrosite after Barite

In recent years, until 2002, Huaron has produced only a very few interesting specimens. Surprisingly, in October 2002 a cavity was discovered with pink rhodochrosite forming perimorphs after dissolved barite. In most cases the flat perimorphs form the bottoms of specimens, but some complete rhodochrosite pseudomorphs after barite to about 6 cm were also found. In some cases the rhodochrosite is covered by hemispherical aggregates of black sphalerite to 3 cm in diameter, accompanied by small pyrite and rarely even tiny pyrargyrite crystals.

Rhodochrosite after Galena

One very interesting specimen found in the Morococha district in January 2004 is a matrix entirely covered by a white crust of tiny quartz crystals, a perimorph after a crust of cuboctahedral crystals to about 1 cm. To judge from their shape, the original crystals were galena, but now all galena has leached away, leaving cavities which are filled completely by massive rhodochrosite or partially by pink rhombohedral rhodochrosite crystals to 3 mm.

Siderite after Galena

Casapalca is a big mine close to Lima which has produced some pseudomorphs. For instance, siderite pseudomorphous after galena occurs as hollow brown molds of cuboctahedral form to 2.5 cm. The molds rest on tetrahedrite crystals and small, corroded galena remnants.

Smithsonite after Calcite

A discovery at Casapalca in 2001 produced a few specimens with druses of small, sharp, gray scalenohedrons to about 3 mm, with a few gypsum crystals to 5 cm resting on the druses. The scalenohedrons are hollow and X-ray diffraction analysis has identified them as smithsonite. This is surprising, because secondary minerals are almost unknown in Peruvian deposits situated at very high altitudes. The specimens probably represent smithsonite perimorphs after calcite.

TUNGSTATES

Hübnerite after Scheelite (?)

The mines of the Pasto Bueno district have produced the world's best hübnerite crystals, and they have also yielded a few nice specimens of hollow hübnerite molds after bipyramidal or octahedral crystals resting on a mixture of quartz with greenish muscovite. The pseudocrystals, reaching about 2 cm, are composed of small dark red hübnerite crystals. There are two possibilities for the identity of the original dissolved crystals: scheelite and fluorite, both common at Pasto Bueno. Scheelite is more probable because its chemistry is closer to that of hübnerite.

SILICATES

Quartz after Barite

A very unusual and aesthetic specimen from the Pachapaqui

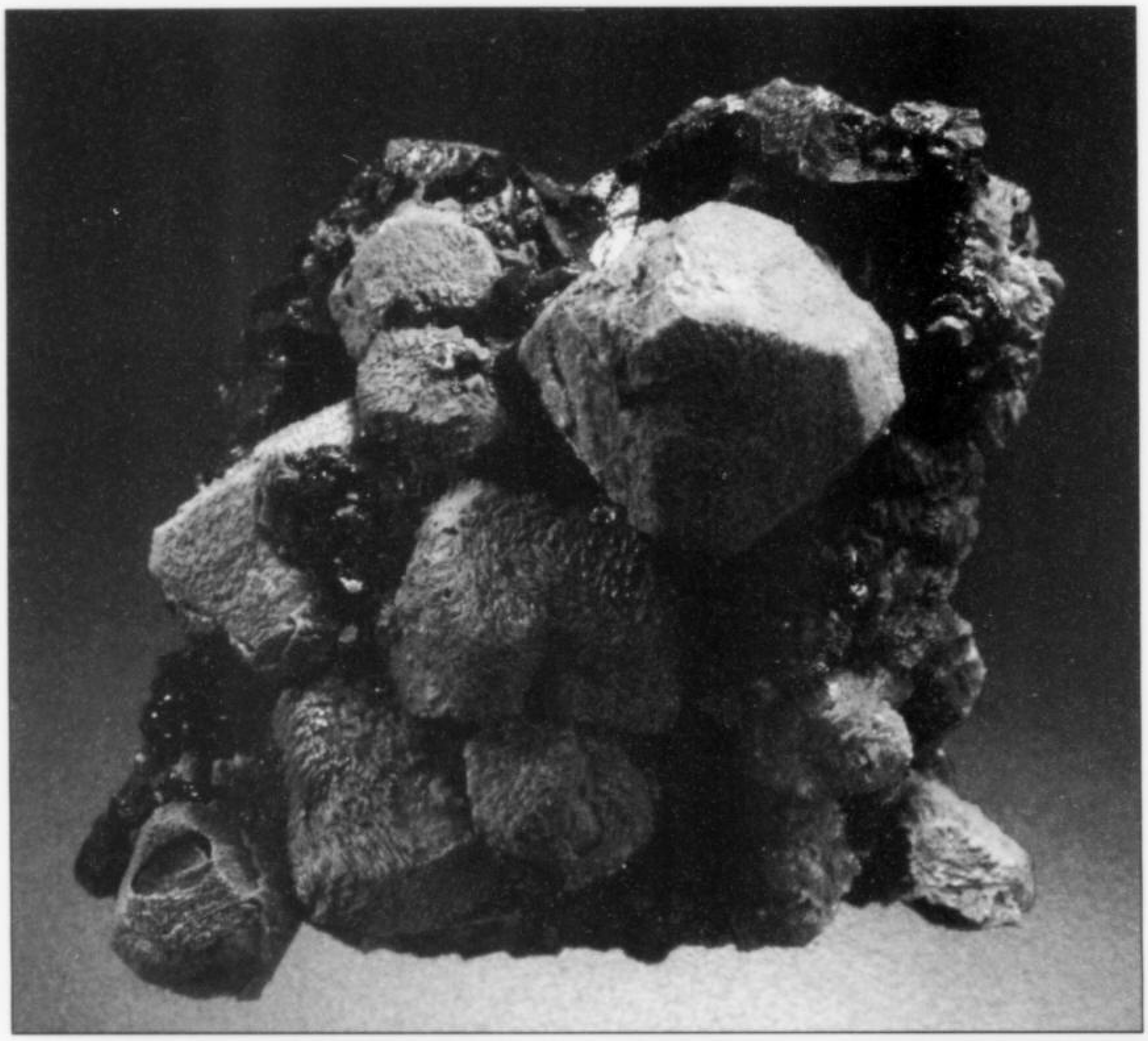

Figure 7. **Siderite after galena, 6.5 cm, from Casapalca. Jaroslav Hyršl collection and photo.**

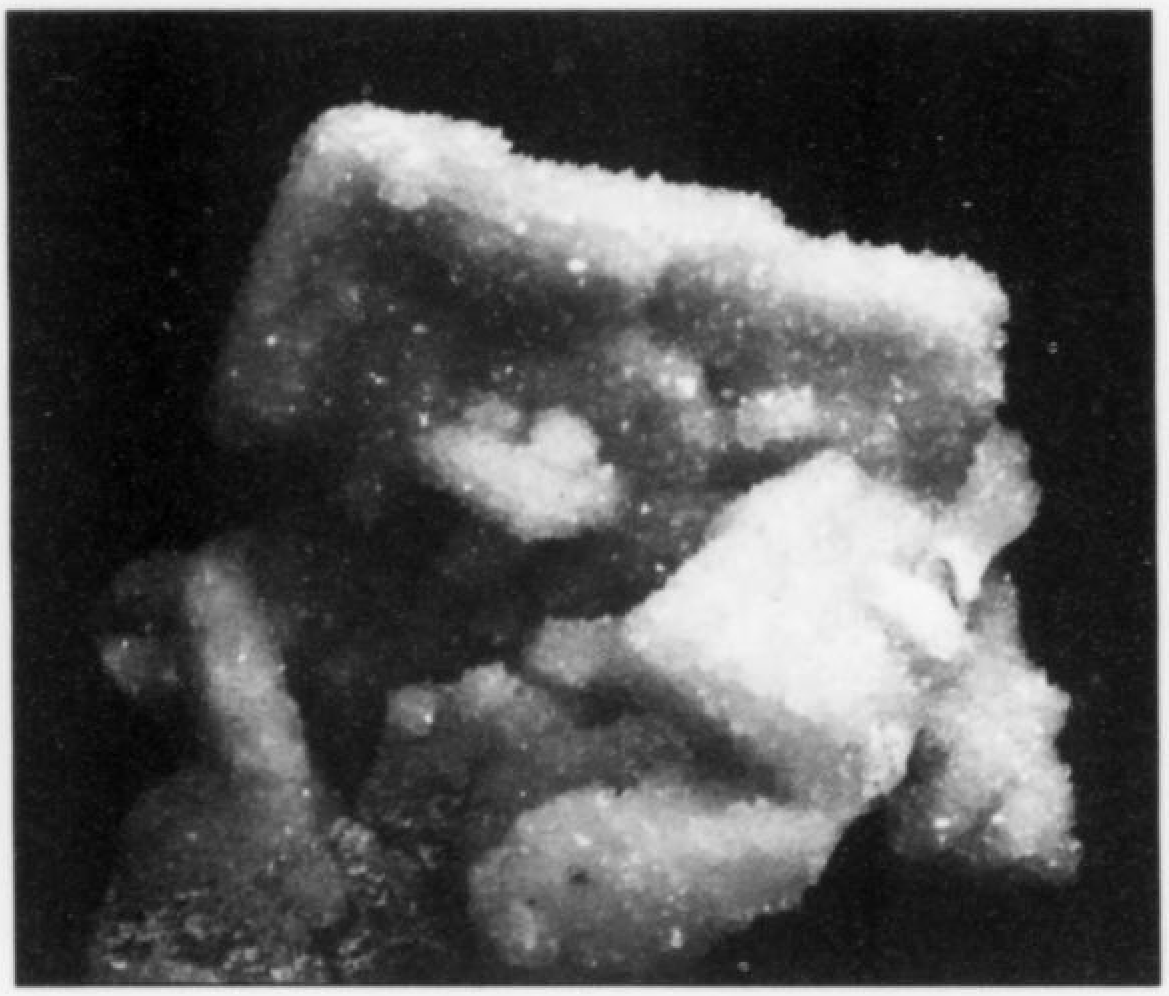

Figure 9. **Quartz after barite, 14 cm, from the Julcani district. Jaroslav Hyršl collection and photo.**

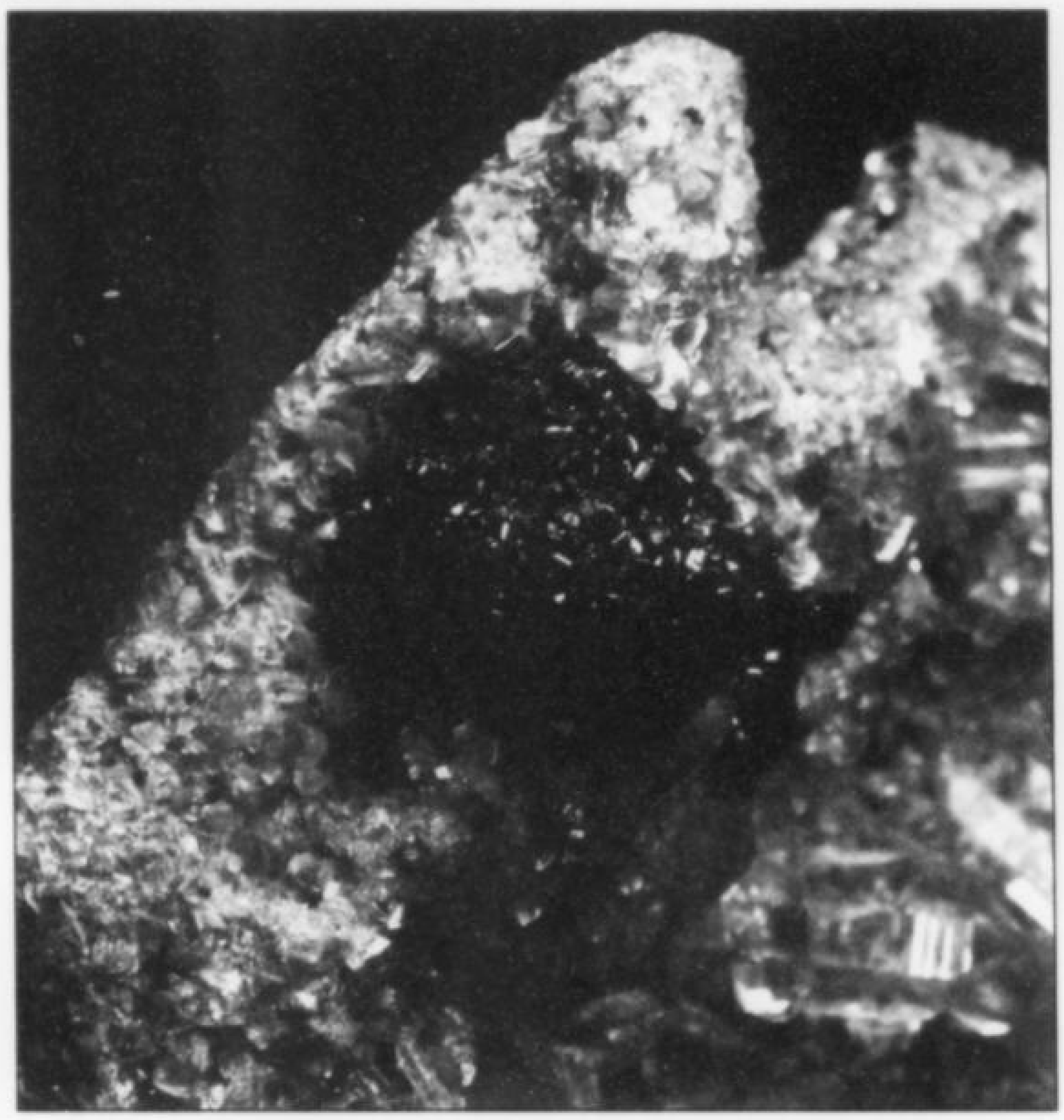

Figure 8. **Hübnerite after scheelite, 1.8 cm, from Pasto Bueno. Rock Currier collection; Jaroslav Hyršl photo.**

district was acquired in Lima in December 2004. It is a quartz perimorph after platy rectangular crystals, probably of barite. The specimen measures 18 × 24 cm and the original barite plates were up to 11 cm long and 2 cm thick. On the front side were originally two layers of parallel barite crystals at an angle of 150 degrees. Barite was covered by quartz crystals to about 1.5 cm and by pyrite cubes to 5 mm, then dissolved away, forming a quartz perimorph. Similar but much inferior specimens from the Pachapaqui district were quite abundant for some time; some of these show younger pink manganese-rich calcite crystallized in cavities. Specimens found at the end of 2005 have abundant pyrite crystals on their surfaces.

Huaron produced good pseudomoprhs of rhodochrosite after barite in 2002 (see earlier). A few specimens from the same vein show platy quartz perimorphs after barite to 7 cm long, covered by barrel-shaped quartz crystals and druses of small rhodochrosite crystals.

Two specimens showing quartz pseudomorphs after barite were collected a long time ago in the Julcani district. Both consist entirely of quartz, which replaced original barite crystals up to 1 × 4 × 8 cm.

The small Palomo mine between Julcani and San Genaro has been producing good stibnite and gypsum specimens since the end of 2003. Specimens found there in December 2005 show well-formed quartz pseudomorphs after barite to 2 cm, some of them with greenish yellow orpiment or hemispheres of stibnite needles resting on them. One pseudomorph is broken and can be seen to be hollow.

Quartz after Calcite

The Milpo and Atacocha mines are both situated near Cerro de Pasco, and available lots of specimens from them are usually mixed together. One of the mines produced a quartz perimorph specimen showing a very thin quartz crust over a vanished 1.5-cm calcite rhombohedron. The perimorph is intergrown with barrel-shaped quartz crystals of the kind that are typical for both mines.

One specimen from the Casapalca district in the Rock Currier collection has two rhombohedral pseudocrystals to 5 cm, each composed of small, thin quartz crystals to about 1 cm long; it is surely a pseudomorph after a carbonate, most probably calcite. A similar specimen found in 2002 has a perimorph of small quartz crystals after two calcite rhombohedrons, and measures about 4 × 6 × 7 cm. Small acicular arsenopyrite crystals occur on the inner surface of the perimorph, and yellow calcite scalenohedrons occur on its outer surface.

Quartz pseudomorphs after very thin, platy calcite crystals are present on a few specimens of pyrite after chalcopyrite from the Pachapaqui district. The largest of these measures about 3 × 5 cm.

Quartz after Fluorite

A few interesting quartz after fluorite pseudomorphs were found a few years ago in the Animon mine. They are hollow molds of small, transparent quartz crystals on black sphalerite which originally grew on octahedral fluorite crystals to 4 cm, after which the fluorite was dissolved completely.

Quartz after Pyrrhotite

One quartz pseudomorph after a hexagonal-tabular pyrrhotite crystal 7 mm wide and 2 mm thick was found among pyrite pseudomorphs after pyrrhotite from the San Cristobal mine in January 2006.

K-feldspar after Fluorite

One of the strangest of the new Peruvian pseudomorphs was found at Pucarrajo in 1999 and again in 2000. The pseudocrystals are snow-white octahedrons to 8 mm, composed, according to X-ray diffraction analysis, of fine-grained microcline or orthoclase. They rest on quartz and are covered by tiny, younger pyrite cubes. To judge by their shape, they are pseudomorphs after fluorite.

Muscovite after Epidote

Pampa Blanca, a famous locality about 80 km east of Pisco, produced a huge number of fan-shaped aggregates of epidote a few years ago, as well as excellent Japan-law twins of quartz to 50 cm. From a border of the deposit came a few specimens showing fan-shaped muscovite pseudomorphs to about 12 cm with quartz crystals. To judge by their shapes, the muscovite must have replaced epidote.

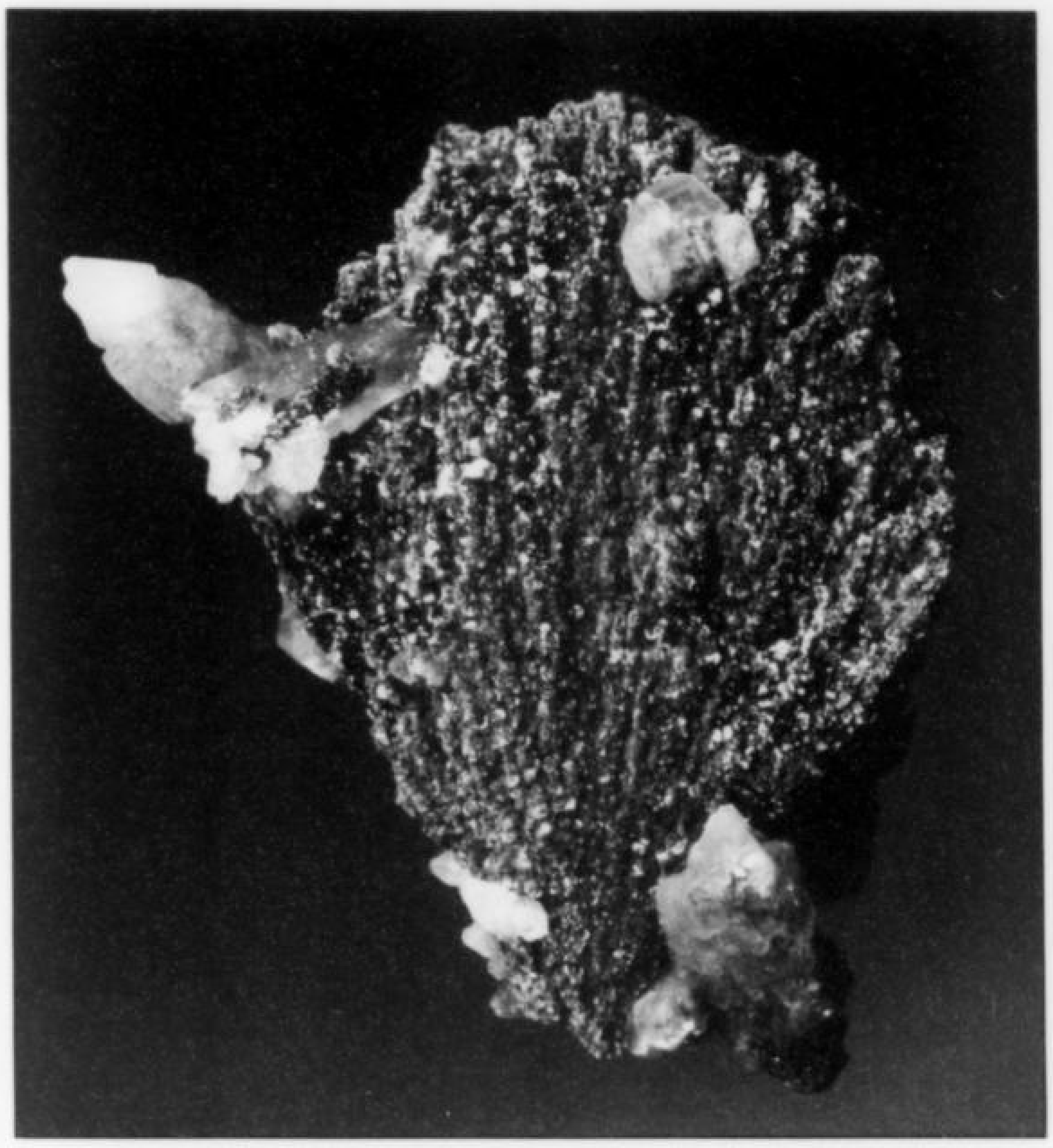

***Figure 10.* Muscovite after epidote, 9.5 cm, from Pampa Blanca. Jaroslav Hyršl collection and photo.**

Neotocite and Quartz after Unknown

Some specimens from Uchucchacua collected in December 2004 show unusual pseudomorphs associated with red scalenohedral crystals of rhodochrosite. The pseudocrystals are sharp, simple tetrahedrons up to 1 cm, formed by a thin quartz crust at the surface and filled with amorphous black neotocite inside. The identity of the original mineral remains a mystery.

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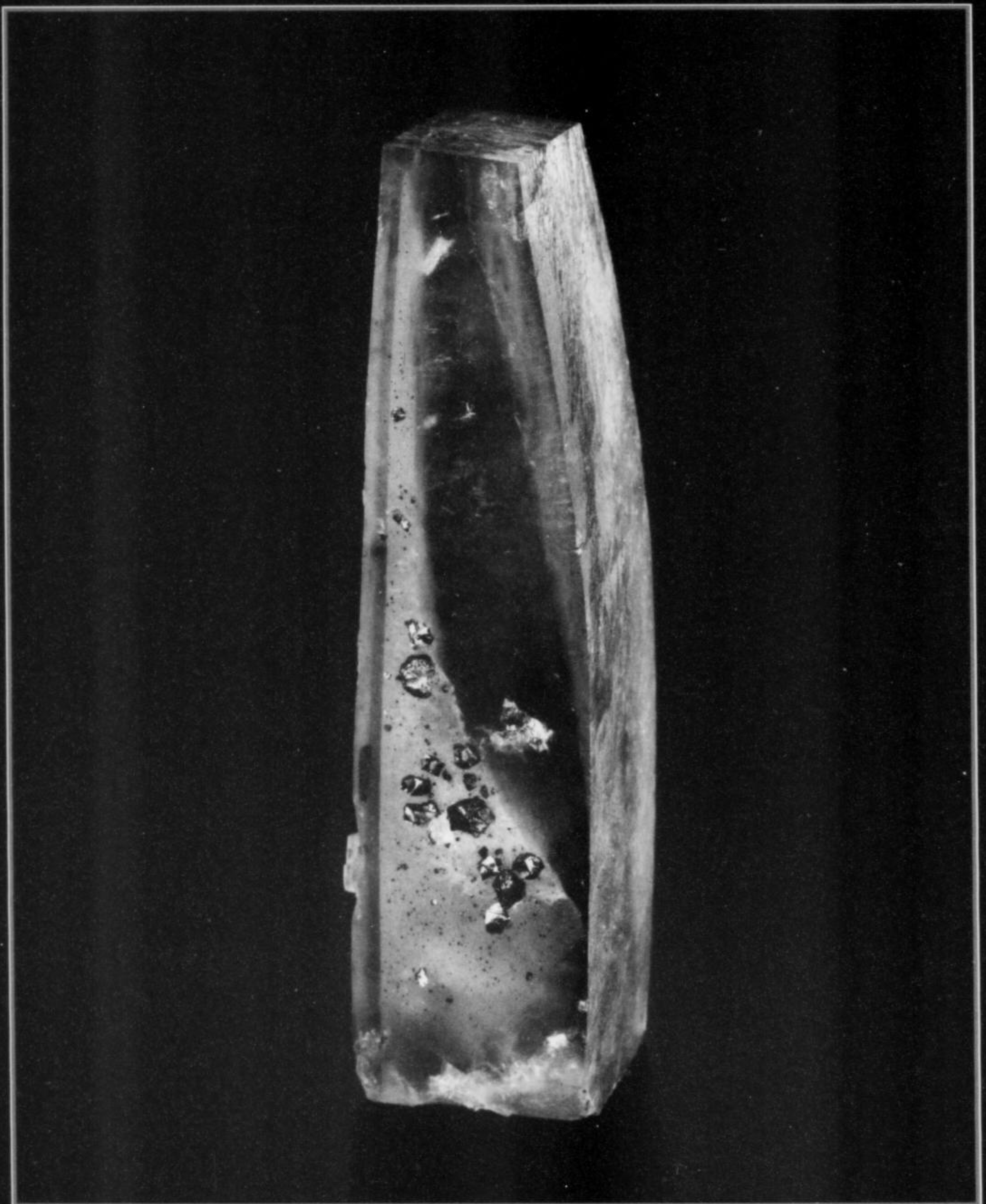

George Washington Fiss
(1835–1925)
and his Micromount Collections

Wendell E. Wilson[1],
Rock H. Currier[2], **Carl A. Francis**[3], and **Sugar White**[4]

George Washington Fiss, one of the first and greatest of all micromounters, created two remarkable collections—one of them built, in part, by the extraordinary expedient of breaking small pieces off of specimens in one of the greatest private mineral collections of all time, that of his friend Clarence S. Bement. Both collections have been preserved more or less intact.

Introduction

George Washington Fiss was born in Philadelphia in March of 1835, the son (probably) of Mary and George Fiss, a shoemaker. He married Ellen L. Mehl in the Germantown neighborhood of Philadelphia in 1860, and made his living as a manufacturer of worsted wool yarn. Fiss lived at 1911 Green Street in Philadelphia for most of his life, but his five daughters were all born in Germantown, probably in the home of his wife's parents, Jacob and Harriet McCalla Mehl. Ellen died shortly after 1870, possibly from childbirth complications following the birth of her daughter Emily in December of that year. George lived thereafter with his daughters Elizabeth (Lizzie), Mary, Carrie, Helen and Emily; though the other daughters eventually moved out one by one, Lizzie never married, and continued to live with her father and care for him until his death at the age of 90 (she died within five years thereafter). They were a reasonably affluent family, inasmuch as they had three live-in servants from 1870 to 1920, though one of them, Blanche Balles (born 1870), was listed as a "friend" in the 1910 and 1920 censuses. Whether she was a "friend" of George or of Lizzie remains unknown.

In 1881 Fiss was among the first collectors in Philadelphia to begin mounting microscopic mineral specimens for study. In fact, he is considered, along with George G. Rakestraw (1827–1904), who began making mounts in the late 1870's, to be a co-founder of the hobby of micromounting (Wills, 1931). However, it appears from surviving correspondence of the British mineral dealer Bryce Wright (Wight, 1993) that William W. Jefferis (1820–1906) began collecting microminerals and mounting them for study much earlier, in the early 1850's, and Dr. J. C. Green of West Chester, Pennsylvania began making mounts as early as 1861.

Fiss was apparently not aware of these other early micromounters. He used small brass enclosure rings glued to standard glass microscope slides for his mounts, then changed to small 1-inch pasteboard boxes in the early 1880's. The use of the boxes was pioneered by Rakestraw, but Fiss was the first to blacken the insides of the boxes to eliminate unwanted reflections, and to affix the specimens on small, carefully shaped cork pedestals. Fiss, who was noted in his day for the quality of his specimens as well as the craftsmanship of his mounts, taught many of his friends and fellow collectors how to make micromounts.

Charles Palache (1951) remembered him thus:

> Mr. George W. Fiss was a noble looking man, tall with a full snowy white beard, splendid carriage and a most charming

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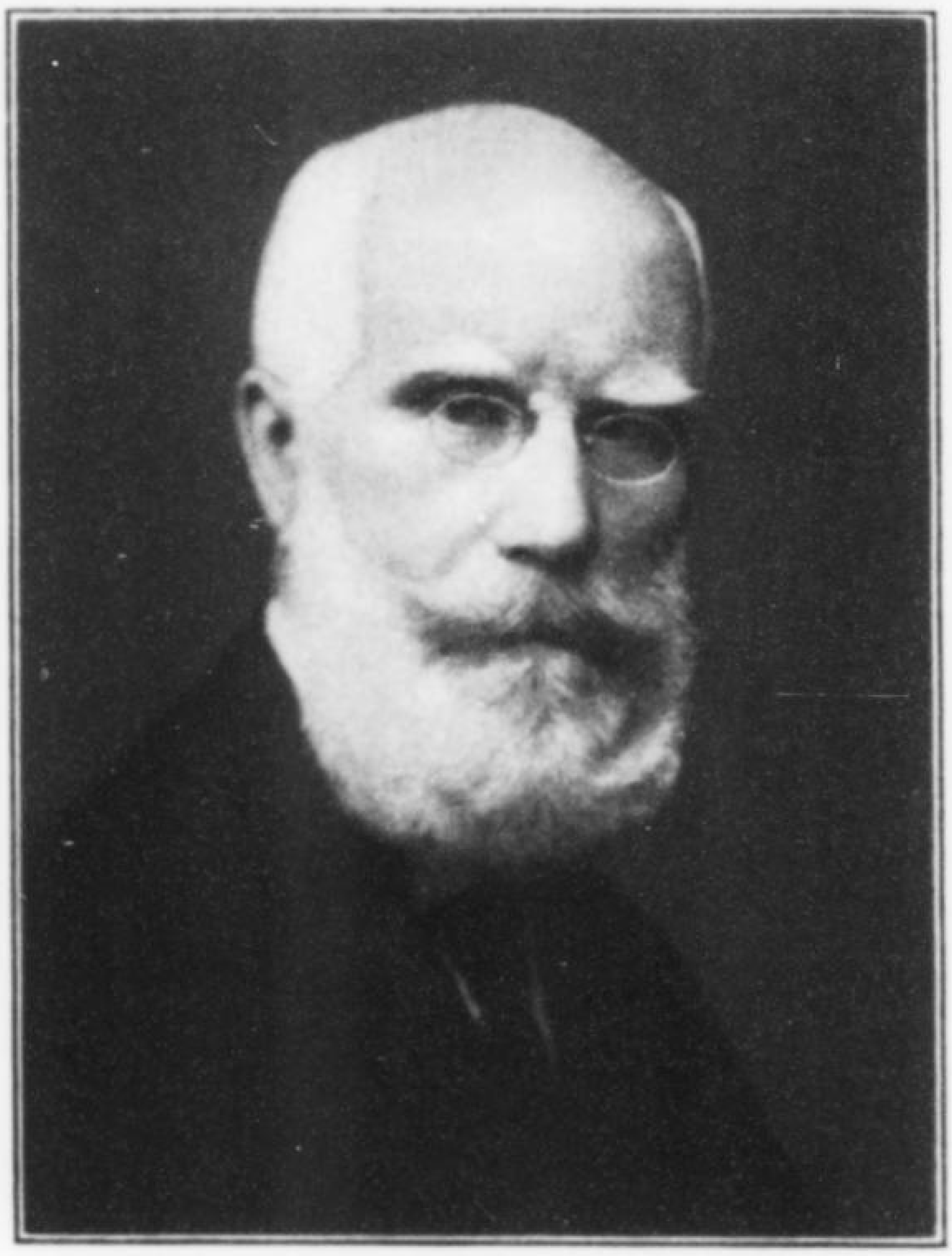
> voice and smile. On my rare visits to Philadelphia he would promptly give me a huge and very strong cigar and plant me at his rotating table with the tall Zentmeyer binocular microscope. He always had new mounts and problems of identification. Hours would pass, and between the fumes of nicotine, the smell of the parafin lamp which he always used and eyestrain, I would find myself physically exhausted until I could not tell quartz from galena at the evening's end. But I found an unending fascination in his careful preparations. I believe he much advanced the art of making these mounts. He was a dear friend—modest, kind and humble.



Geo. W. Fiss

Figure 1. **George Washington Fiss (1835–1925).**

Fiss also had a close relationship with the two leading American mineral dealers of his day, Albert E. Foote (1846–1895) and George L. English (1864–1944), both of whom had their offices in Philadelphia—though English relocated to New York in 1892. Fiss obtained much of his working material from them. In fact, English sold Fiss finished mounts prepared for him by George Rakestraw. Fiss also obtained many specimens for mounting from the New York mineral dealer Lazard Cahn (1865–1940) before Cahn moved to Colorado Springs around 1915.

Despite his enthusiastic work as a micromounter, Fiss was modest regarding his own qualifications as an amateur mineralogist of any sort. He was also a bird-watcher and horticulturist, but when invited to attend a botanical symposium in 1904, he responded:

> Since our old friend the Doctor left us I have given practically no attention to botanical matters, my intent being centered in

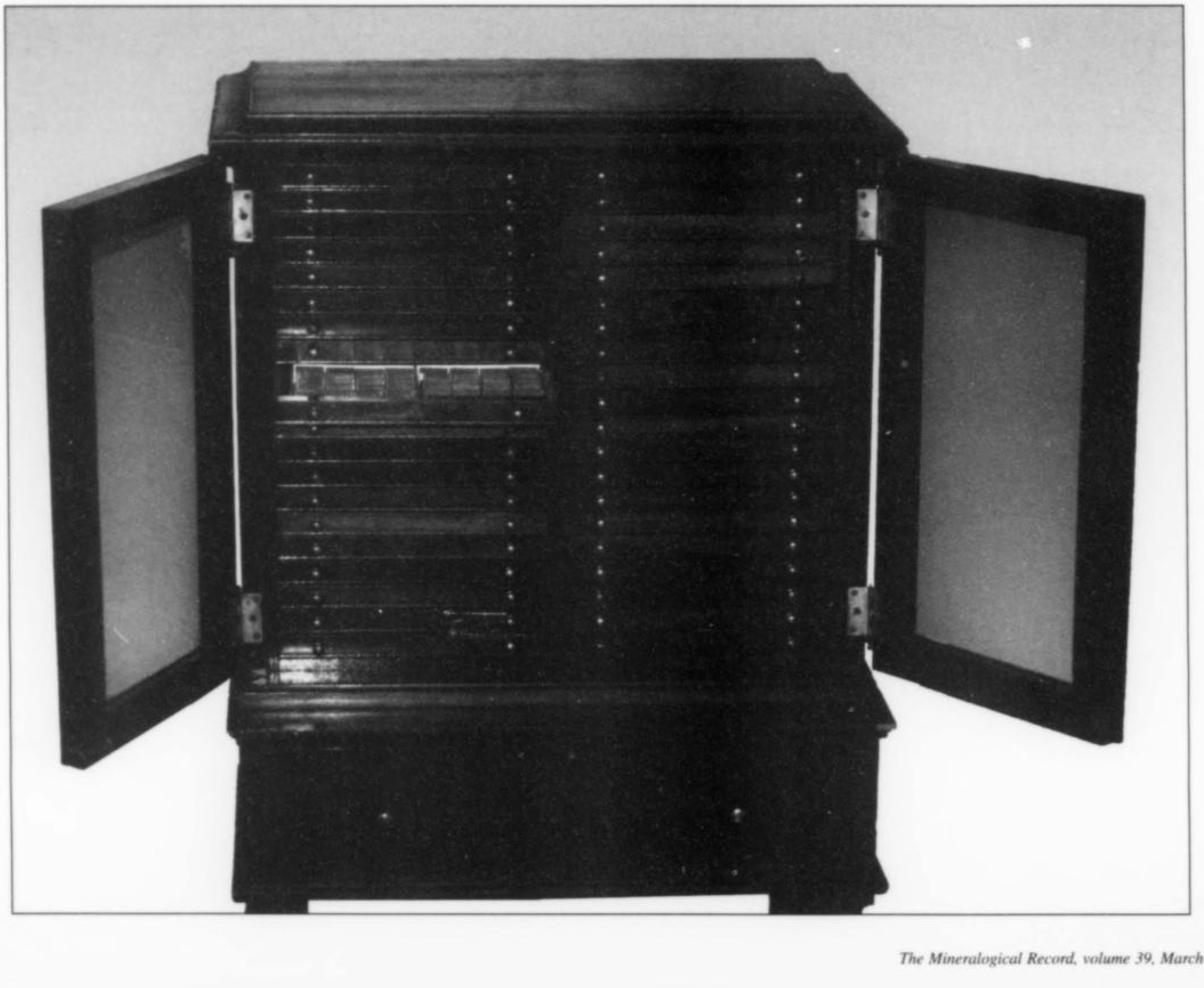


Figure 2. **The Fiss-Keeley micromount cabinet bequeathed to Frank Keeley in 1925, donated to the Philadelphia Academy of Natural Sciences in 1949, and sold to Wayne Leicht in 2007. Wendell Wilson photo.**

Figure 3. **An 80-specimen drawer in the Fiss-Keeley cabinet. The pale blue labels identify specimens from the Frank Keeley collection that were added to fill gaps. Wendell Wilson photo.**

Figure 4. **Typical top and bottom labels from a specimen mounted by Fiss. Wendell Wilson photo.**

> building up my collection of microscopic mineral crystals to the exclusion of all other hobbies. I say "hobbies" because these branches have really been so *to me*, and I have never ventured to call myself a *student* in any department of natural history.

The Two Fiss Micromount Collections

Fiss was also a close friend of the great Philadelphia collector Clarence S. Bement (1843–1923) (Peters and Pearson, 1990). Beginning around 1897 he helped Bement build a micromount collection and eventually acquired it for himself as well. Then, after taking what he wanted from it, he offered it for sale to his friend Albert Fairchild Holden of Cleveland. Fiss recounted the history of the Bement micromount collection in a letter to Holden dated August 21, 1912:

> I began making a collection of these micro minerals in 1881, when I found I had neither time nor money to make a collection of first class cabinet specimens and so decided to gather crumbs that came from your big collectors tables and I believe I am the first to attempt to gather these *scraps* systematically. Bement from the first took a warm interest in what I was doing. Together we went over his large collection and broke off any micro things when it could be done without injury to the cabinet specimen.
>
> Whenever there was a duplicate, I mounted it and set it aside for him, for he said "if ever I part with my large minerals I will take up this branch." In this way up to [1900] when he sold his collection I had accumulated for him quite a good many mounts including material I had gotten from dealers and from correspondents in the West and elsewhere. He also bought a selection of 500 mounts from another party [G. G. Rakestraw] who had taken up the work. All these I remounted for him. He then took up in earnest (after he sold his collection in [1900]) to collect micro material and begin work with the microscope.
>
> You know his collecting habit, and on his yearly trips to Europe he searched everywhere for suitable material and except for his enthusiasm in this line, I believe some of his trips would never have been made. In this way he added many fine and rare things to both our cabinets without regard to cost. We always had an understanding that in case of the death of either, the survivor was to inherit the [micromount] collection of the other. Happily he is still living and in good health, but unhappily his eyesight has failed. He has many times said "You take my collection for I cannot enjoy it anymore." This I always declined to do and finally he agreed to sell it to me at a nominal price.

Fiss went through the Bement micromount collection after purchasing it and took out those specimens that he needed to upgrade or fill gaps in his own collection. He then replaced most of the ones he had taken with lesser duplicates from his own collection. Holden was quite happy to buy the Bement collection from Fiss, even though it had been high-graded in this manner. In fact, two other collectors had also expressed an interest in it: a Mr. Nicol and "Dr. Goldschmidt," both of whom were sorely disappointed that Holden had gotten it instead.

As it turned out, Fiss kept for himself between a third and a half of the Bement collection, replacing those taken with his own duplicates, for the most part, but also with 77 specimens from J. B. Brinton, Frank J. Keeley and L. C. Wills, and another 56 mounts from five different unidentified collectors. The Bement micromount collection as received by Holden consisted of a total of 2,278 mounts representing 475 species as catalogued at the time (of which 435 remain valid today).

Unfortunately, Holden never even got to examine his purchase. Fiss shipped the collection to him in early September 1912, and soon thereafter Holden was hospitalized and died of abdominal cancer. The Bement collection with its many substitutions, as packed for shipment by Fiss, had never been opened when it was passed on to the Harvard Mineralogical Museum in the spring of 1913, as part of Holden's bequest of his main collection of cabinet specimens. The collection is preserved today in the Harvard Mineralogical Museum, except for a substantial number of duplicates which were distributed by Harvard to various micromounters of the day. To distinguish this

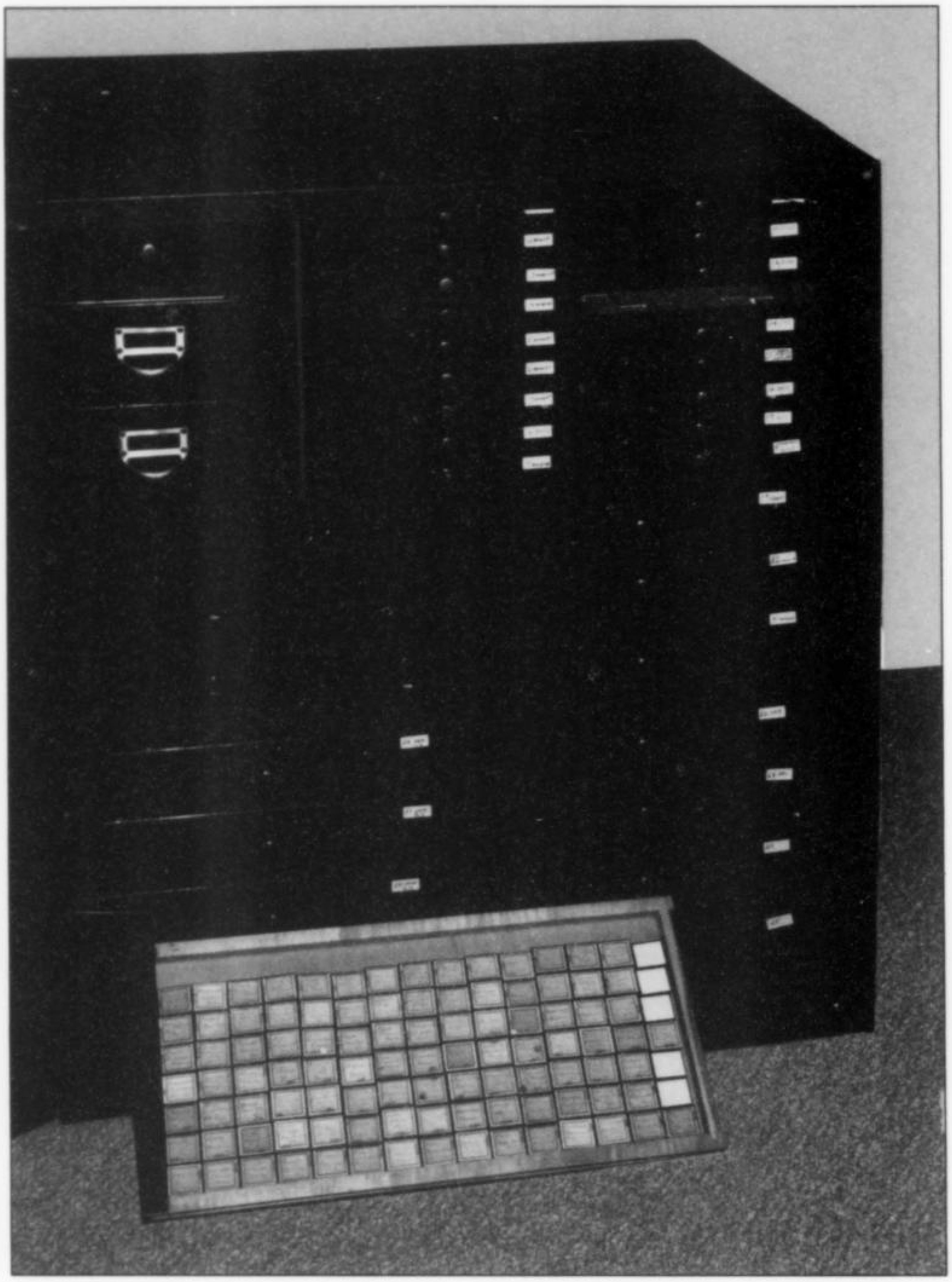


Figure 5. **The Fiss-Holden micromount collection cabinet, now in the Harvard Mineralogical Museum. Carl Francis photo.**

collection from what Fiss considered to be his personal collection, we shall refer to it here as the "Fiss-Holden" collection, whereas Fiss's personal collection, which later went to his friend Frank Keeley and thence to the Academy of Natural Sciences in Philadelphia, shall be referred to as the "Fiss-Keeley" collection.

The Fiss-Holden Collection

The specimen boxes in the Fiss-Holden collection, like those in the Fiss-Keeley collection, are characterized by a rectangular gummed label with his initials ("GWF") and "PHILA" affixed to the bottom, and another with the species and locality neatly written on the lid. On a few of Fiss's oldest mounts the bottom labels are printed on green paper rather than white, and many of the mounts carry a serial number written in red ink on the lower left corner of the lid and the base. These numbers probably refer to catalog entries, but more importantly they perform the vital function of assuring that the lid (with species and locality data) can always be matched up correctly with the corresponding box in which the specimen is held. Chemical class and crystal system are noted in abbreviated form on the inside of the lids. Fiss was so meticulous that he marked with an "F" the side of the box which should be held facing the viewer, noting that each mount is best viewed with the light coming from the upper left. A recommended power of magnification is also marked on the box in each case.

The Fiss-Keeley Collection

Fiss continued his work on microminerals until a few days before his death at the age of 90. His friend Frank J. Keeley, curator of minerals at the Philadelphia Academy of Natural Sciences, inherited Fiss's collection following his death in 1925. Much of Fiss's collection, in its attractive mahogany cabinet, as well as his microscope, accessories and revolving table, was presented by Frank Keeley to the Philadelphia Academy in 1949. Some Fiss specimens from the Fiss-Holden collection also found their way into the collection of the late Lou Perloff and subsequently went to the Natural History Museum of Los Angeles County. In 2007 much of the mineral collection of the Philadelphia Academy of Natural Sciences was sold to a consortium of three mineral dealers; one of the three, California mineral dealer and micromounter Wayne Leicht, obtained the Fiss-Keeley collection as part of the transaction.

The Fiss-Keeley collection is still kept in its original two-column cabinet of drawers with glass-windowed doors. Each drawer in

Figure 6. **Adamite crystals to 0.5 mm, from Cap Garonne, France (no. 8). Sugar White photo.**

Figure 7. **Autunite crystal, 1 mm, from near Deadwood, South Dakota (no. 182). Sugar White photo.**

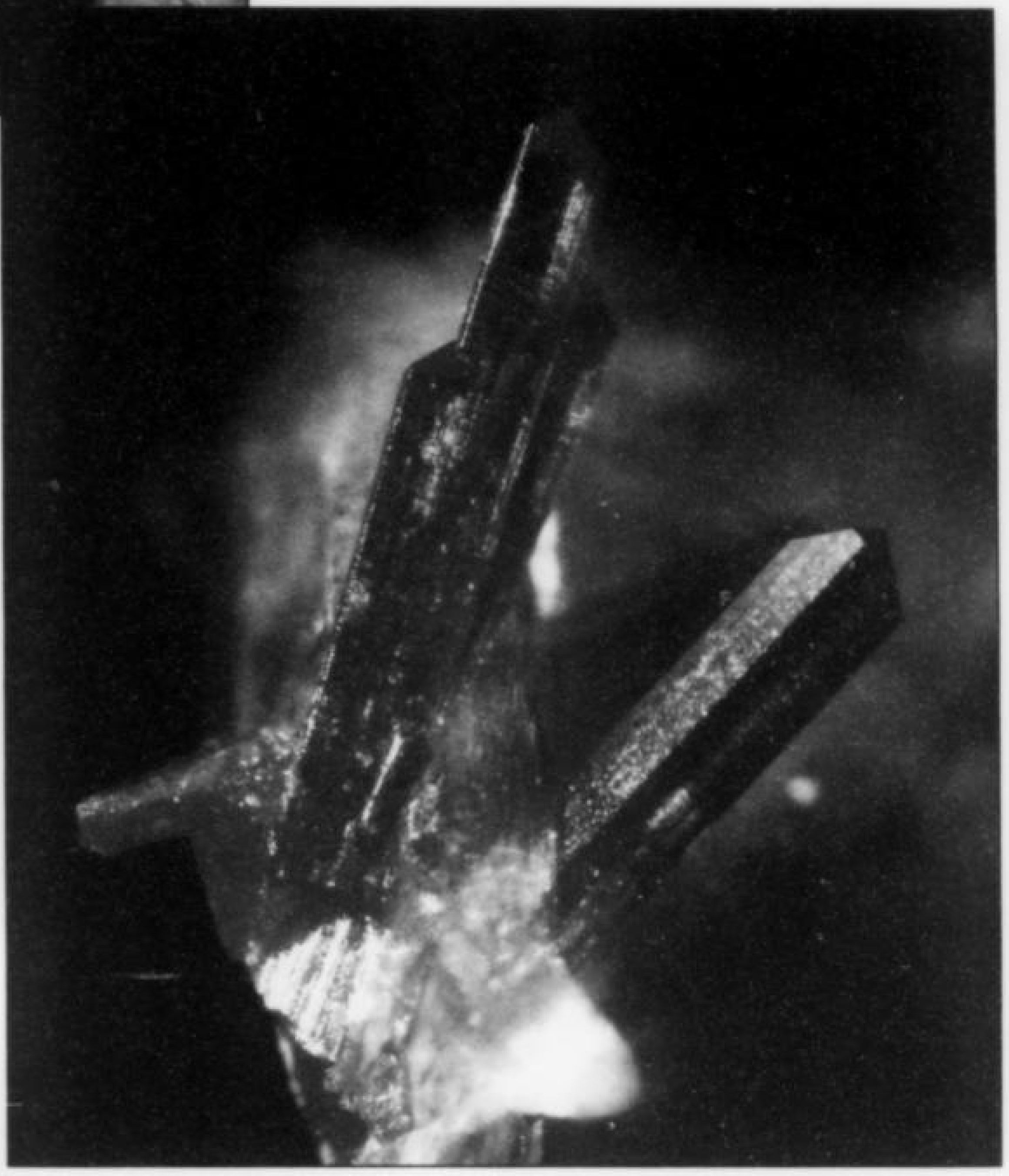


Figure 8. **Amarantite crystals to 1 mm, from the type locality: Tocopilla, Caracoles, Sierra Gorda District Chile (no. 28). Sugar White photo.**

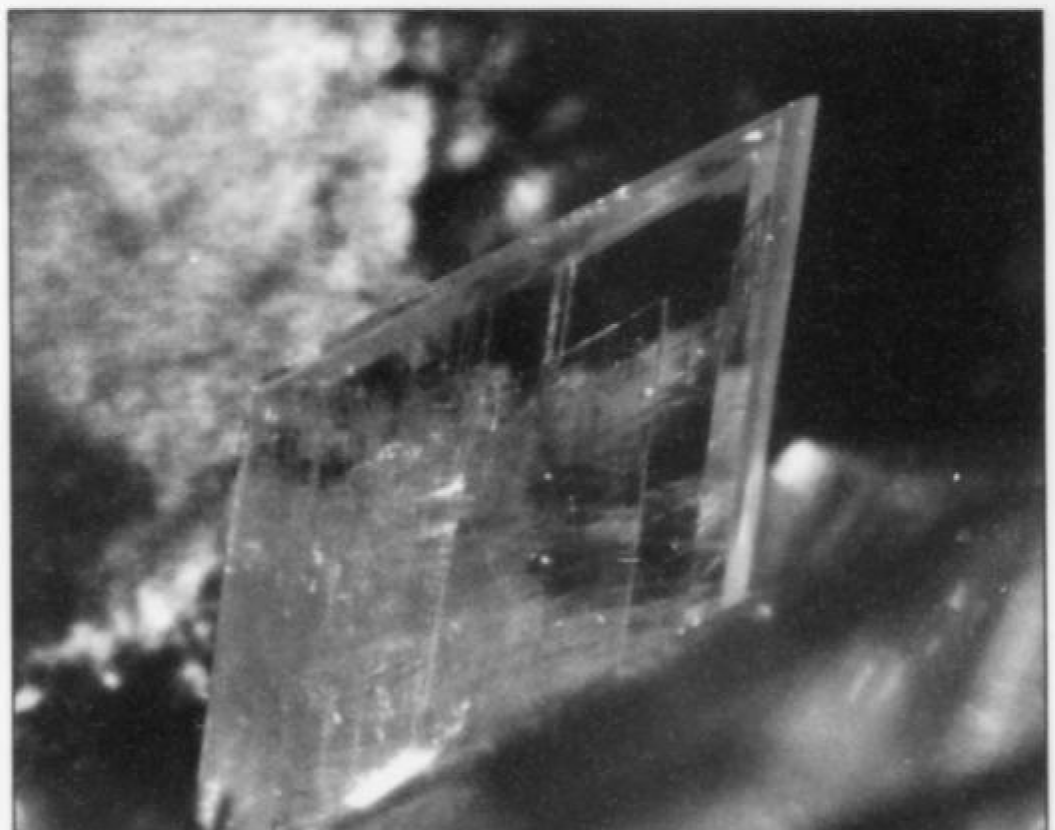


Figure 9. **Annabergite crystal, 1 mm, from Laurium, Greece (no. 338). Sugar White photo.**

the cabinet has four small trays, each containing 20 micromounts (four across and five down). The boxes are paper fiberboard with black bottoms and red tops. The red is mostly covered with a white paper label and a white strip of paper wrapped around the sides of the top.

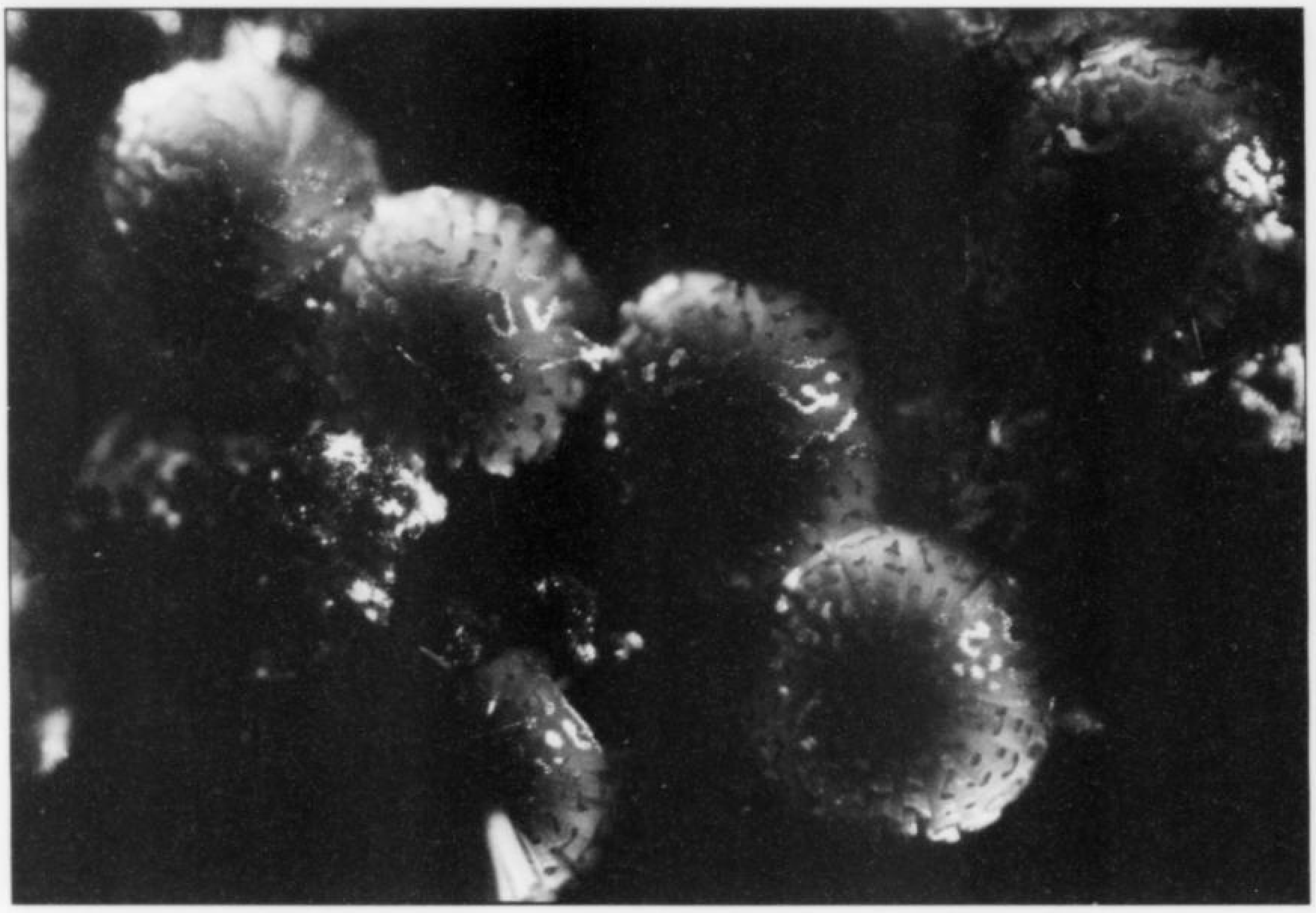
There are some specimens that have vanished over the years, and also some that have decomposed. If the latter were removed (depending on what you would consider decomposed beyond use), there would probably be something over 2,100 specimens remaining in the collection. The overall quality is very high, and most micromounters today would not be able to achieve a collection of comparable depth and quality. The mounting of the specimens is, contrary to Fiss's reputation, rather careless in the shaping of the corks, often employing corks much larger than the specimen and very crudely cut to size. Often the specimens are not centrally mounted in the box and one wonders whether, over the years, the specimen/adhesive bond has suffered some "creep," and the specimens have slid off to one side.

The micromounts are arranged alphabetically by species. They are numbered consecutively in the upper left corner of the top label, in blue ink, running from #1 for the first specimen, an adamite from Greece, to # 2230, a "zydadite" (variety of albite). In the lower left

Figure 10. **Cerussite, from Wallace, Idaho (no. 436). Sugar White photo.**

Figure 11. **Annabergite crystal cluster, 7.5 mm, from Laurium, Greece (no. 338). Sugar White photo.**

Figure 12. **Cacoxenite spheres, 1 mm, from Waldgirmes, Nassau, Germany (no. 339). Sugar White photo.**



corner is a catalog number in red ink. Gaps have apparently been filled by empty boxes marked "missing," probably inserted after Fiss's time by an Academy curator. The person who inserted the empty boxes knew what should have been in the box and, in most instances, where it was from (probably by reference to the Fiss-Keeley collection catalog, which survives in the Academy archives). The consecutive numbering was probably added at a later time to make it easier to see whether any specimens had been taken from the collection. Had it been an active collection, such a numbering system would not have been used because it would not allow for any further additions; obviously it was a "frozen" collection being preserved intact at the time the consecutive numbers were added.

On the inside of the lid is written, in pencil, a notation about the chemistry of the main species on the specimen and the crystal

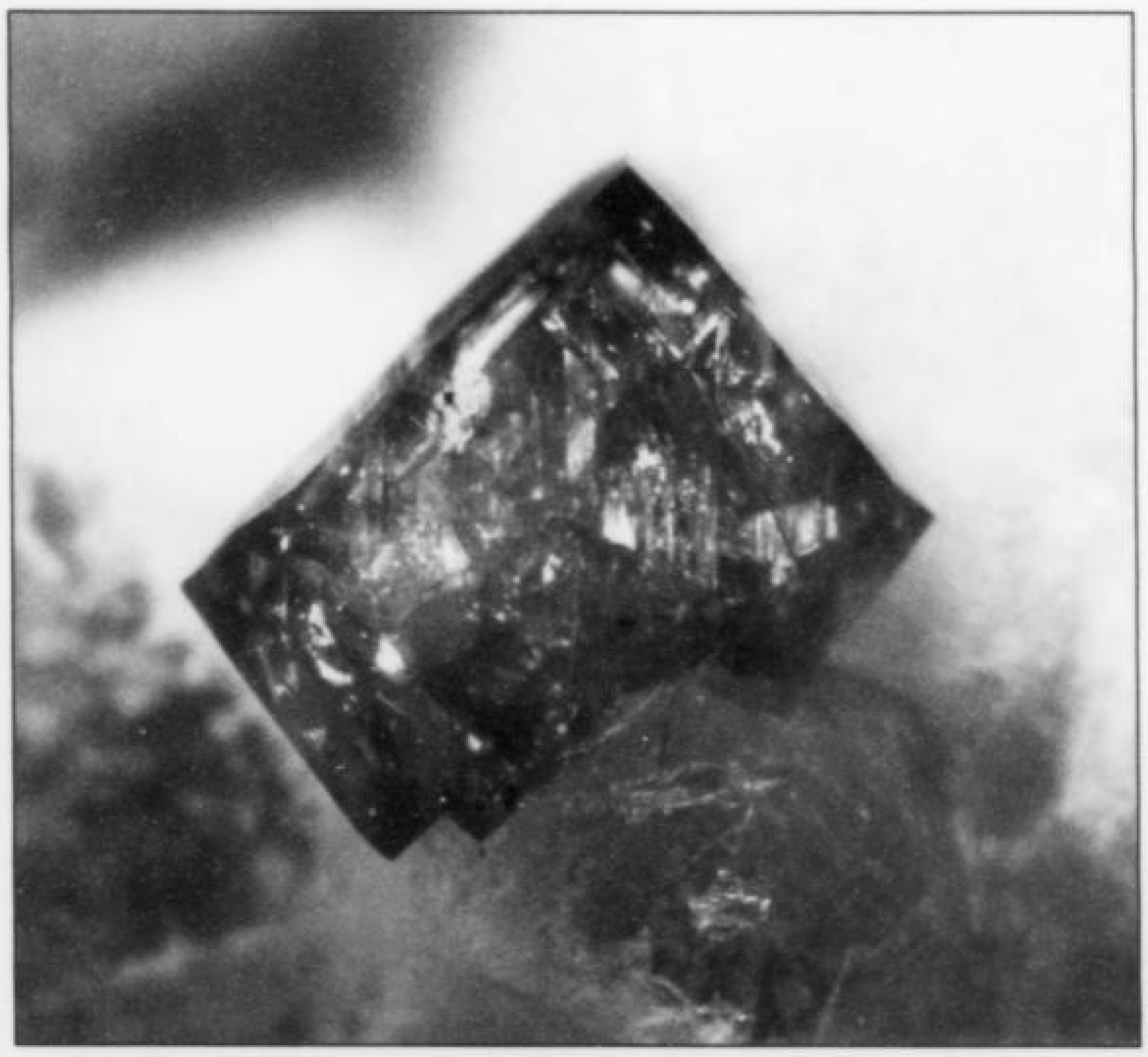


***Figure 13.* Childrenite crystal, 1.2 mm, from the G & C (George & Charlotte) mine, Cornwall, England (no. 494). Sugar White photo.**

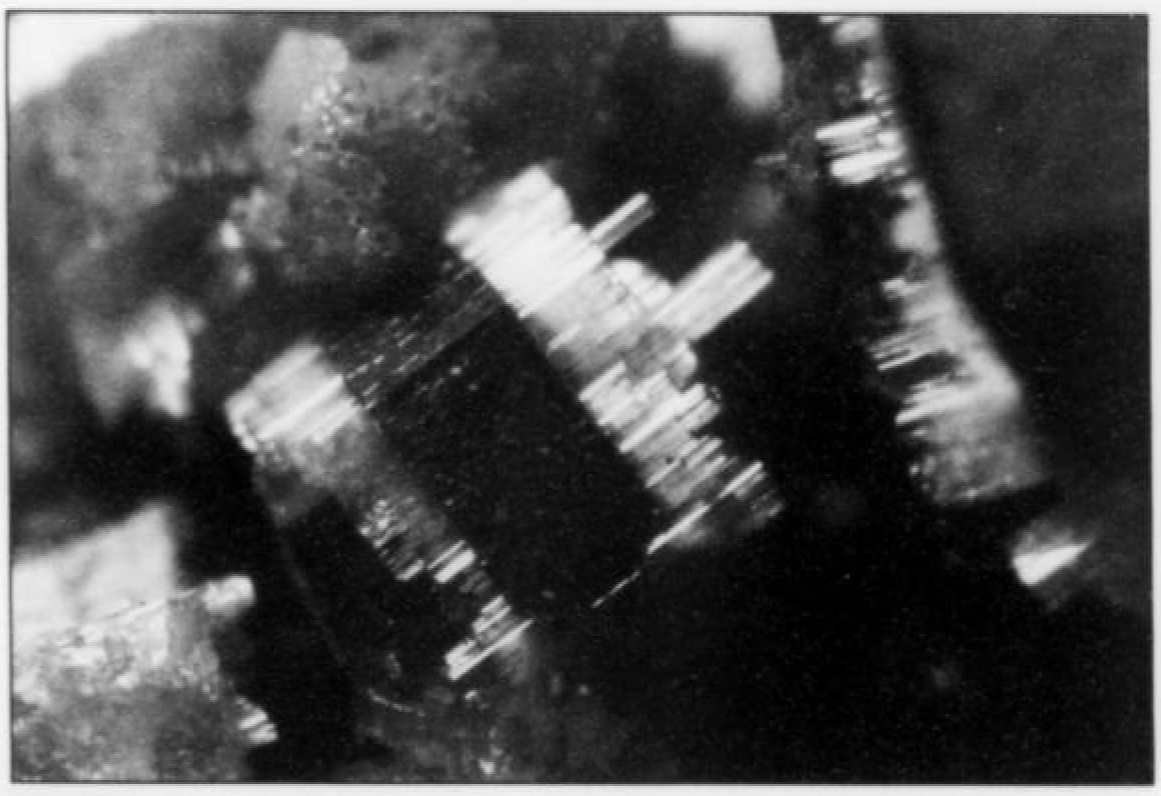


***Figure 14.* Vanadinite ("endlichite") crystals to 1.2 mm, from Lake Valley, New Mexico (no. 755). Sugar White photo.**

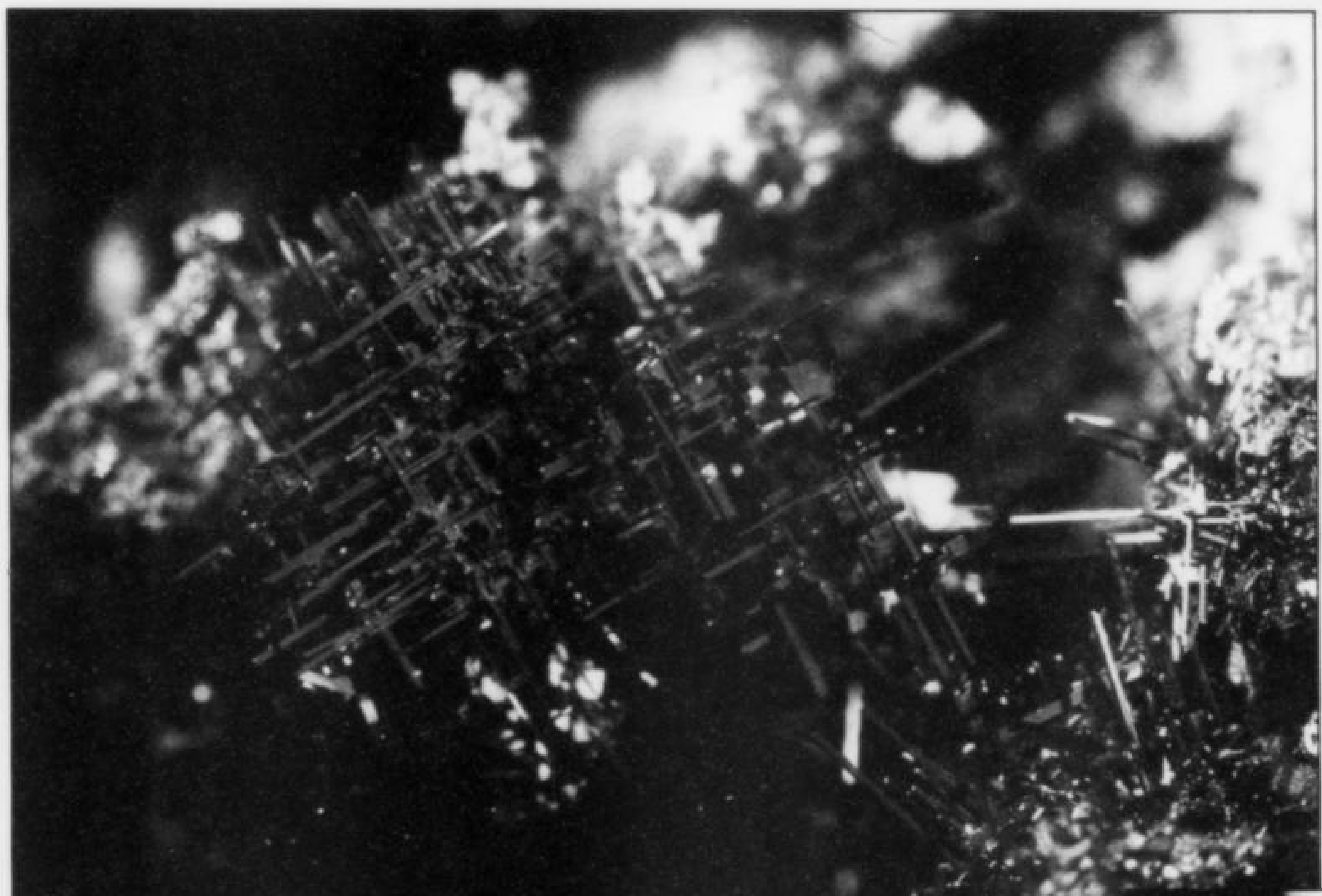


***Figure 15.* Cuprite in a reticulated crystal cluster, 4 mm, from Bisbee, Arizona (no. 614). Sugar White photo.**

***Figure 16.* Friedelite crystal, 1.4 mm, from the Harstig mine, Pajsberg, Sweden (no. 857). Sugar White photo.**

system, for example, "Carb-Cop, Mono" for an azurite. On the bottom of the box is a rectangular label printed in black ink with the initials "GWF" and "PHILA." and a repetition of the catalog numbers mentioned above. In addition, on the sides of the bottom black boxes are written in black pencil other numbers like "8/10" or "1½," which are magnification numbers relating to the recommended choice of microscope objectives, and "F," indicating which side should be oriented toward the "Front" (i.e. facing the viewer). Not all the boxes carry an "F." On many of the sides of the tops is a three digit number like "187" which is present on some but not all of the azurite specimens. The barites carry the number "719," the cacites are "270," cinnabars are "66," coppers are "15," etc. We at first thought these to be Dana numbers, but the numbers do not match up with those in any edition of *Dana's System,* and instead probably refer to some now-lost master list of species represented in the collection, numbered in the order in which they were acquired.

Incorporated into the collection are some specimens added by Frank Keeley. These are in identical boxes that have a pale blue paper label on the top of the box marked "F.J. Keeley" along the bottom edge. The quality of these mounts, while good, is not generally up to the quality standard of the Fiss specimens.

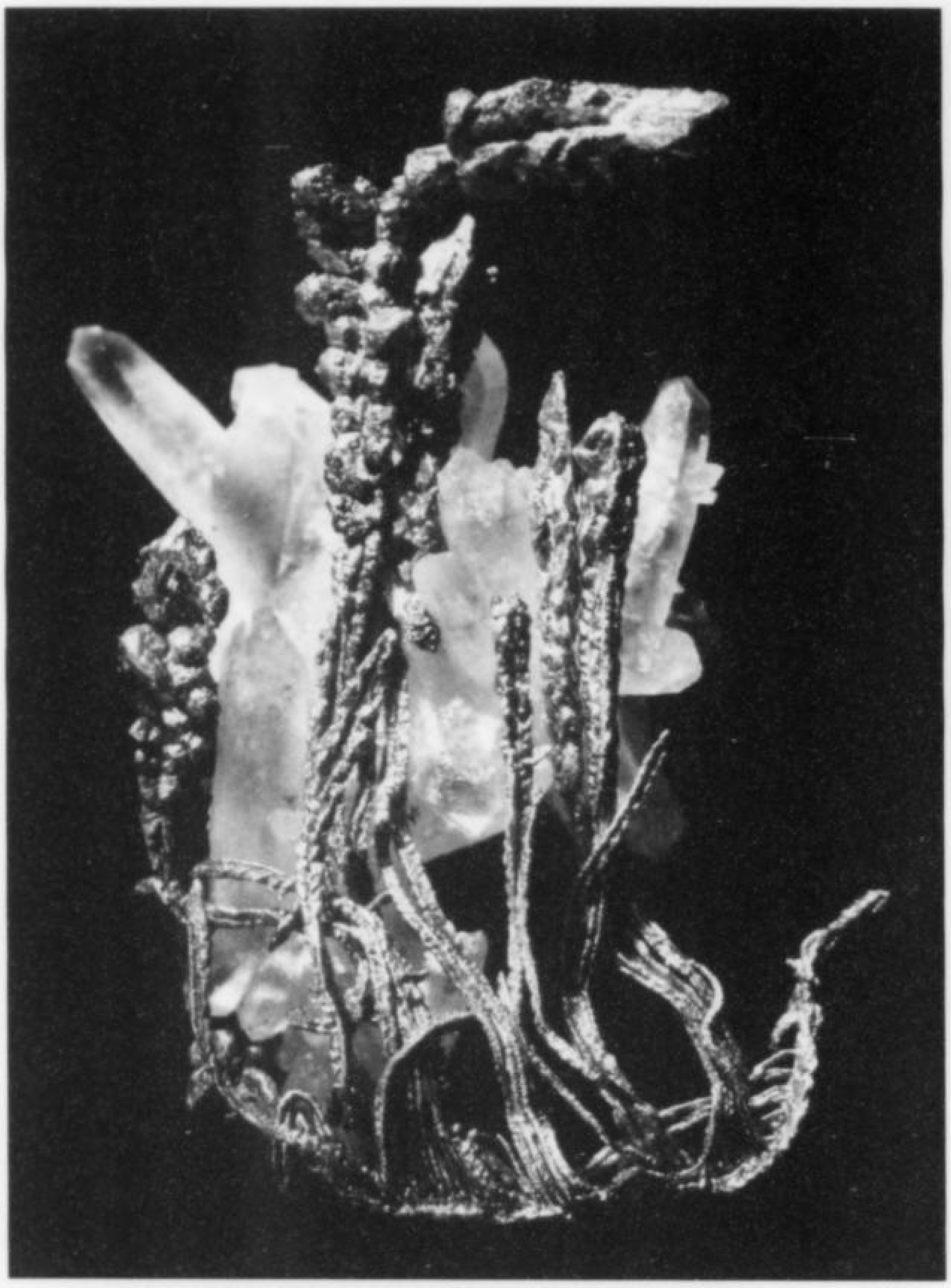
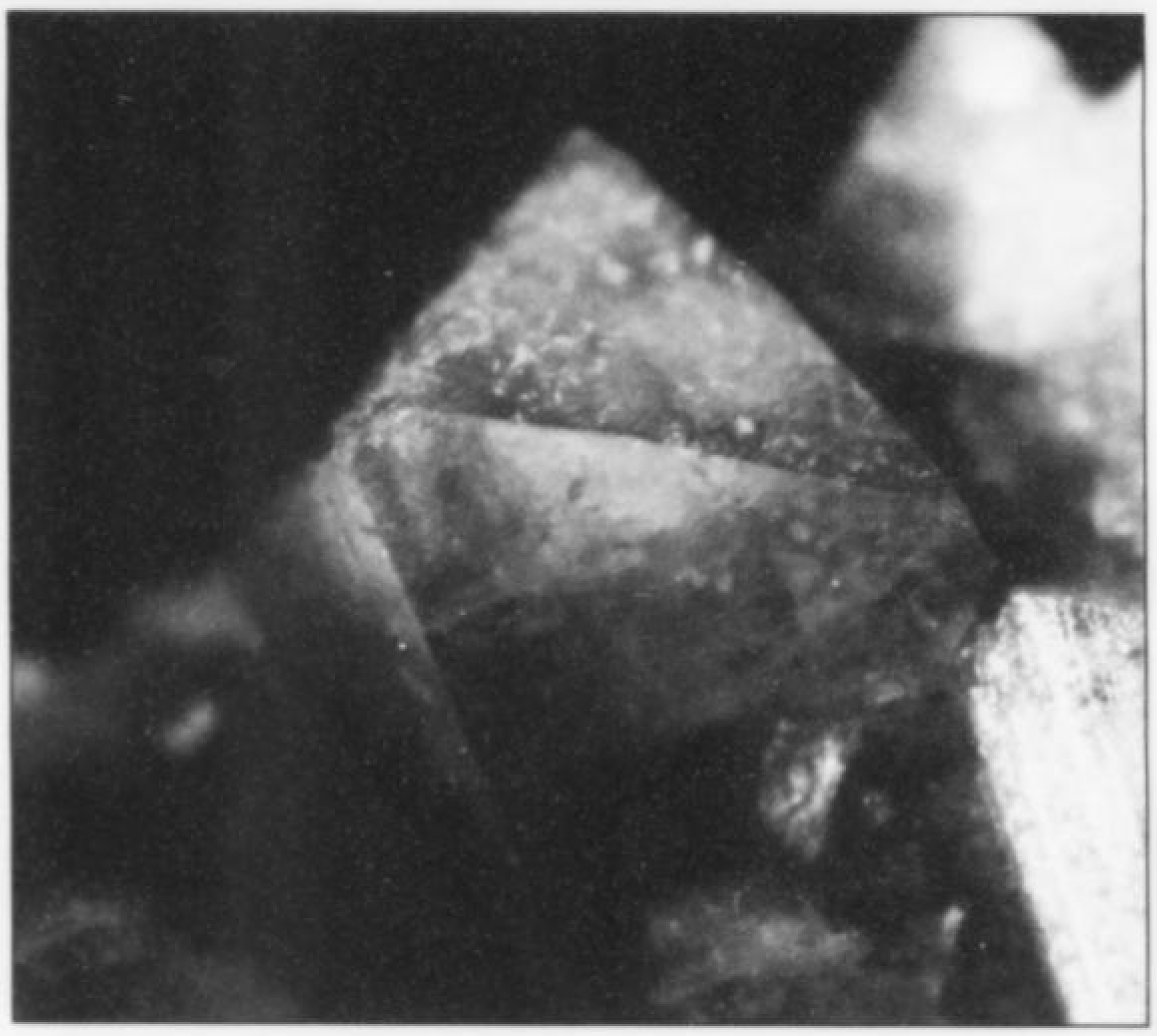


Figure 17. **Kermesite crystal sprays to 7 mm, from Braunsdorff, Saxony, Germany (no. 1145). Sugar White photo.**

Figure 18. **Gold, 8.8 mm, from California (no. 953). Sugar White photo.**

Figure 19. **Lawsonite crystals to 3 mm, from Marin County, California (no. 1176). Sugar White photo.**



The best of the micromounts have a little "x" in the upper right-hand corner of the top of the box. The very best have "xx," "xxx" or even "xxxx" in the upper right corner. The specimens marked in this way are not necessarily the best, at least to modern eyes, but must have been Fiss's favorites for one reason or another. In a few cases the person who supplied the specimen is also noted on the top label, e.g. Genth, Palache or Penfield (this is typical of Lazard Cahn mounts).

Some other random observations: There are many more adamites from Laurium, Greece than from Mapimi (only one). It is surprising to see Fairfield phosphates at this early date, as well as cyanotrichite

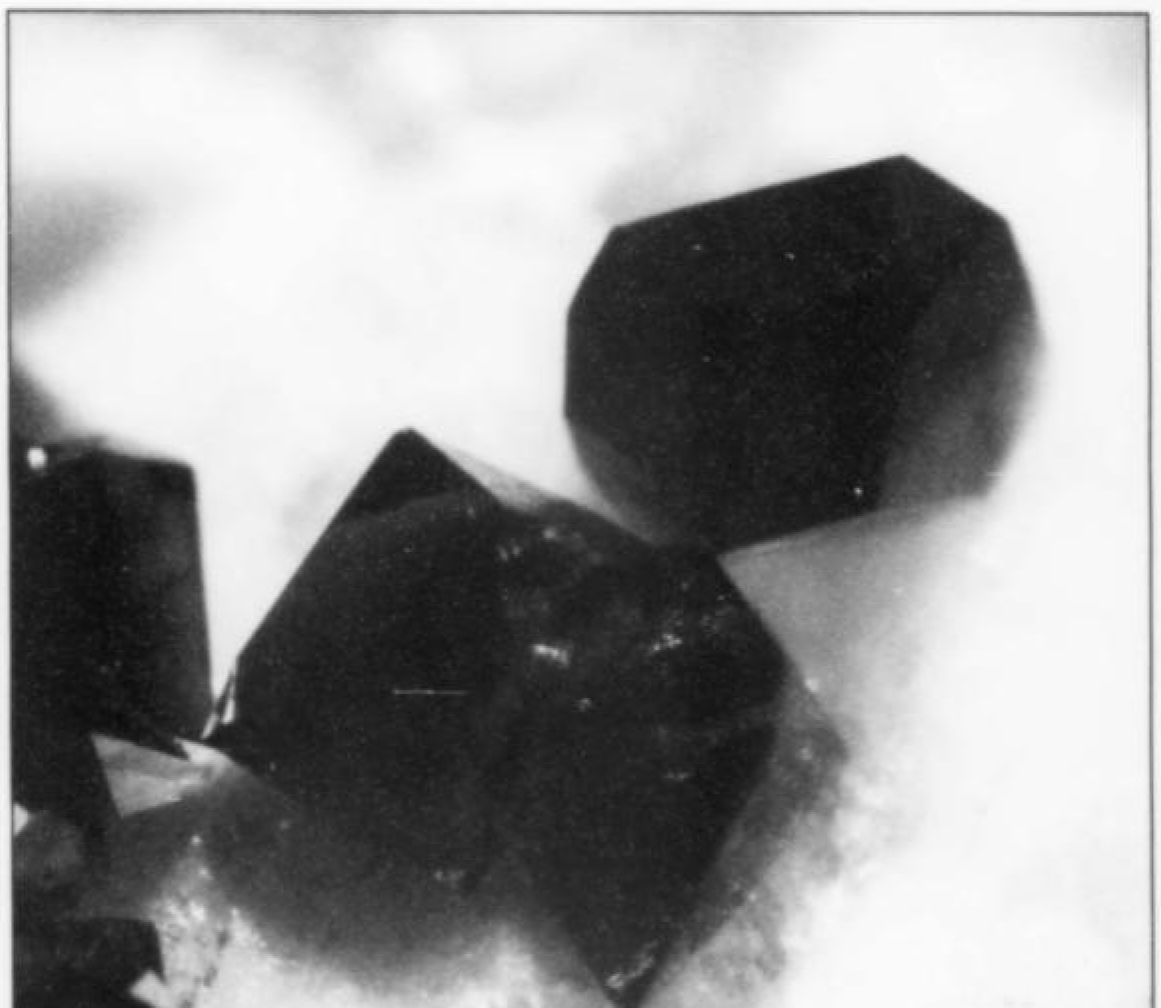


Figure 20. **Libethenite crystals to 1.7 mm, from Cornwall, England (no. 1192). Sugar White photo.**

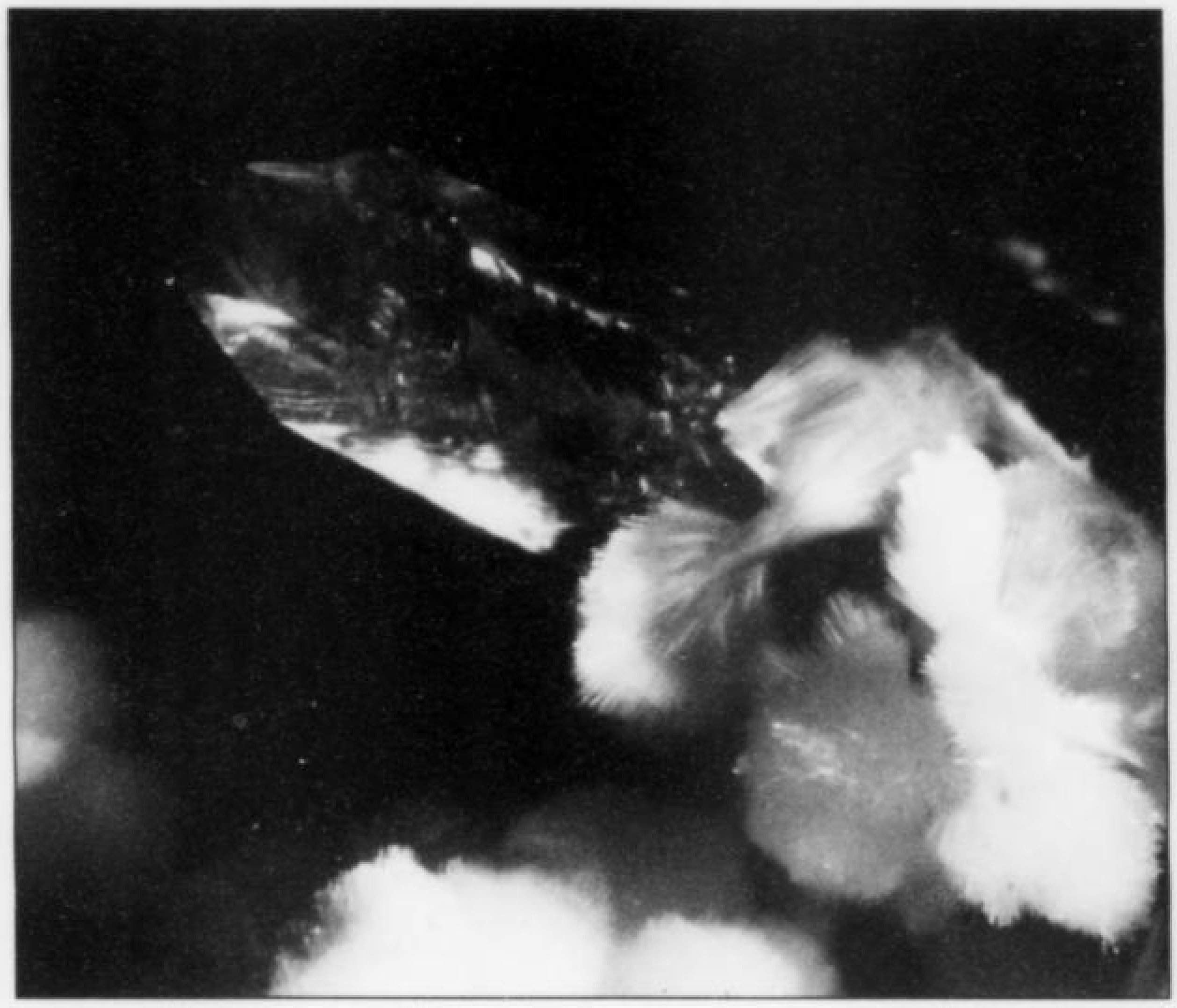


Figure 21. **Siderite crystal, 3 mm, with mesolite, from Richmond (no. 1294), Victoria, Australia. Sugar White photo.**

Figure 22. **Montroydite crystal, 0.7 mm, from Terlingua, Texas (no. 1349). Sugar White photo.**

and brochantite from the Last Chance mine (today known as the Grandview mine) in the Grand Canyon, Arizona. Tiger was not a producing locality back then, but one wulfenite from "Schulz, Arizona" was noted. Many good caledonites are present, but none from Tiger. Cuprites seemed to have been a favorite of Fiss, and he kept more of them than their quality would seem to warrant. The minerals from Vesuvius are well represented, perhaps as well as those from Franklin, New Jersey.

Incidentally, it is interesting to note, with regard to microcrystals, that Fiss found a way to prove that no two snowflakes are alike. He is said to have developed a hot-wax photographic plate method of capturing snowflakes and then developing the plate. He produced four albums of plates; three were given to the Yale library and one to a daughter.

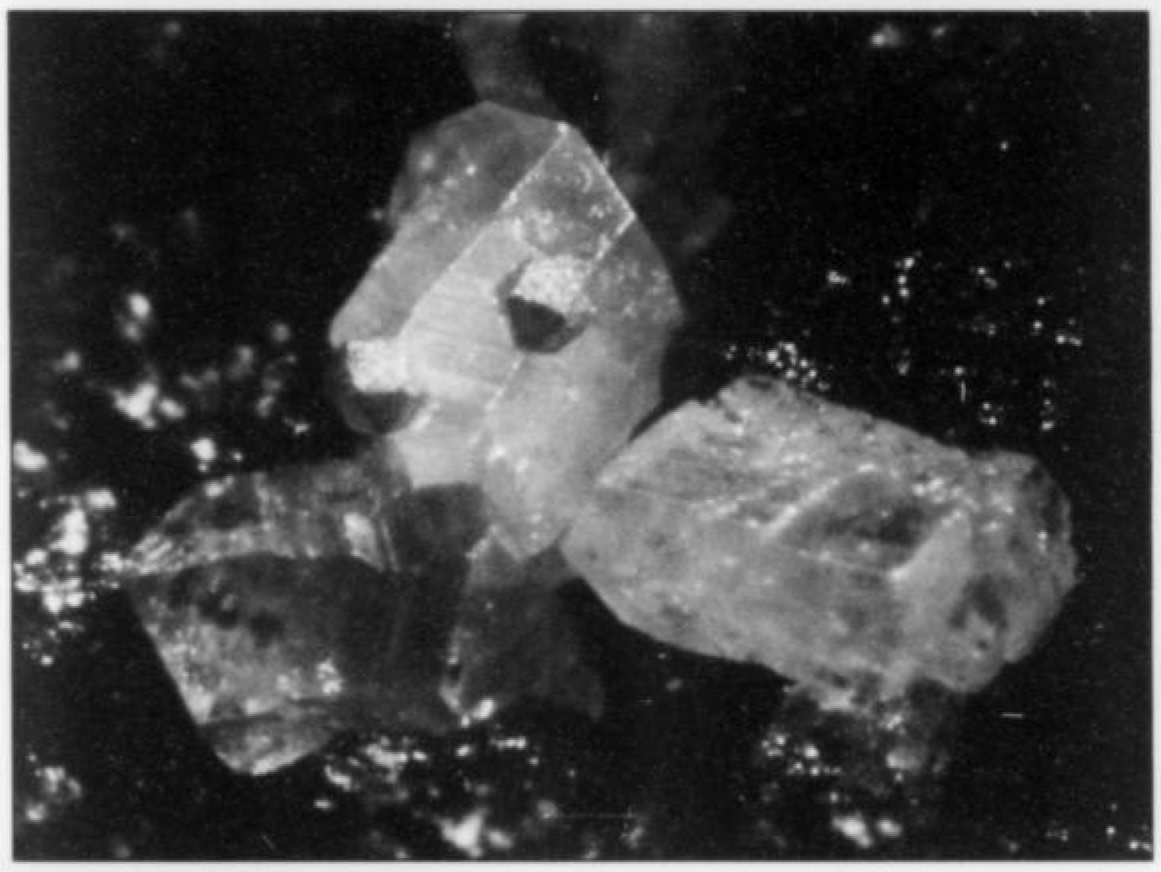


Figure 23. **Embolite crystals to 0.2 mm on stolzite crystals to 0.8 mm, from Broken Hill, New South Wales, Australia (no. 1927). Sugar White photo.**

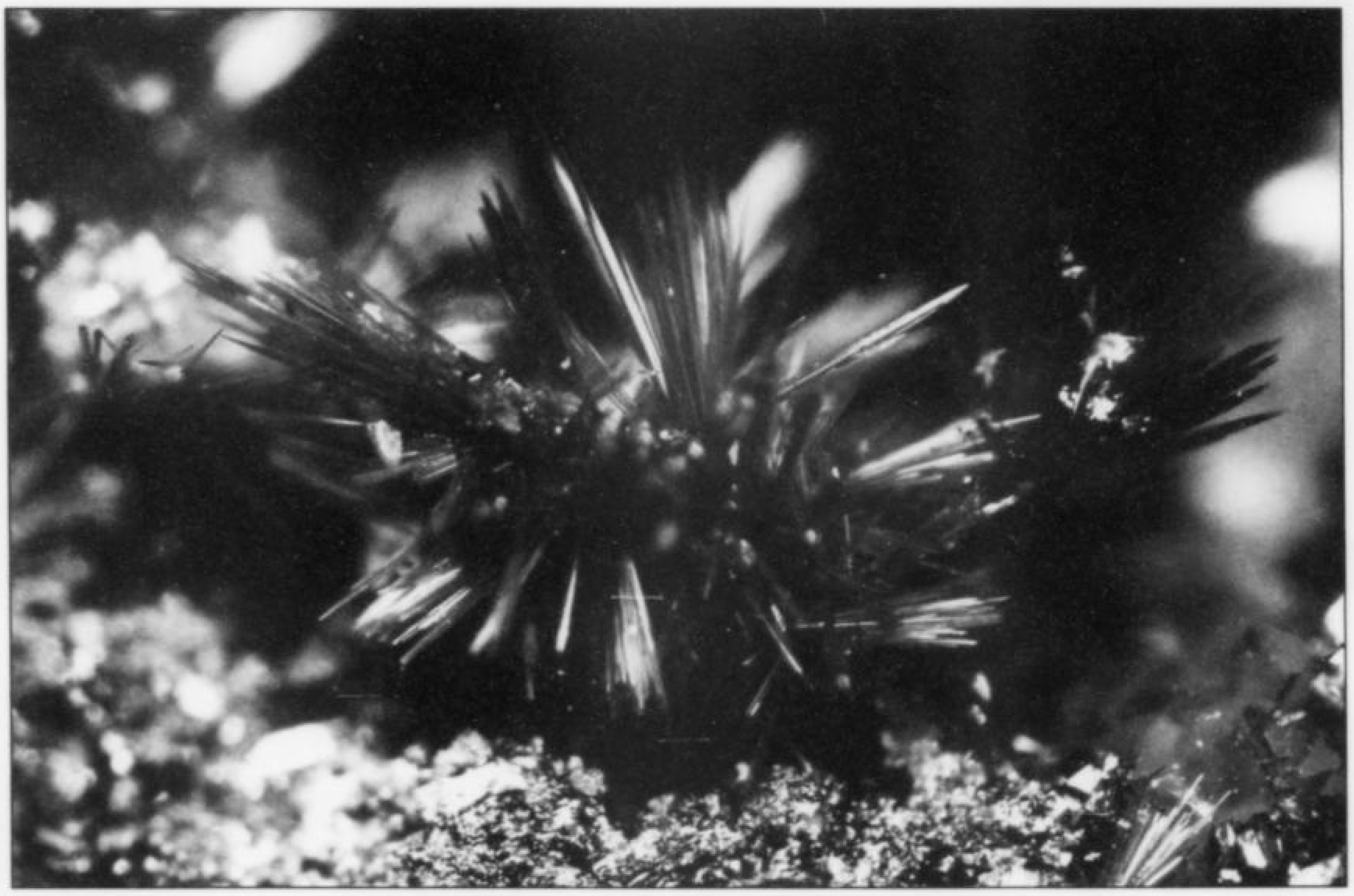


Figure 24. **Carminite crystal spray, 2.1 mm, from the Centennial mine, Eureka, Nevada (no. 1410). Sugar White photo.**

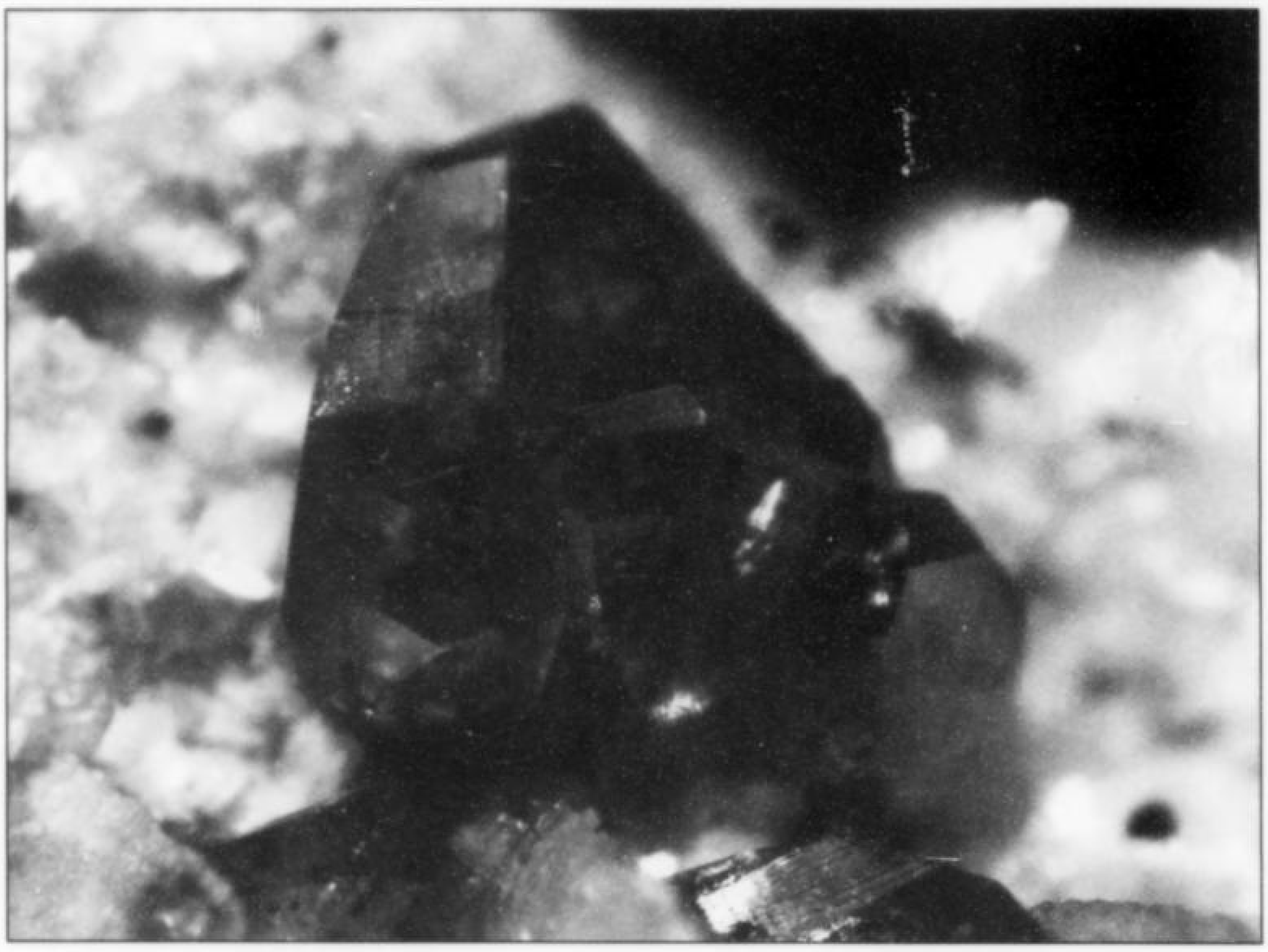


Figure 25. **Sphalerite crystals to 1.6 mm, from Müsen, Prussia (Westphalia, Germany) (no. 1866). Sugar White photo.**

Table 1. **Some especially notable specimens in the Fiss-Keeley collection. Three-star specimens (presumably Fiss's favorites) are shown in bold. Locality information added by deduction is shown in square brackets.**

Amarantite, Tocopilla Province Antofagasta Region, Chile [probably from the type locality: Caracoles, Sierra Gorda District], no. 28***
Anhydrite, Aussee, Styria, Austria, no. 73
Apatite and Rhodochrosite [Mt. Mica], Auburn, Maine, no. 85
Apatite and Epidote [probably Knappenwand, Untersulzbachtal], Sulzbach, Tyrol, no. 96
Apatite, St. Gotthard, Switzerland, no. 98
Aphthitalite, Mt. Vesuvius, Italy, eruption of 1893, no. 109
Apophyllite and copper, Lake Superior [Upper Michigan], no. 120
Apophyllite on quartz, Guanajuato, Mexico, no. 124
Argentopyrite, Joachimsthal, Bohemia, no. 144
Arsenolite, Le Monteel, Loire, France, no. 150
Atacamite, Sierra Gorda, Chile no. 169
Atelestite, Schneeberg, Saxony, no. 174
Aurichalcite and Calcite [Kelly mine], Magdalena, New Mexico, no. 178
Axinite, Franklin, New Jersey, no. 188
Azurite and Carminite, Tintic, Utah, no. 197
Barite, Frostberg, Maryland no. 230 and 231***
Barite and Quartz [Frizington?], Cumberland, England no. 235
Binnite [=tennantite], **Binnental, Switzerland no. 261*****
Biotite, Mt. Vesuvius, Italy, no. 265
Cabrerite [=Annabergite], Laurium, Greece, no. 338
Cacoxenite, Waldgirmes, Nassau, Germany, no. 339
Calamine, Franklin, New Jersey, no. 345
Calcite and pyrochroite, Franklin, New Jersey, no. 369
Copper in calcite and copper in quartz [rare!], Lake Superior [Upper Michigan], no. 376
Calcite on descloizite, Georgetown, New Mexico, no. 383
Calcite on amethyst, Guanajuato, Mexico, no. 386
Caledonite, Inyo Co. California, no. 394
Cassiterite, Durango, Mexico (twins), no. 407
Cerargyrite, Centennial mine, Eureka, Utah, no. 424
Cerussite and Pyromorphite, Wallace, Idaho no. 434 and 436***
Cerussite and Aurichalcite, Kelly mine, New Mexico no. 444
Chalcopyrite, Pribram, Bohemia, no. 484
Childrenite, G & C mines, Cornwall, England, no. 494
Chondrodite twin, Mt. Vesuvius, Italy, no. 501
Cinnabar, Redington mine, Napa Co., California, no. 513
Clinochlore, Pfitsch, Tyrol, Austria, no. 525
Clinohumite and magnetite, Mt. Vesuvius, Italy, (Penfield), no. 538
Cookeite, Paris Hill [Mt. Mica], Maine, no. 552
Copper on analcime, Lake Superior [Michigan], no. 568
Copper on analcime, Lake Superior [Michigan], no. 569***
Cuprite, chalcotrichite, Bisbee, Arizona, no. 614
Cuprite, National mine, Lake Superior [Michigan], no. 621
Dalalite, Bartlett, New Hampshire, (Palache), no. 656
Descloizite, Cordoba, Argentina, no. 686
Dolomite, Lengenbach Quarry, Binnental, Switzerland, no. 728
Egglestonite, Terlingua, Texas, no. 736
Endlichite, Lake Valley, New Mexico, no. 755 [many good ones]
Euchroite, Libethen, Hungary, no. 795
Eulytite, Schneeberg, Saxony, Germany, no. 801 and 802***
Fiedlerite, and Laurionite, Laurium, Greece, no. 812***
Fluorite, Lake City, Colorado, no. 825
Franklinite, Franklin, New Jersey, (Palache), no. 849
Franklinite in Willemite, Franklin New Jersey, no. 854***
Friedelite, Harstig mine, Pajsberg, Sweden, no. 857
Garnet, Chaffee Co., Colorado, no. 891
Garnet and Diopside, Ala, Piedmont, Italy, no. 899
Garnet and Anglesite, Broken Hill, New South Wales, Australia, no. 919
Gold and Quartz, California, no. 953
Goethite, Crystal Peak, Teller Co. Colorado, no. 976
Goethite, Best mine, Cornwall, England, no. 977
Guarinite on ryacolite, Mt. Vesuvius, Italy, no. 993
Hancockite and Axinite, Franklin, New Jersey, no. 1008
Helvite, quartz and pink dolomite, Kapnik, Hungary, no. 1026
Hematite and ferruginous Quartz, Cumberland, England, no. 1041

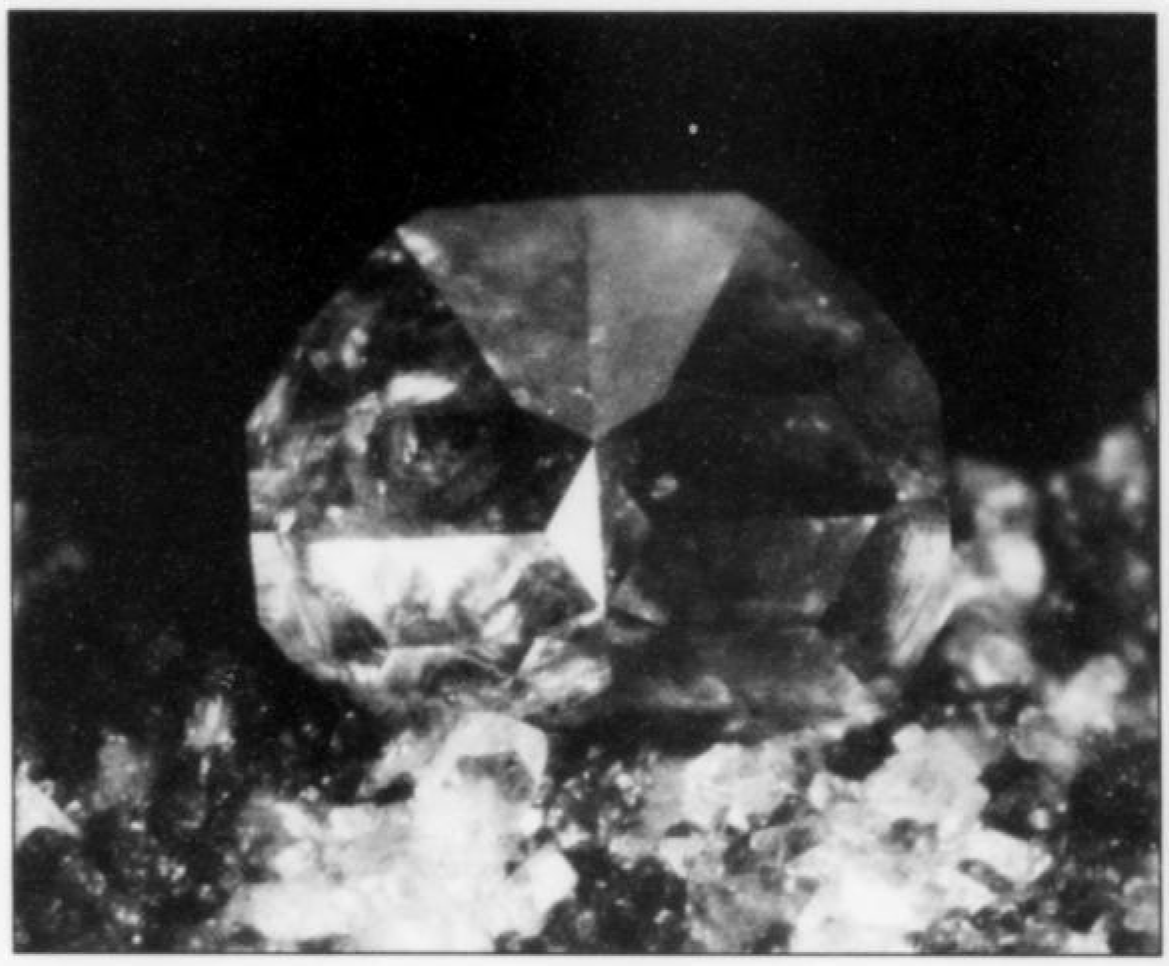


Figure 26. **Titanite twin, 1.7 mm, from Binnental, Switzerland (no. 2019). Sugar White photo.**

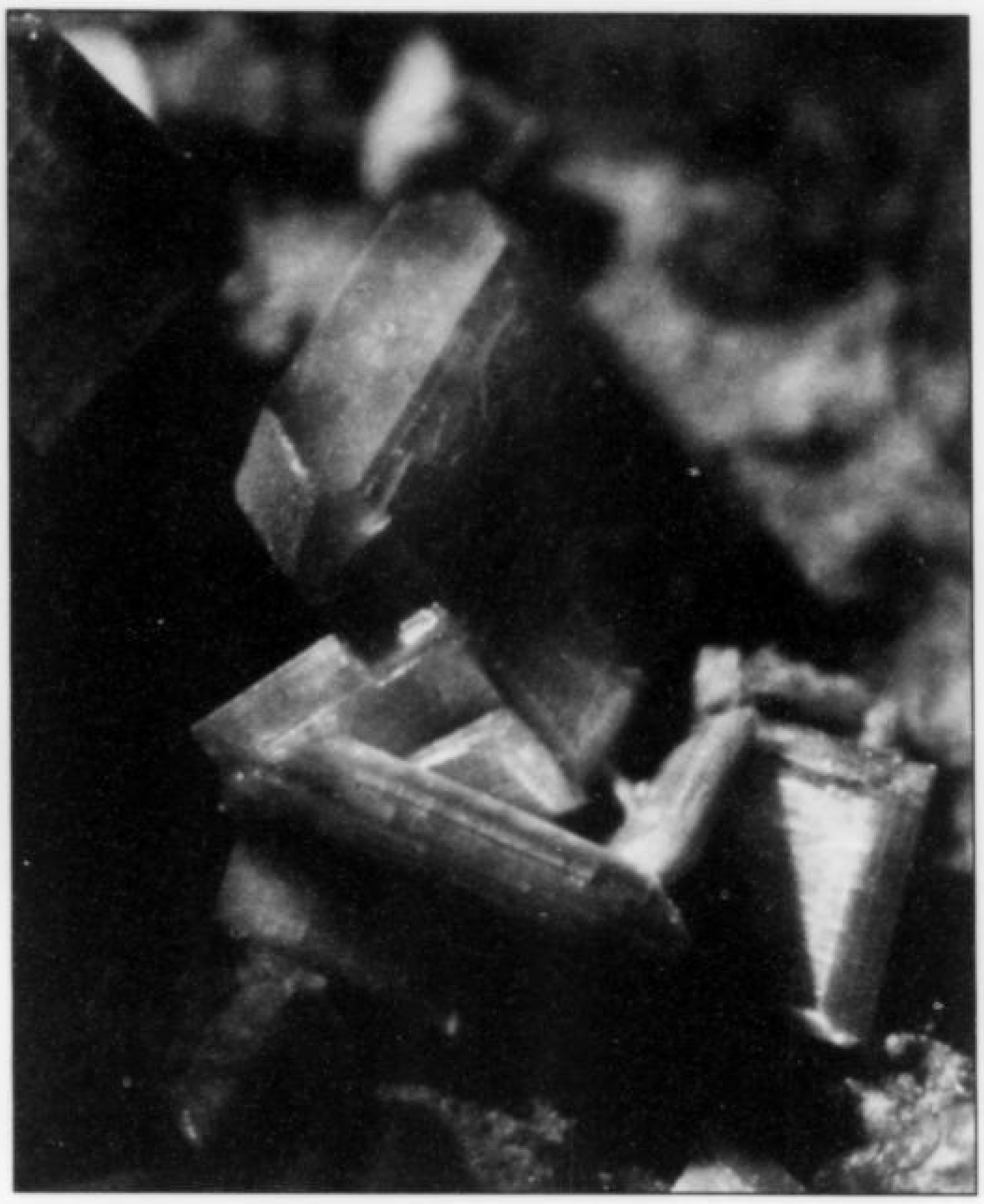


Figure 27. **Metatorbernite crystals to 0.8 mm, from Cornwall, England (no. 2036). Sugar White photo.**

Hematite, France, no. 1043
Hematite, Mt. Vesuvius, Italy, no. 1058
Heulandite, Jones Falls, Maryland, no. 1072
Holdenite, Franklin, New Jersey, (Palache, type), no. 1086
Humite, Mt. Vesuvius, Italy, no. 1093
Hyalite, Queretaro, Mexico, no. 1096
Johannite, Joachimisthal, Bohemia, no. 1139
Lanarkite and Leadhillite, Leadhills, Scotland, no. 1162
Lanthanite [Ueberroth mine, Friedensville], Saucon Valley, Pennsylvania, no. 1166
Laurionite and Phosgenite, Laurium, Greece, no. 1173
Leadhillite, Leadhills, Scotland, no. 1179
Libethenite, Cornwall, England, no. 1192
Linnaeite, Musen near Siegen, Prussia, no. 1209
Liroconite and Pharmacosiderite, Cornwall, England, no. 1210***
Liroconite, Cornwall, England, no. 1213 (John B.Brinton mount)
Lorandite and Realgar, Alchar, Macedonia, Greece, no. 1216
Magnetite and Biotite, Mt. Vesuvius, Italy, no. 1234
Malachite, Mojave Co. California, no. 1239
Meionite, Mt. Vesuvius, Italy, no. 1284
Melanophlogite (twin) on celestine, Sicily, Italy, no. 1285
Melanotekite, Hillsboro, Sierra Co. New Mexico, no. 1287
Meneghinite, Bottino, Tuscany, Italy, no. 1291
Mimetite and Carminite, Centennial mine, Eureka, Utah, no. 1331
Natrochalcite, Chuquicamata, Chile, no. 1361
Niccolite, Eisleben, Saxony, Germany, no. 1380
Parisite, Quincy, Massachusetts, no. 1451
Petzite and Gold, Sonora, California, no. 1463
Pharmacosiderite, Tintic, Utah, no. 1470
Phillipsite, Mt. Vesuvius, Italy, no. 1485
Phillipsite and Calcite, Richmond, Victoria, Australia, no. 1487
Phosgenite, Laurium, Greece, no. 1490***
Plumbogummite and Mimetite, Drygill, Cumberland, England, no. 1506
Proustite, O'Brien mine, Cobalt, Ontario, Canada, no. 1527
Pucherite, Pucher mine, Schneeberg, Saxony, Germany, no. 1541
Pyrite on Quartz, Middletown, Connecticut, no. 1560
Pyromorphite, Cornwall, England, no. 1614
Pyroxene and Biotite, Mt. Vesuvius, Italy, no. 1636
Quartz, Amelia Co. Virginia, no. 1654
Quartz and Copper, Lake Superior [Upper Michigan], no. 1662
Rubies (artificial) Professor Fremy, Paris, France, no. 1710
Rutile on Corundum, Franklin, New Jersey, no. 1713
Rutile, Alexander Co., North Carolina, no. 1720
Schneebergite, Schneeberg, Saxony, Germany, no. 1759
Schwarzenbergite, Chile, no. 1760
Scorodite, Tintic mine, Eureka, Utah, no. 1764
Sideronatrite on Kröhnkite, Chuquicamata, Chile, no. 1796
Sphalerite, Binnenthal, Switzerland, no. 1859
Sphalerite, Müsen, Prussia, Germany, no. 1866***
Spinel, Mt. Vesuvius, Italy, no. 1882
Stephanite, Xanthoconite and Proustite, Cobalt, Ontario, Canada, no. 1895
Sternbergite, Joachimsthal, Bohemia, no. 1902
Stolzite and Embolite, Broken Hill, New South Wales, Australia, no. 1927
Sulfur and Cinnabar, Lake Co. California, no. 1939
Sulfur, Artifical, (Palache), no. 1946
Svabite, Harstig mine, Pajsberg, Sweden, no. 1954
Synadelphite and Allactite, Nordmark, Sweden, no. 1963
Tennantite, Cornwall, England, no. 1978
Tephroite, Franklin, New Jersey, no. 1984
Terlinguaite/Montroydite etc Terlingua, Texas, no. 1985, 1986
Titanite (twin), Binnental, Switzerland, no. 2019
Torbernite (Metatorbernite), Cornwall, England, no. 2036
Walpurgite, Neustadtal, Saxony, Germany, no. 2120***
Wavellite, Chester Co. Pennsylvania, no. 2132
Willemite and Franklinite, Franklin, New Jersey, no. 2142

Conclusions

We are remarkably fortunate today that the two historic Fiss collections have come down to us in such a good state of preservation. They represent a window in time when many specimens unavailable today could still be acquired, and also a place, Philadelphia, that holds a hallowed position in the long history of mineralogy and mineral collecting. The photos shown here (all drawn from the Fiss-Keeley collection) depict micromineral specimens having an elite historical pedigree—specimens that were studied, enjoyed and discussed by some of mineralogical history's most interesting and notable characters. Those old gentlemen would surely be amazed and delighted by the idea of such a publication as this for all collectors to enjoy.

Acknowledgments

Our sincere thanks to Wayne C. Leicht for granting the authors access to the collection so that it could be studied, and for loaning the specimens pictured here for photography. Thanks also to Eileen C. Mathias, information services librarian at the Ewell Sale Stewart Library in the Philadelphia Academy of Natural Sciences, for providing us with a complete photocopy of the Fiss-Keeley Collection catalog, prepared by Frank Keeley in 1949 just before his death.

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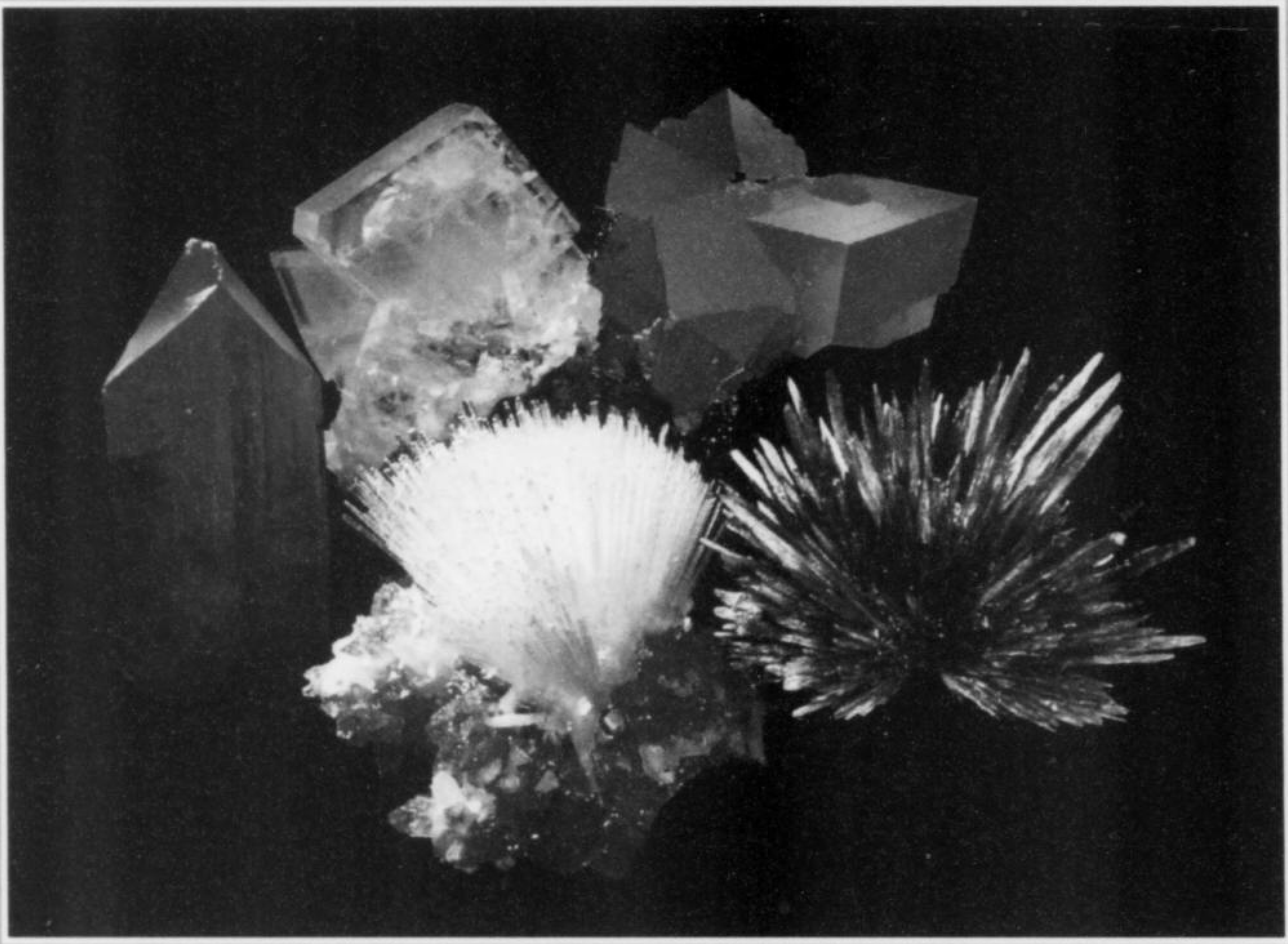

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CA-MG-FE-RICH RHODONITE

from the

MORRO DA MINA MINE, CONSELHEIRO LAFAIETE, MINAS GERAIS, BRAZIL

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Large and superb crystals of translucent to gemmy, brilliant red rhodonite found in a manganese mine near Conselheiro Lafaiete, Brazil have been reaching the mineral market in recent years. The crystals have been analyzed and proved to be significantly enriched in calcium, magnesium and iron.

INTRODUCTION

The city of Conselheiro Lafaiete (20°40′S, 43°48′W) is located about 100 km south of Belo Horizonte in the interior of Minas Gerais, Brazil. It lies in the southern section of the Quadrilátero Ferrífero ("Iron Quadrangle"), a 7000 km^2 section of the São Francisco craton, characterized by Archean gneisses, Neoarchean greenstones and Paleoproterozoic sediments. The area around Conselheiro Lafaiete is part of the highly folded Barbacena Greenstone Belt, which has been intruded by a series of granodiorites and aplitic to pegmatitic dikes (Pires, 1977), and is host to a number of significant manganese deposits (Derby, 1901; Pires, 1977, 1983; Pires and Cabral, 2001).

The major mine in the district is the Morro da Mina open pit (opened in 1894), which produced some 12 million tons of oxide and silicate ore between 1902 and 1995 and is currently operated by Companhia Vale do Rio Doce. The deposit is characterized by rocks known as *gondites*, composed of quartz and spessartine, and *queluzites*, which are rich in spessartine, rhodonite, and rhodochrosite. Dominant primary manganese minerals include spessartine, tephroite, rhodonite, pyroxmangite, neotocite, bementite, Mn-rich cummingtonite, rhodochrosite and Mn-rich apatite (Pires, 1977, 1983).

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Figure 1. **Locality map.**

Of particular interest to this study is a hydrothermally derived assemblage composed of spessartine, rhodonite and asbestiform Mn-rich cummingtonite (Pires, 1977). Recently, a considerable quantity of deep pink, gem-quality material supposed to be rhodonite from the Morro da Mina mine has appeared on the specimen market. The rhodonite is invested with varying amounts of cummingtonite needles, but some of the rhodonite is free of such inclusions.

Thomas Moore (in preparation), in his compendious Mineral Discoveries 1960–2010, writes of the occurrence as follows:

> Rhodonite crystals "of gem quality" from Conselheiro Lafaiete, Minas Gerais have been reported as early as 1971. In the second half of the 1990's, a few specimens of rhodonite emerged from the Mn-rich, spessartine/amphibole/rhodonite/pyroxmangite skarn at Conselheiro Lafaiete; they are miniature-size, medium pink to pink-red aggregates of parallel, tightly intergrown, bladed crystals (reported in "What's new in minerals" in 1995 and 1999). Beginning around 2005, further work was done at the mine with a view to extracting rhodonite specimens from the Mn-rich skarn deposit, and at the 2006 Tucson Show a few fine rhodonite specimens were offered by an American dealer. They are thumbnails and miniatures, and two extraordinary specimens; one is a 5.2-cm cluster of gemmy, deep pink rhodonite crystals with a single, sharp individual measuring 2 × 3 cm; the other is a parallel group of two well-terminated crystals measuring 6 cm. These specimens are laboriously prepared by removing the hard mixture of amphibole, spessartine, and massive rhodonite/pyroxmangite from around the calcite-filled vugs which harbor the rhodonite crystals.

Both of the major specimens mentioned by Moore are pictured here.

Because of a question surrounding the true identity of the rhodonite specimens (Luiz Menezes, personal communication), we have investigated the material using a combination of electron microprobe, X-ray powder diffraction and single-crystal X-ray techniques. The study, results of which are reported below, has shown that the material in question is indeed a Ca-Mg-Fe-rich rhodonite.

EXPERIMENTAL

Crystals of rhodonite from the Morro da Mina mine were supplied by Luiz Menezes. A crystal fragment free of cummingtonite inclusions was embedded in epoxy resin, polished and carbon-coated. No zoning of the rhodonite was evident in BSE (back-scattered electron) images, but a single small inclusion some 30 μm across was noted. Five spot analyses of rhodonite and four of the inclusion were carried out using a Jeol 8600 electron microprobe (WDS mode, 30 kV, 20 nA, 3 μm beam diameter). Analytical data are given in Table 1. The empirical formula of the rhodonite based on 5 $(Si,Al)O_4$ groups is:

$$(Mn_{3.76}Ca_{0.50}Mg_{0.34}Fe_{0.33})_{\Sigma 4.93}(Si_{4.97}Al_{0.03})O_{15},$$

and the simplified formula normalized for an M^{2+} cation total of 5 pfu is:

$$(Mn_{3.81}Ca_{0.51}Mg_{0.35}Fe_{0.33})Si_5O_{15}.$$

The small inclusion has an empirical formula of:

$$(Mn_{3.69}Ca_{0.51}Fe_{0.33}Mg_{0.32})_{\Sigma\zeta 4.85}(Si_{4.97}Al_{0.03})O_{15},$$

Figure 2. **Rhodonite crystal with albite, 5.2 cm, from the Morro de Mina mine, Conselheiro Lafaiete, Minas Gerais, Brazil. Mike Bergmann specimen; Jeff Scovil photo.**

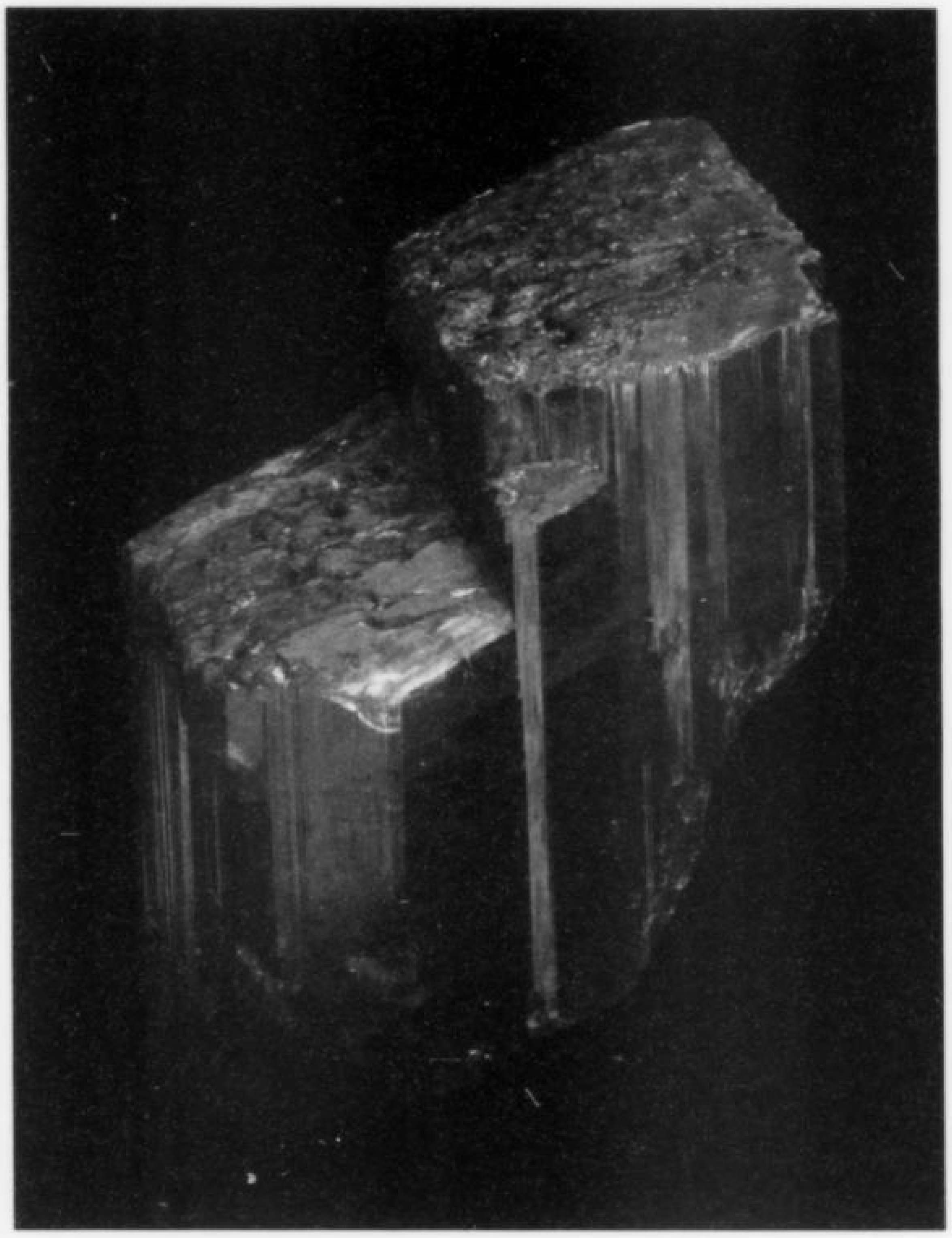

Figure 3. **Rhodonite, 6 cm, two terminated crystals in parallel growth from the Morro de Mina mine, Conselheiro Lafaiete, Minas Gerais, Brazil. Wayne Thompson and Jerry Romanilla specimen, now in a private collection; Jeff Scovil photo.**

with the cation deficiency presumably accounted for by appropriate protonation of some of the silicate oxygen atoms. This phase was not studied further.

Powder X-ray diffraction data (Table 2) were recorded using a Philips PW1925-20 powder diffractometer (Cu Kα radiation, λ = 1.5406 Å, with pure Si as internal standard). For the single-crystal structure analysis, a cleavage fragment 0.45 × 0.45 × 0.30 mm in size was mounted on a Bruker SMART CCD diffractometer. A careful inspection of the reflection record showed that only one phase is present, i.e., the crystal used is free of inclusions. Unit cell dimensions were determined by least-squares refinement of the complete data set and are listed in Table 3 together with associated crystal data. All data were collected at 273(2) K using graphite-monochromatized Mo Kα radiation, corrected for Lorentz and polarization effects, and an absorption correction using SADABS was applied (Sheldrick, 1996). The structure was completely determined by direct methods using SHELXS (Sheldrick, 1997a) and refined on F^2 by full-matrix least-squares methods using SHELXL97 (Sheldrick, 1997b). All atoms were found to be in positions similar to the analogous atoms in the magnesian rhodonite reported by Peacor *et al.* (1978), and an initial isotropic refinement assuming all five metal sites were fully occupied by Mn gave $R1$ = 0.051 with no unusual thermal parameters. Allowing the five metal site occupancies to also vary at this stage reduced $R1$ to 0.037 and gave a good indication of the electron density present at each of the five metal sites. This was then used in conjunction with the electron microprobe analyses to deduce the probable distribution of Mn, Mg, Ca and Fe in each of the sites, noting also the preference of the various different metal ions present to occupy these five non-equivalent metal sites (as discussed below) and the need to achieve acceptable thermal parameters for each site. A final anisotropic refinement of this distributed metal ion model resulted in most acceptable and nearly uniform U_{eq} values for each of the five metal sites and an $R1$ of 0.0242 and $wR2$ of 0.0646. The weighting scheme used was $w = 1/(\sigma^2 F_o^2 + 0.0364P^2 + 0.600P)$, where $P = (F_o^2 + 2F_c^2)/3$, as defined by SHELXL97 (Sheldrick 1997b). Crystal data and refinement details are given in Table 3. Final atomic parameters are listed in Table 4, anisotropic displacement parameters in Table 5, and selected bond lengths in Table 6.

RESULTS AND DISCUSSION

Analyses of rhodonite from the Morro da Mina mine (Table 1) are entirely consistent with the formulation of the mineral, with enrichment of Ca, Mg and Fe. Powder X-ray diffraction data listed in Table 2 are compared with those for an Mg-rich rhodonite from the Balmat mine No. 4, New York, USA, which has the composition $(Mn_{3.73}Mg_{0.73}Ca_{0.51}Fe_{0.03})Si_5O_{15}$ (Peacor *et al.*, 1978; JCPD File 83-2212). Powder X-ray data for rhodonite are quite sensitive to small variations in unit cell constants (Viswanathan and Harneit, 1986; Pinckney and Burnham, 1988), but those for the two cases above are very similar, due to the analogous Ca and Mg+Fe contents.

A number of studies have been directed towards understanding the distribution of cations among the five non-equivalent sites in rhodonite (Peacor and Niizeki, 1963; Dickson, 1975; Marshall and Runciman, 1975; Ohashi and Finger, 1975a,b; Peacor *et al.*, 1978; Nelson and Griffen 2005). It is clear that Ca substitutes in the M5 site, which is 7-coordinated and distorted. Fe distribution has been studied using Mössbauer spectroscopy (Dickson, 1975) and Fe(II) has been found to be present in all five sites, but not equally. Although Dickson (1975) was somewhat equivocal about the site preferences for Fe, it is evident that site occupancies for M1, M2 and M3 sites are approximately equal and M4 is slightly preferred; the M5 site is least preferred. Based on fitted intensities in the Mössbauer spectra at 77 K of a number of samples with varying Fe contents, the relative site occupancies for Fe in sites M1 to M5 are 0.67:0.67:0.67:1:0.24, respectively. We have distributed Fe in the present structure using the same regime, but note that with Mn dominant in sites M1 to M4 and almost equal to Ca in M5, the one-electron difference between Mn and Fe will have negligible bearing on the temperature factors, whatever the relative Fe:Mn distribution. Mg has been distributed over the five sites in the following way. For sites M1 to M3, sof values were assigned to give comparable U(eq) values, and for M4 and M5 to account for the remainder in such a way as to mimic slightly higher relative U(eq) values in line with the structure determination of Peacor *et al.* (1978). We cannot be absolutely certain of the sof values for Fe and Mg, but the structure refined sensibly and no anomalous patterns emerged in the anisotropic thermal parameters or the final difference map as a result of the adopted procedure.

There is no discrepancy in the structure as compared with others that have been reported for rhodonite (Peacor and Niizeki, 1963; Ohashi and Finger, 1975a,b; Peacor *et al.*, 1978; Pertlik and Zahiri, 1999; Nelson and Griffen 2005). In the present structure, and in line with the above reports, the M1, M2 and M3 sites are all quasi-octahedral, with the M4 site being somewhat more distorted to give a [5+1] coordination sphere (Table 6). The M5 site, which accommodates the larger Ca^{2+} ion, is 7-coordinated, with the usual [4+3] distribution of M-O bonds. Table 6 also indicates that the usual geometry of the silicate chain is present as evidenced by the Si-O bond lengths. For further structural details, the supplementary material should be consulted.

Table 1. Analytical data (wt%) for rhodonite and pyroxenoid inclusion.

Rhodonite	*1*	*2*	*3*	*4*	*5*	*av.*	*Inclusion*	*1*	*2*	*3*	*4*	*av.*
MgO	2.06	1.97	2.58	2.03	1.99	2.13	MgO	2.08	1.99	1.97	1.97	2.00
Al_2O_3	0.45	0.59	0.47	0.46	0.49	0.49	Al_2O_3	0.46	0.58	0.47	0.39	0.48
SiO_2	46.94	46.45	46.77	47.01	47.01	46.84	SiO_2	46.71	47.07	47.45	47.15	47.10
CaO	4.45	4.32	4. 37	4.33	4.52	4.40	CaO	4.43	4.36	4.60	4.56	4.49
MnO	41.86	40.84	42.55	42.73	41.41	41.88	MnO	41.00	41.80	41.33	41.20	41.33
FeO	3.87	3.66	3.78	3.84	3.72	3.77	FeO	3.78	3.85	3.78	3.60	3.75
Total	99.63	97.83	100.52	100.40	99.14	99.50	Total	98.46	99.65	99.60	98.87	99.15

Table 2. Powder X-ray diffraction data for rhodonite.

Morro da Mina[a]		*Balmat mine No. 4*[b]	
d_{obs}/Å	I_{rel}	d_{obs}/Å	I_{rel}
7.146	44	7.1	50
6.733	24	6.67	15
4.783	34	4.76	50
4.126	9	4.12	8
3.817	16	3.81	15
3.562	61	3.55	85
3.406	13	3.40	11
3.336	32		
3.255	15	3.25	12
3.138	58	3.13	76
3.091	89	3.08	100
2.970	100	2.969	100
2.927	50	2.925	63
2.805	16	2.809	10
2.783	22	2.781	26
2.759	26	2.748	46
2.651	16	2.648	18
2.597	39	2.593	34
2.540	11	2.535	7
2.513	55	2.505	65
2.452	10		
2.430	9	2.427	10
2.398	8	2.382	8
2.372	17	2.369	16
2.316	9	2.312	4
		2.259	3
2.223	68	2.220	24
		2.208	8
2.178	51	2.178	53
2.159	10	2.152	6
2.114	15	2.113	11
2.089	13	2.084	7
2.066	10	2.061	8
2.046	6		
1.980	10		
1.950	6	1.949	4
1.894	17	1.892	11
1.864	20	1.860	13
		1.831	7
plus 27 lines to 1.277			

[a] This work; $(Mn_{3.81}Ca_{0.51}Mg_{0.35}Fe_{0.33})Si_5O_{15}$.

[b] Peacor *et al.*, 1978; $(Mn_{3.73}Mg_{0.73}Ca_{0.51}Fe_{0.03})Si_5O_{15}$.

Table 3. Crystal data and structure refinement details for rhodonite.

Empirical formula	$(Mn_{3.81}Ca_{0.51}Fe_{0.33}Mg_{0.35})Si_5O_{15}$
Formula weight	637.15
Temperature	273(2) K
Wavelength	0.71073 Å
Crystal system	Triclinic
Space group	$P\bar{1}$
Unit cell dimensions	a = 6.6818(13) Å α = 105.49(3)° b = 7.6330(15) Å β = 92.49(3)° c = 11.795(2) Å γ = 94.01(3)°
Volume	577.1(2) $Å^3$
Z	2
Density (calculated)	3.667 Mg m^{-3}
Absorption coefficient	5.341 mm^{-1}
$F(000)$	616
Crystal size	0.45 × 0.45 × 0.45 mm
θ range for data collection	1.80 to 28.62°
Index ranges	$-9 \le h \le 8$, $-9 \le k \le 9$, $-15 \le l \le 15$
Reflections collected	5685
Independent reflections	2675 [R(int) = 0.0184]
Completeness to θ = 28.62°	90.7%
Refinement method	Full-matrix least-squares on F^2
Data/restraints/parameters	2675/0/227
Goodness-of-fit on F^2	1.004
Final R indices [$I>2\sigma(I)$]	$R1$ = 0.0242, $wR2$ = 0.0623
R indices (all data)	$R1$ = 0.0286, $wR2$ = 0.0646
Extinction coefficient	0.0040(5)
Largest diff. peak and hole	0.491 and −0.533 e $Å^{-3}$

Table 4. Atomic coordinates (× 10^4), site occupancy factors (sof) and equivalent isotropic displacement parameters ($Å^2 \times 10^3$ for rhodonite. U(eq) is defined as one third of the trace of the orthogonalized U_{ij} tensor. All silicon and oxygen atom sites are fully occupied.

	x/a	*y/b*	*z/c*	*sof*	*U(eq)*
Mn(1)	1260(1)	3164(1)	4448(1)	0.88	6(1)
Mg(1)	1260(1)	3164(1)	4448(1)	0.05	6(1)
Fe(1)	1260(1)	3164(1)	4448(1)	0.07	6(1)
Mn(2)	−302(1)	8822(1)	8521(1)	0.89	6(1)
Mg(2)	−302(1)	8822(1)	8521(1)	0.04	6(1)
Fe(2)	−302(1)	8822(1)	8521(1)	0.07	6(1)
Mn(3)	1877(1)	5101(1)	7300(1)	0.87	6(1)

(continued on next page)

Table 4. *(continued)*

	x/a	*y/b*	*z/c*	*sof*	*U(eq)*
Mg(3)	1877(1)	5101(1)	7300(1)	0.06	6(1)
Fe(3)	1877(1)	5101(1)	7300(1)	0.07	6(1)
Mn(4)	2046(1)	7011(1)	10246(1)	0.75	7(1)
Mg(4)	2046(1)	7011(1)	10246(1)	0.15	7(1)
Fe(4)	2046(1)	7011(1)	10246(1)	0.10	7(1)
Mn(5)	3549(1)	−437(1)	3015(1)	0.42	10(1)
Ca(5)	3549(1)	−437(1)	3015(1)	0.51	10(1)
Fe(5)	3549(1)	−437(1)	3015(1)	0.02	10(1)
Mg(5)	3549(1)	−437(1)	3015(1)	0.05	10(1)
Si(1)	2938(1)	5420(1)	2626(1)		7(1)
Si(2)	3628(1)	7355(1)	5307(1)		6(1)
Si(3)	1537(1)	763(1)	6542(1)		6(1)
Si(4)	5038(1)	7814(1)	8751(1)		6(1)
Si(5)	2463(1)	12561(1)	9110(1)		7(1)
O(1)	1099(3)	2514(2)	6113(2)		8(1)
O(2)	1933(3)	5999(2)	5641(2)		9(1)
O(3)	396(3)	440(2)	3210(2)		8(1)
O(4)	1063(3)	4006(2)	2690(2)		8(1)
O(5)	577(3)	11579(2)	9603(2)		8(1)
O(6)	5161(3)	5794(2)	7797(2)		8(1)
O(7)	1926(3)	4525(2)	9025(2)		9(1)
O(8)	3767(3)	6832(2)	3885(2)		10(1)
O(9)	−3388(3)	9348(2)	8543(2)		8(1)
O(10)	4183(3)	2440(3)	4074(2)		15(1)
O(11)	2998(3)	1396(2)	7778(2)		9(1)
O(12)	5521(3)	7437(2)	10047(2)		8(1)
O(13)	2657(3)	8007(2)	8688(2)		8(1)
O(14)	2551(3)	6805(3)	11862(2)		12(1)
O(15)	2940(3)	9467(2)	5621(2)		12(1)

***Table 5*. Anisotropic displacement parameters (Å² × 10³) for rhodonite. The anisotropic displacement factor exponent takes the form $-2\pi^2[h^2a^{*2}U_{11} + ... + 2hka^*b^*U_{12}]$.**

	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
M(1)	6(1)	7(1)	6(1)	1(1)	0(1)	0(1)
M(2)	5(1)	7(1)	6(1)	1(1)	0(1)	1(1)
M(3)	5(1)	6(1)	6(1)	1(1)	−1(1)	1(1)
M(4)	8(1)	9(1)	5(1)	2(1)	1(1)	4(1)
M(5)	9(1)	6(1)	15(1)	−1(1)	4(1)	−1(1)
Si(1)	6(1)	8(1)	6(1)	2(1)	1(1)	1(1)
Si(2)	6(1)	9(1)	5(1)	2(1)	0(1)	0(1)
Si(3)	6(1)	6(1)	6(1)	1(1)	0(1)	0(1)
Si(4)	5(1)	8(1)	6(1)	1(1)	0(1)	1(1)
Si(5)	6(1)	8(1)	6(1)	2(1)	0(1)	0(1)
O(1)	9(1)	8(1)	8(1)	3(1)	0(1)	1(1)
O(2)	9(1)	9(1)	8(1)	3(1)	1(1)	0(1)
O(3)	7(1)	9(1)	8(1)	2(1)	0(1)	−1(1)
O(4)	5(1)	9(1)	9(1)	2(1)	1(1)	1(1)
O(5)	7(1)	9(1)	8(1)	3(1)	1(1)	1(1)
O(6)	7(1)	9(1)	7(1)	0(1)	2(1)	0(1)
O(7)	10(1)	9(1)	9(1)	4(1)	−1(1)	1(1)
O(8)	11(1)	10(1)	7(1)	0(1)	1(1)	−2(1)
O(9)	8(1)	9(1)	8(1)	3(1)	1(1)	0(1)
O(10)	9(1)	27(1)	12(1)	10(1)	−1(1)	1(1)
O(11)	7(1)	10(1)	7(1)	1(1)	−1(1)	0(1)
O(12)	7(1)	10(1)	7(1)	3(1)	−1(1)	0(1)
O(13)	6(1)	8(1)	10(1)	3(1)	1(1)	1(1)
O(14)	11(1)	15(1)	11(1)	6(1)	−1(1)	2(1)
O(15)	14(1)	6(1)	16(1)	1(1)	8(1)	1(1)

***Table 6*. Selected bond lengths [Å] for rhodonite.**

M(1)−O(10)	2.100(2)	M(2)−O(13)	2.130(2)
M(1)−O(1)	2.155(2)	M(2)−O(5)	2.175(2)
M(1)−O(3)	2.220(2)	M(2)−O(4)#1	2.257(2)
M(1)−O(2)	2.246(2)	M(2)−O(3)#1	2.258(2)
M(1)−O(2)#1	2.276(2)	M(2)−O(5)#2	2.327(2)
M(1)−O(4)	2.330(2)	Mn(2)−O(9)	2.128(2)
M(3)−O(1)	2.109(2)	M(4)−O(14)	1.971(2)
M(3)−O(4)#1	2.123(2)	M(4)−O(7)	2.046(2)
M(3)−O(7)	2.193(2)	M(4)−O(5)#2	2.110(2)
M(3)−O(6)	2.236(2)	M(4)−O(13)	2.211(2)
M(3)−O(2)	2.241(2)	M(4)−O(12)	2.352(2)
M(3)−O(13)	2.386(2)	M(4)−O(9)#2	2.827(2)
M(5)−O(9)#1	2.211(2)		
M(5)−O(14)#3	2.219(2)		
M(5)−O(10)	2.218(2)		
M(5)−O(3)	2.258(2)	Si(1)−O(14)#7	1.589(2)
M(5)−O(8)#4	2.568(2)	Si(1)−O(4)	1.614(2)
M(5)−O(11)#5	2.606(2)	Si(1)−O(8)	1.632(2)
M(5)−O(15)#6	2.727(2)	Si(1)−O(6)#6	1.641(2)
Si(2)−O(10)#5	1.585(2)	Si(3)−O(1)	1.591(2)
Si(2)−O(2)	1.613(2)	Si(3)−O(3)#9	1.614(2)
Si(2)−O(8)	1.626(2)	Si(3)−O(15)#4	1.638(2)
Si(2)−O(15)	1.657(2)	Si(3)−O(11)	1.657(2)
Si(4)−O(9)#10	1.594(2)	Si(5)−O(7)#8	1.594(2)
Si(4)−O(13)	1.609(2)	Si(5)−O(5)	1.628(2)
Si(4)−O(12)	1.652(2)	Si(5)−O(12)#11	1.639(2)
Si(4)−O(6)	1.657(2)	Si(5)−O(11)#8	1.654(2)

Symmetry transformations used to generate equivalent atoms are #1: $-x,-y+1,-z+1$; #2: $-x,-y+2,-z+2$; #3: $x,y-1,z-1$; #4: $x,y-1,z$; #5: $-x+1,-y,-z+1$; #6: $-x+1,-y+1,-z+1$; #7: $x,y,z-1$; #8: $x,y+1,z$; #9: $-x, -y,-z+1$; #10: $x+1,y,z$; #11: $-x+1,-y+2,-z+2$; #12: $x-1,y,z$.

SUPPLEMENTARY MATERIAL

Full lists of crystallographic data excluding structure factor tables have been deposited with the Inorganic Crystal Structure Database (ICSD), Fachinformationszentrum, Karlsruhe, Germany; CRYSDATA@FIZ-Karlsruhe.DE. Any request to the ICSD for this material should quote the full literature citation and the CSD number 418082. Lists of observed and calculated structure factors are available from the authors upon request.

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TIDYING UP MINERAL NAMES: AN IMA-CNMNC SCHEME FOR SUFFIXES, HYPHENS AND DIACRITICAL MARKS

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Mineral names which do not conform to the current nomenclature guidelines of the Commission on New Minerals, Nomenclature and Classification have to be corrected, and in the future a suffix-based nomenclature is to be used for new mineral names.

INTRODUCTION

In 2004, Peter Bayliss successfully proposed (IMA 04-C) to change the two-word mineral name cesium kupletskite to kupletskite-(Cs). In October 2005, Bayliss submitted a proposal to the Commission on New Minerals and Mineral Names (CNMMN) to eliminate the space in all similar two-word cases. This proposal was forwarded to the members for comments, but was not voted on because the CNMMN chairman and vice-chairman were of the opinion that a more generalized correction exercise was needed. Bayliss then revised his proposal into a wider discussion paper (March 2006) on suffix and prefix nomenclature, which was made available to the members on the occasion of the IMA meeting in Kobe, July 2006. It was decided in Kobe that the Chairman of the newly merged Commission on New Minerals, Nomenclature and Classification (CNMNC) would take up the issue for further discussion.

The efforts of Bayliss coincided indeed with the experiences of the Chairman during the operation to clean up the GQN* minerals (Burke, 2006): on going through the list of mineral names it was evident that mineralogical nomenclature has not always been applied in a consistent way. Many names have been given to minerals before the CNMMN started to draft any rules for nomenclature, and later such rules have regularly been ignored, even by the CNMMN itself.

The present paper aims to give a view on suffix nomenclature versus prefix nomenclature, to list mineral names with correct diacritical marks, and to correct mineral names consisting of two words or having superfluous hyphens and diacritical marks. The names and the name changes given in this paper have been approved by the CNMNC (proposal IMA 07-C, September 2007). Names written in **bold** in this paper were approved by the CNMNC to be correctly spelled names.

SUFFIX NOMENCLATURE VERSUS PREFIX NOMENCLATURE

Bayliss has summed up in his 2006 discussion paper the pros and the cons of the suffix nomenclature versus the prefix nomenclature, and his conclusion was that the CNMNC should require that the author(s) of a new-mineral proposal should use a suffix nomenclature rather than a prefix nomenclature.

The suffix nomenclature has been introduced by Levinson (1966) for rare-earth mineral species. This nomenclature has been extended to other chemical elements with minerals such as ardennite, jahnsite, julgoldite, meurigite, pumpellyite, struvite, wallkilldellite, and whiteite. Bayliss and Levinson (1988) made a revision and extension to the suffix nomenclature, where multiple chemical elements in parentheses indicate different structural positions such as jahnsite-(CaMnFe).

The suffix nomenclature (single and multiple) has subsequently been used in revised nomenclature schemes for several mineral groups: zeolites (Coombs *et al.*, 1997), labuntsovites (Chukanov *et al.*, 2002), arrojadites (Chopin *et al.*, 2006) and epidotes (Armbruster *et al.*, 2006). Chemical-element suffixes without parentheses indicate extra-framework cations (e.g., zeolites and labuntsovites).

The CNMNC should perhaps impose that a suffix nomenclature be used in new-mineral proposals, but making a general rule of this principle would encounter several problems. The authors of the eudialyte report (Johnsen *et al.*, 2003) have given strong arguments for using unique names in this group. Bayliss himself stated that the vast majority of the about 500 existing mineral names with prefixes that indicate a structural analogue or polymorph should remain unchanged. It is not the intention of the CNMNC to propose to change these traditional names, as the advantage of

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*G (Grandfathered) = names considered to represent valid species described before 1959; Q (Questionable) = names published before 1959 and considered not to represent valid species; N (Non-approved) = names published after 1959 without CNMMN approval.

changing these names would not be greater that the chaos created by changing these names. The CNMNC should thus adhere to its traditional principle that each nomenclature proposal should be considered on its own merits.

In the past years, there have been repeated complaints from the mineralogical community, especially from mineral collectors, that several well-known traditional names are no longer mineral names because of the prefix nomenclature used in these cases, and thus do not appear in an alphabetical index of mineral names. Bayliss proposed to change a number of mineral groups to suffix-nomenclature names; the proposal was taken over and approved by the CNMNC:

chlorapatite = **apatite-(CaCl)**
fluorapatite = **apatite-(CaF)**
hydroxylapatite = **apatite-(CaOH)**
strontium apatite = **apatite-(SrOH)**
clinohydroxylapatite = **apatite-(CaOH)-*M***

This system would allow "apatite-(SrF)," etc., if found, and it follows the criteria of Bayliss and Levinson (1988).

Carbonate-fluorapatite and carbonate-hydroxylapatite are not valid mineral names.

chlorellestadite = **ellestadite-(Cl)**
fluorellestadite = **ellestadite-(F)**
hydroxylellestadite = **ellestadite-(OH)**

fluorapophyllite = **apophyllite-(KF)**
hydroxyapophyllite = **apophyllite-(KOH)**
natroapophyllite = **apophyllite-(NaF)**

This system would allow "apophyllite-(NaOH)" if found, and it follows the criteria of Bayliss and Levinson (1988).

ferro-axinite = **axinite-(Fe)**
magnesio-axinite = **axinite-(Mg)**
manganaxinite = **axinite-(Mn)**

ferrocolumbite = **columbite-(Fe)**
magnesiocolumbite = **columbite-(Mg)**
manganocolumbite = **columbite-(Mn)**

ferrotantalite = **tantalite-(Fe)**
magnesiotantalite = **tantalite-(Mg)**
manganotantalite = **tantalite-(Mn)**

ferrotapiolite = **tapiolite-(Fe)**
manganotapiolite = **tapiolite-(Mn)**

ferropyrosmalite = **pyrosmalite-(Fe)**
manganpyrosmalite = **pyrosmalite-(Mn)**

TWO-WORD NAMES

According to the current CNMNC procedures and guidelines on mineral nomenclature (Nickel and Grice, 1998), names should consist of one word only. As mentioned above, proposal 04-C by Bayliss to change cesium kupletskite into kupletskite-(Cs) was approved by the CNMNC. There are 12 more two-word mineral names that also have to be changed into one word only. Several renaming systems are applied here, according to which is the best compared with other existing mineral names.

calcium catapleiite = **calciocatapleiite**:
there are many minerals with calcio- as prefix
cobalt pentlandite = **cobaltpentlandite**:
there is an argentopentlandite and several minerals with cobalt- as prefix
hydronium jarosite = **hydroniumjarosite**:
there are plenty of minerals with hydro-, hydroxy- or hydroxyl- as prefixes
magnesium astrophyllite = **magnesioastrophyllite**:
there are many minerals with magnesio- as prefix
potassium alum and
sodium alum = **alum-(K)** and **alum-(Na)**
sal ammoniac = **salammoniac**
strontium apatite (also written as
strontium-apatite) = **apatite-(SrOH)**: see above.
sodium betpakdalite, sodium boltwoodite, sodium pharmacosiderite (also written as sodium-pharmacosiderite) and sodium uranospinite (also written as sodium-uranospinite) = respectively **natrobetpakdalite**, **natroboltwoodite**, **natropharmacosiderite** and **natrouranospinite**: to bring these names in accordance with other names with natro- as prefix

SUPERFLUOUS HYPHENS

According to the current CNMNC procedures and guidelines on mineral nomenclature (Nickel and Grice, 1998), hyphens are used in mineral names to connect suffixed symbols, such as polytype suffixes and Levinson modifiers, and the use of a hyphen to distinguish a prefix from the root name is to be discouraged, but where an unhyphenated name is awkward and a hyphen assists in deciphering the name, it may be used, e.g., bario-orthojoaquinite. In spite of this, there are several dozen mineral names with such superfluous hyphens. It has been decided to delete such hyphens from the names. Amphibole-group mineral names, however, have deviating rules for the use of hyphens (Leake *et al.*, 2003, Burke & Leake, 2004), and are not considered here.

alumino-magnesiohulsite = **aluminomagnesiohulsite**
barium-pharmacosiderite = **bariopharmacosiderite**
calcio-andyrobertsite = **calcioandyrobertsite**
calcio-ancylite = **calcioancylite**
carbonate-cyanotrichite = **carbonatecyanotrichite**
cobalt-zippeite = **cobaltzippeite**
ferro-alluaudite = **ferroalluaudite**
ferro-aluminoceladonite = **ferroaluminoceladonite**
ferro-axinite = renamed to **axinite-(Fe)**
(see above)
hydroxyl-bastnäsite = **hydroxylbastnäsite**
hydroxyl-herderite = **hydroxylherderite**
hydroxyl-pyromorphite = **hydroxylpyromorphite**
magnesio-axinite = renamed to **axinite-(Mg)**
(see above)
magnesium-chlorophoenicite = **magnesiochlorophoenicite**
magnesium-zippeite = **magnesiozippeite**
manganese-hörnesite = **manganohörnesite**
manganese-shadlunite = **manganoshadlunite**
mangan-neptunite = **manganoneptunite**
meta-lodèvite = **metalodèvite**
meta-natro-autunite = **metanatroautunite**
meta-uramphite = **metauramphite**
meta-uranocircite = **metauranocircite**
meta-uranopilite = **metauranopilite**
meta-uranospinite = **metauranospinite**
Na-komarovite = **natrokomarovite**
natro-autunite = **natroautunite**
nickel-boussingaultite = **nickelboussaingaultite**
nickel-skutterudite = **nickelskutterudite**

nickel-zippeite = **nickelzippeite**
niobo-aeschynite = **nioboaeschynite**
potassic-carpholite = **potassiccarpholite**
sodium-pharmacosiderite = **natropharmacosiderite**
sodium-uranospinite = **natrouranospinite**
sodium-zippeite = **natrozippeite**
tantal-aeschynite = **tantalaeschynite**
tetra-ferri-annite = **tetraferriannite**
tetra-ferriphlogopite = **tetraferriphlogopite**
zinc-melanterite = **zincmelanterite**
zinc-zippeite = **zinczippeite**

Because of possible problems in deciphering the name, hyphens are preserved in **bario-orthojoaquinite**, **calcio-olivine**, **meta-aluminite**, **meta-alunogen**, **meta-ankoleite**, **meta-autunite**, **para-alumohydrocalcite** and **tetra-auricupride**.

There is, however, georgeericksenite, which for the sake of conformity is to be changed to **george-ericksenite**.

DIACRITICAL MARKS

A diacritical mark (also called accent mark) is a small sign added to a letter to alter pronunciation or to distinguish between similar words. Its main usage is to change the phonetic value of the letter to which it is added. Diacritical marks in mineral names include the *acute accent* (e.g., in andrémeyerite), the *grave accent* (e.g., in cesàrolite), the *circumflex accent* (e.g., in laforêtite), the *double acute accent* (unique to Hungarian) (e.g., in felsőbányaite), the *cedilla* (e.g., in françoisite), the *ring* (e.g., in håleniusite), the *caron* (e.g., in čechite), the *trema* (or umlaut or diaeresis) (e.g., in moëloite), the *tilde* (e.g., in ordoñezite), the *bar* (or slash) (e.g., in jørgensenite), and the *apostrophe* (e.g., in d'ansite).

The use of diacritical marks in mineral names has been the subject of several proposals to the CNMMN, lastly in 1999 by the former member for New Zealand, Douglas Coombs. The aim of these repeated proposals was to avoid insertion of diacritical marks into mineral names in which they had not been in standard use in the past, and to eliminate diacritical marks from existing mineral names as published in English. These repeated proposals have not been approved by the CNMMN. These decisions were correct, as they follow the current CNMNC procedures and guidelines on mineral nomenclature (Nickel and Grice, 1998):

> "If the mineral is to be named after a geographical occurrence, care must be taken to ensure that the spelling conforms to that in use at the locality; the spelling should not be taken from translations."
>
> "If the mineral is to be named after a person (…). Otherwise, the original spelling of the person's name should be retained."

Such mineral names after persons or geographical occurrences have these diacritical marks as an integral part of these names, e.g., the mineral jaskólskiite was named for the Polish person S. Jaskólski, and the mineral örebroite was named for the Swedish town Örebro. In both cases these names were approved by the CNMMN with their diacritical marks, and they should consequently be used as such. A decision to eliminate these diacritical marks would definitely amount to a kind of amputation of these names.

Sometimes mineral names have been approved (and published) without diacritical marks although the name of the person or locality for which they were named had such marks; these names are corrected here.

Special cases are the names nybøite, ferronybøite and fluoronybøite, originally published as nyböite, etc., supposedly after the Norwegian island "Nybö," but the letter ö is not part of the Norwegian alphabet; the correct name of the island is Nybø. The tourmaline-group mineral schorl is often written as "schörl"; Ertl (2006, and pers. comm.) is of the opinion that the name of the mineral is derived from the village Schorl (later Schorlau, today Zschorlau) and thus should be written without diacritical mark, in spite of the widespread use of "schörl" in the German-speaking areas, starting in the 18th century and continuing until today (see title of Ertl, 2006).

Mandarino (2007) published on his own initiative, disregarding the then ongoing discussion within the CNMNC, a list of mineral names which in his opinion needed diacritical marks. The following CNMNC-approved list gives mineral names having correct diacritical marks; some recently approved names have not yet been published by their authors.

åkermanite
alacránite
andrémeyerite
barićite
bastnäsite-(Ce)
bastnäsite-(La)
bastnäsite-(Y)
bílinite
blödite
bøggildite
bøgvadite
böhmite
brüggenite
bukovskýite
bütschliite
byströmite
calderónite
čechite
čejkaite
černýite
cesàrolite
chabournéite
chaméanite
cobaltneustädtelite
d'ansite
daubréeite
daubréelite
dufrénite
dufrénoysite
felsőbányaite
ferrohögbomite-2*N*2*S*
ferrokësterite
ferronybøite
fizélyite
fluoronybøite
fluorthalénite-(Y)
fougèrite
françoisite-(Ce)
françoisite-(Nd)
fülöppite
gaspéite
görgeyite
götzenite
guérinite
guimarãesite
häggite
håleniusite-(La)
haüyne
heyrovskýite
hiärneite
hodrušite
høgtuvaite
hörnesite
horváthite-(Y)
hübnerite
hügelite
hydroroméite
hydroxylbastnäsite-(Ce)
hydroxylbastnäsite-(La)
hydroxylbastnäsite-(Nd)
hyttsjöite
ilímaussite-(Ce)
jáchymovite
jaguéite
jankovićite
jaskólskiite
jôkokuite
jørgensenite
joséite-A
joséite-B
joséite-C
kaňkite
karupmøllerite-Ca
kësterite
kochsándorite
köttigite
kôzulite
kratochvílite
kröhnkite
krut'aite
kupčíkite
laforêtite
långbanite
låvenite
lévyclaudite
lévyne-Ca
lévyne-Na
lindströmite
löllingite
lópezite
lorándite
löweite
lüneburgite
lun'okite
magnesiohögbomite-2*N*2*S*
magnesiohögbomite-2*N*3*S*
magnesiohögbomite-6*N*6*S*
mäkinenite
manganohörnesite
marécottite

maricite
mélonjosephite
metaköttigite
metalodèvite
metanováčekite
metasaléeite
moëloite
mogánite
mrázekite
mückeite
nagyágite
natrodufrénite
népouite
neustädtelite
nežilovite
nickelblödite
nordenskiöldine
nordströmite
nováčekite I
nováčekite II
novákite
nybøite
o'danielite
ordoñezite
örebroite
ottrélite
pääkkönenite
paděraite
parthéite
patrónite
phosphorrösslerite
písekite-(Y)
plombièrite
potosíite
protojoséite
ranciéite
rhönite
rokühnite
romanèchite
roméite
römerite
röntgenite-(Ce)
rosickýite
rosièresite
rösslerite
saléeite
sanrománite
schäferite
schneiderhöhnite
schöllhornite
schröckingerite
seinäjokite
sénarmontite
sérandite
sillénite
sjögrenite
slavíkite
söhngeite
sørensenite
součekite
šreinite
staněkite
strätlingite
stützite
švenekite
szaibélyite
sztrókayite
szymańskiite
takéuchiite
tarapacáite
thalénite-(Y)
thérèsemagnanite
thorbastnäsite
törnebohmite-(Ce)
törnebohmite-(La)
trögerite
trüstedtite
tschörtnerite
tučekite
ulvöspinel
västmanlandite-(Ce)
vavřínite
väyrynenite
veselovskýite
vésigniéite
villamanínite
wöhlerite
wölsendorfite
wülfingite
wüstite
ye'elimite
zaïrite
zálesíite
zdeněkite
zenzénite
zincohögbomite-2*N*2*S*
zincohögbomite-2*N*6*S*
zincohögbomite
zýkaite

SUPERFLUOUS DIACRITICAL MARKS

In some languages (e.g., French, Portuguese) diacritical marks have been added to mineral names as a pronunciation guide because the words would otherwise become incomprehensible in that language. French examples are, e.g., curiénite and roquésite, but the persons which they honoured had no such marks in their names: Hubert Curien and Maurice Roques. In English such diacritical marks should be left out of these mineral names. The following list gives mineral names which have been used with superfluous diacritical marks in English-language literature and handbooks.

aerinite, not aërinite
akaganeite, not akaganéite
behierite, not béhierite
benavidesite, not bénavidésite
boleite, not boléite
ceruleite, not ceruléite or céruleite
cobaltomenite, not cobaltoménite
cumengeite, not cumengéite
curienite, not curiénite
diaboleite, not diaboléite
francevillite, not françevillite
henritermierite, not henritermiérite
hureaulite, not huréaulite
imiterite, not imitérite
julienite, not juliénite or juliënite
kamitugaite, not kamitugaïte
kamotoite, not kamotoïte
kolwezite, not kolwézite
kutinaite, not kutínaite
magnesiocarpholite, not magnésiocarpholite
mantienneite, not mantiennéite
metavanmeersscheite, not métavanmeersscheite
minguetite, not minguétite
molybdomenite, not molybdoménite
neltnerite, not neltnérite
noelbensonite, not noélbensonite
offretite, not offrétite
ojuelaite, not ojuélaïte
plancheite, not planchéite
pseudoboleite, not pseudoboléite
renierite, not reniérite
roquesite, not roquésite
routhierite, not routhiérite
schorl, not schörl
schubnelite, not schubnélite
sengierite, not sengiérite
tremolite, not trémolite
uchucchacuaite, not uchucchacuaïte

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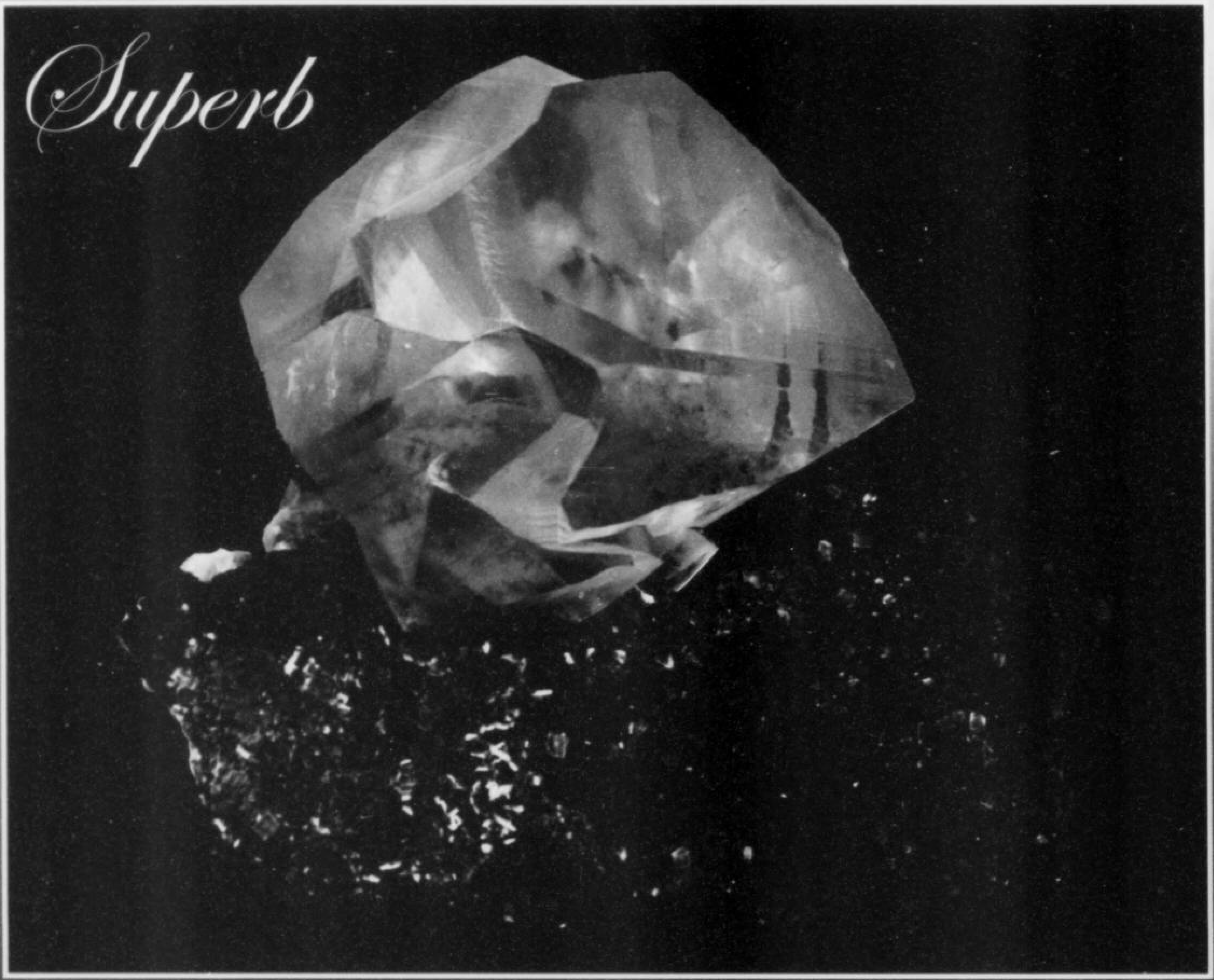
Superb

PODLESNOITE $BaCa_2(CO_3)_2F_2$

A NEW MINERAL SPECIES FROM THE KIROVSKII MINE KHIBINY, KOLA PENINSULA, RUSSIA

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ABSTRACT

The new mineral podlesnoite, ideally $BaCa_2(CO_3)_2F_2$*, was found at the Kirovskii underground apatite mine, Mount Kukisvumchorr, Khibiny alkaline massif, Kola Peninsula, Russia. Podlesnoite occurs in cavities within a hydrothermal lens-shaped body located in urtite rock. Associated minerals include natrolite, biotite, ilmenite, aegirine, lorenzenite, barytocalcite, calcite, fluorite, astrophyllite and burbankite. Two morphological varieties of podlesnoite were found: (variety I) perfect prismatic crystals up to 1 × 1 × 4 mm typically combined in groups, and (variety II) radial fibrous spherulites up to 8 mm in diameter. Crystal forms are: {100}, {110}, {210}, {001}, {101}, {112}, {313}, {111} and {021}. Crystals (variety I) are colorless, transparent and water-clear; radial fibrous spherulites (variety II) are snow-white and translucent. The streak is white; the luster is vitreous. The mineral is brittle with no observed cleavage. Fracture is conchoidal; Mohs' hardness 3.5–4.* $D_{meas} = 3.62(1)$, $D_{calc} = 3.63$ *g/cm*^{3}*. In shortwave ultraviolet light, colorless crystals show strong pinkish orange fluorescence, whereas white spherulites show weak bluish lilac fluorescence. Optically, the mineral is biaxial (–),* $\alpha = 1.500(2)$, $\beta = 1.612(2)$, $\gamma = 1.614(2)$, $2V_{meas} = 10(5)°$*, orientation:* $X = a$, $Y = b$, $Z = c$*. Chemical composition is:* Na_2O *0.11,* K_2O *0.05, CaO 29.02, SrO 0.13, BaO 40.77, MnO 0.07, FeO 0.25,* CO_2 *22.9, F 9.95,* $-O=F_2$ *4.19, total 99.06 wt.%. The empirical formula based on six oxygens is:*

$$Ba_{1.02}(Ca_{1.98}Fe_{0.01}Na_{0.01}Sr_{0.005})_{\Sigma 2.005}C_{1.99}O_6F_{2.00}.$$

Symmetry is orthorhombic, space group Cmcm; unit cell dimensions are: $a = 12.511(5)$, $b = 5.857(2)$, $c = 9.446(4)$ Å, $V = 692.2(8)$ Å^3, $Z = 4$*. The strongest reflections of the X-ray powder diagram (d,Å-I[hkl]) are: 5.303-21[110]; 3.527-100[112]; 3.397-71[310]; 2.609-20[402]; 2.313-43[222], 2.302-22[510], 2.211-20[204], 1.948-39[422], 1.940-40[314]. Podlesnoite represents a new structural type remotely related to the aragonite group. The mineral was named in honor of Aleksandr Semenovich Podlesnyi (b. 1948), Russian amateur mineralogist and mineral collector, in recognition of his significant contributions to the mineralogy of the Khibiny massif. The holotype specimen is deposited in the Fersman Mineralogical Museum, Moscow.*

INTRODUCTION

The famous Khibiny massif on the Kola Peninsula is the world's largest alkaline complex, covering an area of 1327 km^2. Huge deposits of a magmatogene apatite are actively mined there, and the Khibiny massif is the world's most prolific geological unit in terms of mineral diversity, with 470 mineral species, and is the type locality for 95 of those species.

The Kukisvumchorr apatite deposit at the southern edge of Mount

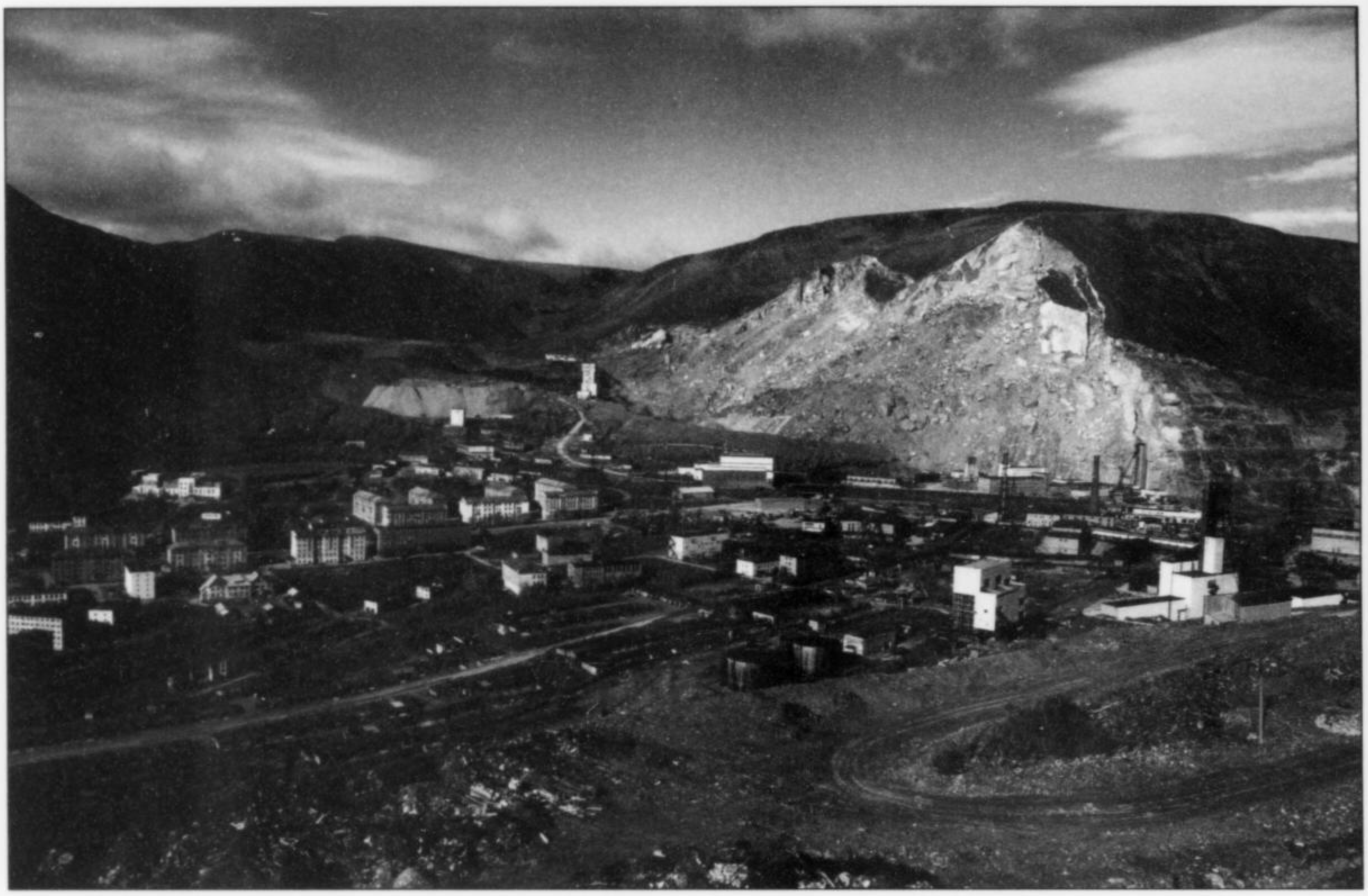

Figure 1. **The Kirovskii mine and the town of Kukisvumchorr near the southern spur of Mount Kukisvumchorr. September, 2002; I. V. Pekov photo.**

Kukisvumchorr was discovered in August, 1926 by Russian mineralogist Aleksandr N. Labuntsov. In October, 1929, the first mine in the Soviet Union situated north of the Arctic Circle was opened there. This mine, first named the Apatitovyi mine, was renamed as the Kirovskii mine in 1935, in memory of the great Soviet political figure Sergey M. Kirov, who actively supported exploration of the Khibiny area. Today, the Kirovskii mine (Fig. 1) operates intensively and on a large scale. It includes extensive underground workings (Fig. 2) and two open pits.

All apatite deposits in Khibiny are localized within a complex of melteigite-urtite[1] rocks. Phosphate ores largely consist of granular, sugar-like fluorapatite with embedded nepheline crystals. The ore rock can contain up to 98% fluorapatite. Nepheline-apatite rocks form numerous lenticular bodies up to several kilometers long and up to 200 meters thick. The Kukisvumchorr deposit is in the northwest portion of a huge (12 km long) lode of nepheline-apatite rock which is prospected and mapped by using boreholes to a depth of 2.5 km. The main orebody of the Kukisvumchorr deposit is a lens roughly 1800 meters long and varying in thickness from 45 to 200 meters (typically 80 to 100 meters). Rocks underlying the orebody are urtites and ijolites[2]; the overlying rocks are rischorrites.[3]

Data on the geology, tectonics and petrology of the Kukisvumchorr deposit were published by Ivanova (1963) and Zak *et al.* (1972), and the mineralogy of apatite ores and host rocks was described by Dudkin *et al.* (1964). The mineralogy of Kukisvumchorr pegmatites and hydrothermal bodies and the history of research and mining at the Kirovskii mine were reported by Pekov and Podlesnyi (2004).

Many hundreds of alkaline pegmatite and hydrothermal bodies with diverse mineralogy were uncovered in the workings of the Kirovskii mine. The pegmatitic-hydrothermal complex of the Kukisvumchorr deposit stands out by its singularity even against a background of the Khibiny massif, an object unique in its mineralogy. The Kirovskii mine is one of the most remarkable mineral localities in Russia, and 220 different minerals are currently known to occur there. It is the type or cotype locality for 23 species, of which nine are found nowhere else: armbrusterite, bussenite, isolueshite, kukharenkoite-(La), kukisvumite, middendorfite, podlesnoite, shirokshinite and tuliokite. The most interesting finds, including 20 new species, were made in the last quarter century at deep levels of the deposit. The presence of an active tectonic zone connected with the large Kukisvumchorr fault facilitated strong hydrothermal activity. As a consequence, an abundance of large cavities were created in which good crystals of numerous minerals have been found—an unusual occurrence for Khibiny. One of the remarkable mineralogical features of the Kukisvumchorr deposit is the diversity of carbonates: 34 carbonate species are known to occur there, most of them containing essential Na, Ca, Sr, Ba or *REE* cations.

A new fluorocarbonate of calcium and barium found at the

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[1] **Melteigite** is a dark colored plutonic rock that is part of the ijolite series and contains nepheline and 60–90% mafic minerals, especially green pyroxene. **Urtite** is a pale-colored member of the ijolite series that is composed chiefly of nepheline and 0–30% mafic minerals, especially aegirine and apatite (Jackson, 1997).

[2] **Ijolite** refers to a series of plutonic rocks containing nepheline and 30–60% mafic minerals, generally clinopyroxene, and including titanite, apatite and sometimes andradite (Jackson, 1997).

[3] **Rischorrite** is a variety of nepheline syenite in which nepheline is poikilitically enclosed in microcline perthite (Jackson, 1997).

Figure 2. **Underground galleries and mine trains in the Kirovskii mine. March, 2003; N. A. Pekova photo.**

Figure 3. **Aleksandr Podlesnyi with underground mine telephone. March, 2003; N. A. Pekova photo.**

Kukisvumchorr deposit (Kirovskii mine) is described in this paper. It has been named ***podlesnoite*** (Cyrillic: подлеснoит) (pronounced "pod-**lez'**-no-ite") in honor of Aleksandr Semenovich Podlesnyi (born 1948), Russian amateur mineralogist and prominent mineral collector, in recognition of his significant contributions to the mineralogy of the Khibiny massif. A. S. Podlesnyi (Fig. 3) has worked in the Kirovskii underground mine since 1977, initially as an operator of a loader, and from 1979 to the present day as a blasting operator. Beginning in 1980, he developed a strong interest in mineralogy, collected minerals and forged close contacts with Russian professional mineralogists. He has assembled the best systematic collection of Kirovskii mine minerals in existence, and has also built one of the most representative collections of Khibiny minerals in general. A book describing the mineralogy of pegmatitic and hydrothermal formations at this outstanding mineral locality (Pekov and Podlesnyi, 2004) was prepared based primarily on his collection. Perhaps the most remarkable aspect of his keen eye is reflected in the fact that A. S. Podlesnyi collected and provided for study the specimens which became the holotype specimens of eleven new species (tuliokite, kukisvumite, sitinakite, belovite-(La), labuntsovite-Fe, lemmleinite-Ba, kukharenkoite-(La), shirokshinite, middendorfite, armbrusterite and podlesnoite) and the cotype specimens of four other new species (kukharenkoite-(Ce), tsepinite-K, neskevaaraite-Fe and potassicarfvedsonite)! This is probably a modern record for the number of new mineral species described based on specimens self-collected by a single amateur.

Both the new mineral and its name have been approved by the IMA Commission on New Minerals, Nomenclature and Classification (IMA 2006-033). The holotype specimen of podlesnoite is deposited in the Fersman Mineralogical Museum of the Russian Academy of Sciences, Moscow, with registration no. 3460/1.

OCCURRENCE AND ASSOCIATED MINERALS

The specimens described in the present paper were collected by A. S. Podlesnyi in early February of 2006, in a stope excavated in the last days of January 2006. Podlesnoite was found in a small hydrothermal body (Fig. 4) composed primarily of natrolite. It is located in urtite rock enriched by pyroxene (aegirine-diopside), titanite and fluorapatite. Urtite there contains numerous xenoliths of fine-grained titanite-rich ijolite rock. The lenticular hydrothermal body dips gently toward the east (about 10°), and measures 3.2 meters in length, with a midpoint thickness of 90 cm. The host urtite gradually transitions to a natrolite body, with a natrolitized urtite transition zone 5 to 10 cm thick. This transition zone is enriched by grayish white fibrous lorenzenite and contains pods of brown cancrinite.

The main mineral of the hydrothermal body is white to gray, coarsely columnar natrolite. Individual natrolite crystals and groups up to 5 cm long form chaotic, sheaf-like or radial aggregates. Sporadically, but especially in the eastern part of the lens and near the lower margin, dark brown biotitic mica is abundant. It occurs as coarse, equant crystals up to 2 cm, isolated or forming aggregates up to 7 × 20 cm. Some areas, typically biotite-bearing, are enriched by green acicular aegirine, aggregates of well-shaped equant crystals (up to 3 mm) of ilmenite with strong metallic luster, and small (up to 0.5 mm), colorless, short-prismatic fluorapatite crystals. Nests (up to 2 cm) of softly fibrous grayish white lorenzenite, strongly

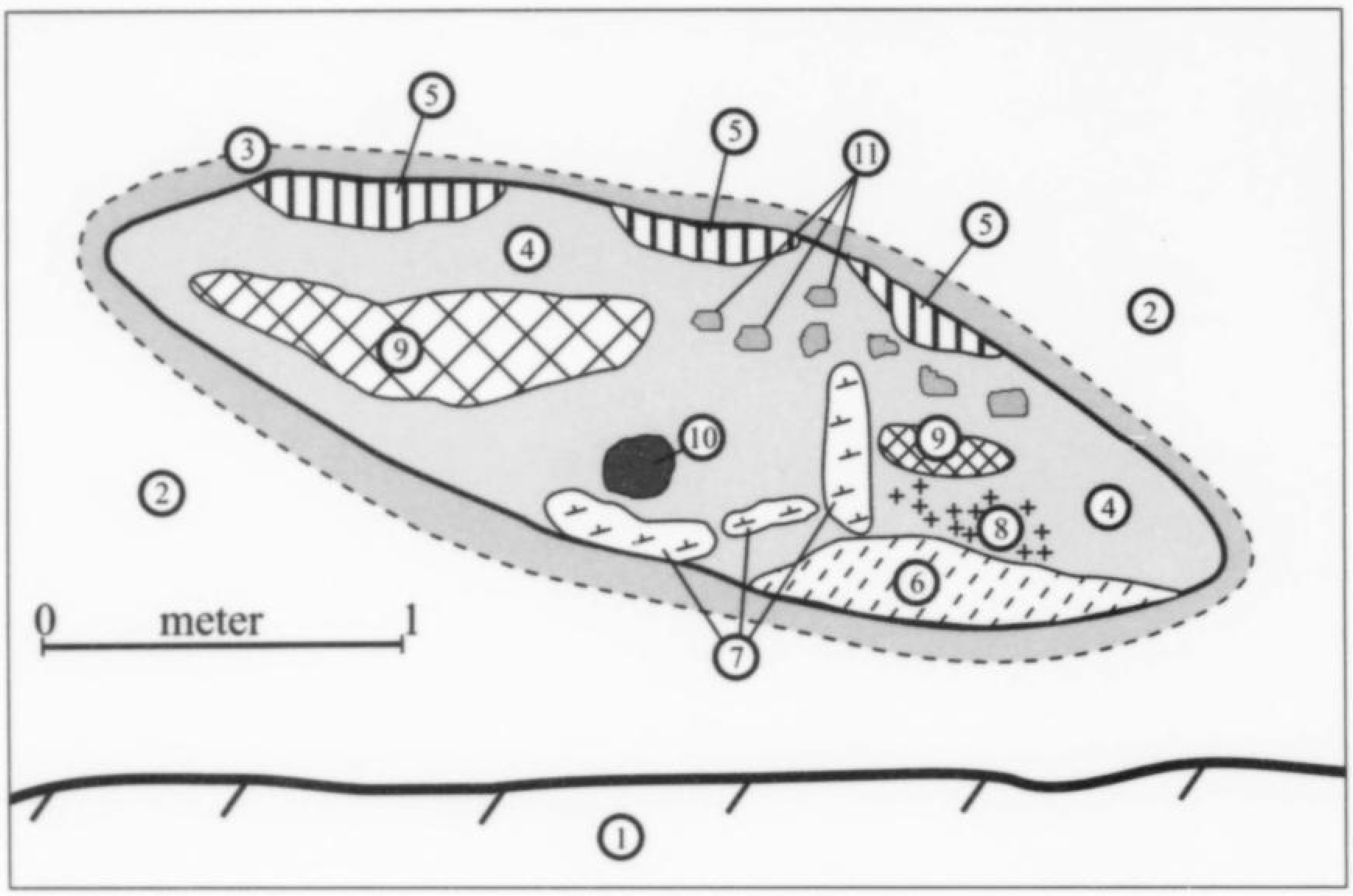

***Figure 4.* Schematic cross-section showing the stucture of the hydrothermal body in which podlesnoite was discovered.**

(1) Footwall rock.
(2) Urtite rock with numerous small xenoliths of fine-grained titanite ijolite rock.
(3) Natrolitized urtite rich in lorenzenite.
(4) Hydrothermal natrolite rock.
(5) Lorenzenite-rich areas.
(6) Aegirine-rich area.
(7) Biotite-rich areas.
(8) Ilmenite-rich area.
(9) Cavernous areas with podlesnoite.
(10) Barytocalcite nest.
(11). Calcite nests.

fluorescent greenish yellow in shortwave ultraviolet light, occur in the interstices between the natrolite crystals. Lorenzenite is especially abundant in the upper part of the body.

Natrolite aggregates contain numerous narrow, slit-like, elongated cavities which are especially large (up to 10 cm) and abundant in the axial zone in the western part of the body. Walls of the cavities are covered by natrolite crystals, and some cavities are filled by a clay-like material. Natrolite in the cavities is overgrown by calcite, fluorite, barytocalcite, podlesnoite, astrophyllite and, in minor amounts, burbankite, lemmleinite-K and fluorapophyllite. Calcite forms colorless rhombohedral crystals and shell-like pseudomorphs after pirssonite(?) crystals. Fluorite occurs as small, pale violet cuboctahedral crystals as well as colorless botryoidal crusts. Astrophyllite forms soft, cottony brown aggregates; burbankite forms greenish gray aggregates of tiny acicular crystals; lemmleinite-K forms isolated, pale yellow, rhomboidal lamellar crystals; and fluorapophyllite occurs as isolated colorless, water-clear tabular crystals. Brown films and spherical black droplets of hard bituminous matter typically occur in these cavities as well.

Barytocalcite was observed mainly in large cavities in the lower part of the body. Three different morphologies and colors were found: (1) transparent, lamellar to tabular, lemon-yellow crystals up to 1 × 3 × 3.2 cm combined in clusters up to 5 cm; (2) gray prismatic crystals up to 0.3 × 1 × 3.5 cm forming a cavernous nest of 10 cm across; and (3) snow-white, fine-grained spherical aggregations up to 1.5 cm in diameter covered by a podlesnoite crust.

Biotite, aegirine, ilmenite and fluorapatite are early minerals of the hydrothermal body, whereas natrolite and lorenzenite were formed later. Calcite, barytocalcite, podlesnoite, fluorite, astrophyllite, burbankite, lemmleinite-K and fluorapophyllite are the latest minerals found only in cavities. No feldspars, nepheline, sodalite, aegirine-diopside, amphiboles or eudialyte were found in this body, nor were there any zirconium minerals. An absence of these minerals, which are very typical for alkaline pegmatites of the Khibiny massif, combined with the presence of the transition zone between a natrolite body and urtite, demonstrates that we are observing a "pure hydrothermal" body but not a pegmatite. Note that several typical pegmatite veins occur a few meters from the lens containing the new mineral. The hydrothermally altered areas inside these pegmatites consist of natrolite and aegirine, and they contain biotite and fibrous lorenzenite visually very similar to the material described above. Calcite, fluorite and barytocalcite were found in the cavities, but podlesnoite was not.

MORPHOLOGY OF CRYSTALS AND AGGREGATES

Podlesnoite occurs as overgrowths on natrolite, ilmenite, biotite and barytocalcite in cavities. The new mineral occurs in two varieties that show distinctive morphology, color and fluorescence, but are otherwise identical in their chemical composition, X-ray powder diffraction pattern, IR spectrum and optical characteristics.

Variety I is represented by perfectly shaped prismatic crystals up to 1 × 1 × 4 mm. They are typically combined in groups and crusts (Figs. 5 and 6) up to 1.5 × 2 cm; isolated crystals are rare.

Variety II forms dense radial spherulites up to 5 mm in diameter which consist of thin acicular to fibrous individuals (Fig. 7). The surface of these variety II spherulites is covered (usually completely) by an overgrowth of variety I crystals oriented in "reclining position" (this orientation is discussed below). This arrangement makes such "combined" spherules (up to 8 mm in diameter) unusual in appearance (Fig. 8). Thus, we can conclude that variety I crystallized later than variety II.

Crystals of variety I are prismatic, elongated along [001] (Fig. 9a–c). Several crystals were measured using a GD-1 two-circle goniometer (LOMO, Russia). In accordance with the X-ray data (see below), podlesnoite is orthorhombic, class *mmm*. Goniometric data are given in Table 1. The major forms observed on podlesnoite crystals (Fig. 10) are: {100}, {110}, {210} and {001}. Forms {101}, {112} and {313} are minor, and forms {111} and {021} are rare. On large crystals the {100}, {001}, {110} and {210} forms are dominant, whereas forms {101}, {112} and {313} are subordinate (Fig. 10a). Such crystals are visually similar to thomsonite crystals. Smaller crystals show more complicated combinations of forms, in some cases including well-developed dipyramidal faces (Fig. 10b–d). Forms {110} and {210} are typically striated parallel to [001]; on some crystals, forms {001} are striated parallel to [010] (Fig. 9). Twins were not observed, but parallel intergrowths are common (Fig. 9d).

As determined by optical study, acicular to fibrous individuals of variety II are elongated along [010], unlike crystals of variety I. The termination of a needle (fiber) of variety II on the surface

Figure 5. **Group of podlesnoite crystals (variety I; the largest is 4 mm long). I. V. Pekov collection. N. A. Pekova photo.**

of a spherulite becomes the nucleation point for a crystal of variety I which overgrows it in parallel orientation. Thus, crystals of variety I, elongated along [001], always have their axis of elongation perpendicular to that of the underlying acicular fibers of variety II, *i.e.* they are oriented tangential to the surface of spherulites (Fig. 11). This auto-epitaxy clearly explains a phenomenon which initially seems quite amazing, that the surface of spherulites of variety II is covered by crusts of variety I consisting of only "reclining" crystals (Fig. 8). Note that the auto-epitactic intergrowths of varieties II and I of podlesnoite are analogous in their structure to well-known oriented intergrowths of quartz and chalcedony (see Lemmlein, 1946): common rhombohedral-prismatic quartz crystals auto-epitactically, in reclining position, overgrow the surface of radial spherules of chalcedony formed by quartz fibers elongated along $[11\bar{2}0]$ or $[10\bar{1}0]$.

Optical, infrared, chemical, X-ray diffraction and structural data on podlesnoite presented in this paper were obtained for well-shaped crystals of variety I.

PHYSICAL AND OPTICAL PROPERTIES

Crystals of podlesnoite (variety I) are colorless and water-clear, while fibrous spherulites (variety II) are snow-white and translucent. The streak is white, and the luster is vitreous. The mineral is brittle, cleavage was not observed, and the fracture is conchoidal. Mohs' hardness is 3.5 to 4. The density, measured using heavy liquids, is 3.62(1), whereas calculated density using the empirical formula is 3.63; calculated density using the idealized formula is 3.60 g/cm^3.

Both varieties of podlesnoite fluoresce in ultraviolet light, but each quite differently (Figs. 6, 8). Colorless crystals of variety I show strong pinkish orange fluorescence in shortwave ultraviolet light (245 nm) and no fluorescence in longwave ultraviolet light (330 nm). Snow-white spherulites of variety II show weak bluish lilac fluorescence in shortwave ultraviolet light and very weak lilac-blue fluorescence under longwave ultraviolet light.

Podlesnoite is optically biaxial negative, $\alpha = 1.500(2)$, $\beta = 1.612(2)$, $\gamma = 1.614(2)$, $2V_{meas} = 10(5)°$, $2V_{calc} = 14°$. Under the microscope, the mineral is colorless and non-pleochroic. Orientation: $X = a$, $Y = b$, $Z = c$.

Accuracy of the determination of the chemical composition, refractive indices and density of podlesnoite is confirmed by the superior values of the Gladstone–Dale compatibility index (Mandarino, 1981): $1 - (K_p/K_c) = 0.005$ for measured density, 0.011 for density calculated using the empirical formula, and 0.002 for density calculated using the idealized formula.

IR SPECTROSCOPY

The infrared spectrum of podlesnoite (Fig. 12a) clearly shows that the mineral is an anhydrous carbonate. No bands are observed in the range 3000–4000 cm^{-1} corresponding to O-H stretching vibrations. The assignment of the strongest bands is as follows: In the range 1300–1600 cm^{-1} there are components of the degenerate band of asymmetric C-O stretching vibrations. At 1067.5 cm^{-1} there are non-degenerate fully-symmetric C-O stretching vibrations. In the range 840–860 cm^{-1} one sees a non-degenerate band of out-of-plane bending vibrations of $(CO_3)^{2-}$ anions. The doublet at 705 + 710 cm^{-1} equals components of the degenerate band of in-plane bending vibrations of $(CO_3)^{2-}$ anions.

The band of out-of-plane bending vibrations is split into two components (at 842 and 855 cm^{-1}), presumably as a result of Fermi resonance. The corresponding overtone doublet has absorption maxima at 1776 and 1782 cm^{-1}.

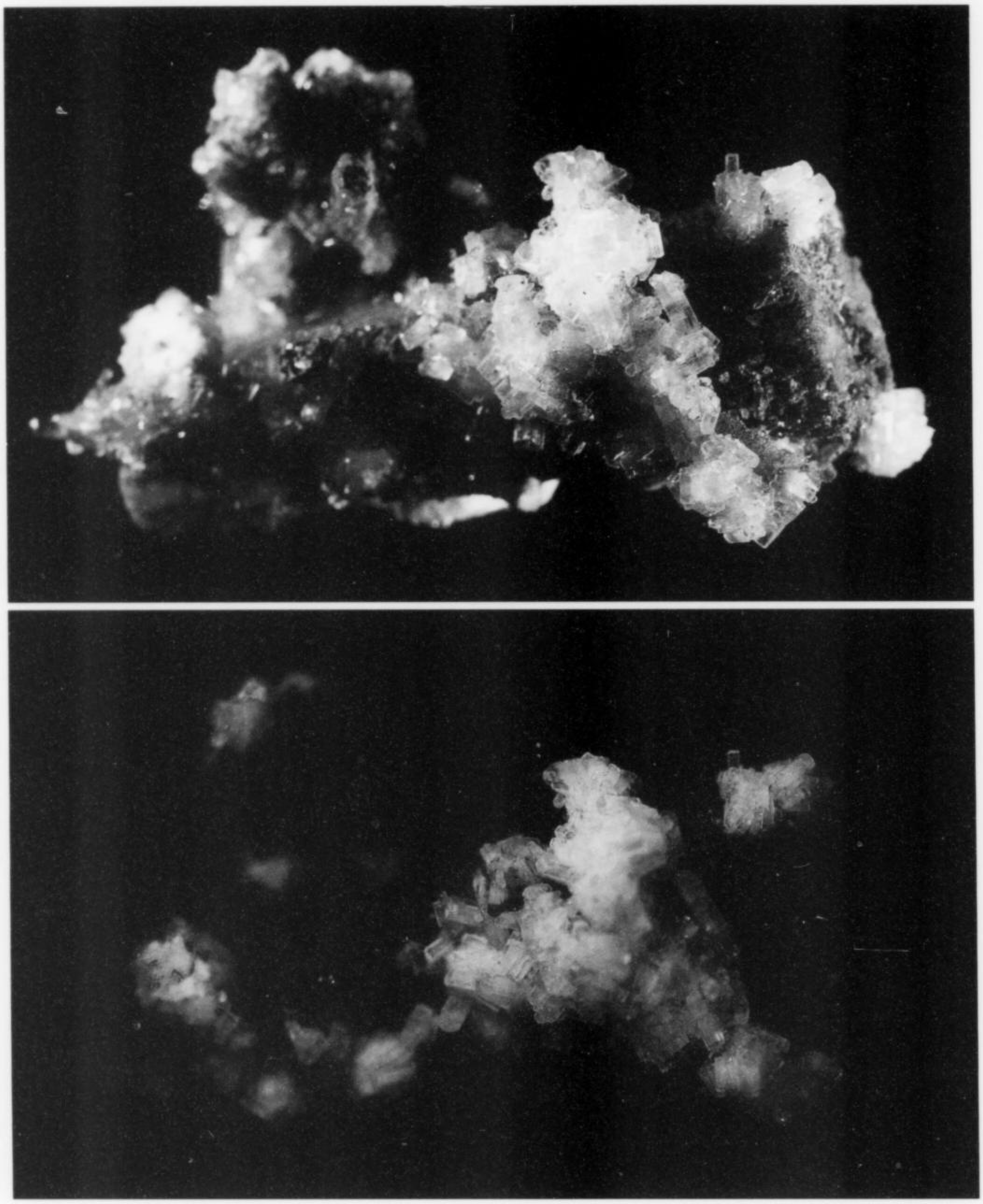

Figure 6. **Groups of podlesnoite crystals (variety I) and spherulites forming a crust on a natrolite crystal: (*a*) in ordinary light, (*b*) in shortwave ultraviolet light. Specimen size: 3 cm. I. V. Pekov collection; N. A. Pekova photo. The difference in the fluorescence color of podlesnoite varieties I and II is well-shown on a broken spherule.**

The absorption activity of non-degenerate, fully-symmetric C-O stretching vibrations is an indication of a distortion of (CO_3) groups. Obviously, this distortion results in the splitting of the band of in-plane bending vibrations. However, band splitting for this reason is impossible for the bands of non-degenerate vibrations. For this reason, the presence of a distinct, very narrow band at 901.5 cm^{-1} (*i.e.* close to the range of out-of-plane bending vibrations of $(CO_3)^{2-}$ anions) is intriguing. It could be explained by a resonance splitting, but this explanation is doubtful because the value of splitting (46.5 cm^{-1}) is too high and essentially exceeds the widths of corresponding individual bands. Such bands are unknown in infrared spectra of other anhydrous carbonate and fluorocarbonate minerals. A possible (though exotic) explanation for the band at 901.5 cm^{-1} could be the hypothetical substitution of a minor part (no more than a few percent?) of carbonate groups by the anions $(CO_2F)^-$. As it was demonstrated for matrix-isolated ion pairs $(CO_2F)^-\cdot Tl^+$ and $(CO_2F)^-\cdot Cs^+$, in particular using the ^{13}C- and ^{18}O-substituted species (Ault, 1982; Shelle and Ault, 1985), the ion $(CO_2F)^-$ is relatively stable and frequencies of its bending vibrations in the IR spectra lie in the range 883–885 cm^{-1}. In the presence of the higher force-strength cation Ca^{2+}, enhancement of this frequency should be expected.

Figure 7. **Two morphological varieties of podlesnoite on grayish natrolite crystals: a broken white spherulite (3 mm in diameter) of variety II and colorless transparent crystals of variety I. I. V. Pekov collection; N. A. Pekova photo.**

In other aspects (except for the unusual band at 901.5 cm^{-1}), the IR spectrum of podlesnoite is close to the spectra of aragonite-group minerals. The greatest similarity is with the spectrum of strontianite (Fig. 12b), and that is probably related to the fact that, by the mean atomic mass and the mean ionic radius, the combination ($BaCa_2$) is close to (Sr_3). The observed splitting of the bands in the IR spectrum of podlesnoite is one of its diagnostic characteristics.

CHEMICAL COMPOSITION AND CHEMICAL PROPERTIES

The contents of cations and fluorine in podlesnoite were determined using electron microprobe in WDS mode via a Camebax SX 100 instrument, at an accelerating voltage of 15 kV and beam current of 15 nA; the electron beam was rastered over an area of 5×5 μm^2. The standards used were: albite (Na), microcline (K), andradite (Ca, Fe), $SrSO_4$ (Sr), $BaSO_4$ (Ba), $MnTiO_3$ (Mn), fluorapatite (F). CO_2 content was determined using the selective absorption method: heating to 1000°C under oxygen stream with CO_2 absorption in pipes filled with "ascarite," an asbestiform material saturated with NaOH.

The chemical composition of podlesnoite (wt.%, averaged values for cations and F from 8 point analyses; ranges are in parentheses) is: Na_2O 0.11 (0.0–0.2), K_2O 0.05 (0.0–0.1), CaO 29.02 (28.3–30.1), SrO 0.13 (0.0–0.2), BaO 40.77 (40.0–41.6), MnO 0.07 (0.0–0.15), FeO 0.25 (0.1–0.4), CO_2 22.9, F 9.95 (9.8–10.2), $-O = F_2$ 4.19, total 99.06. Contents of Mg, Pb, Y, lanthanides, Al, Si and Cl are below detection limits. Absence of H_2O in the mineral is confirmed by the IR spectrum and structural data.

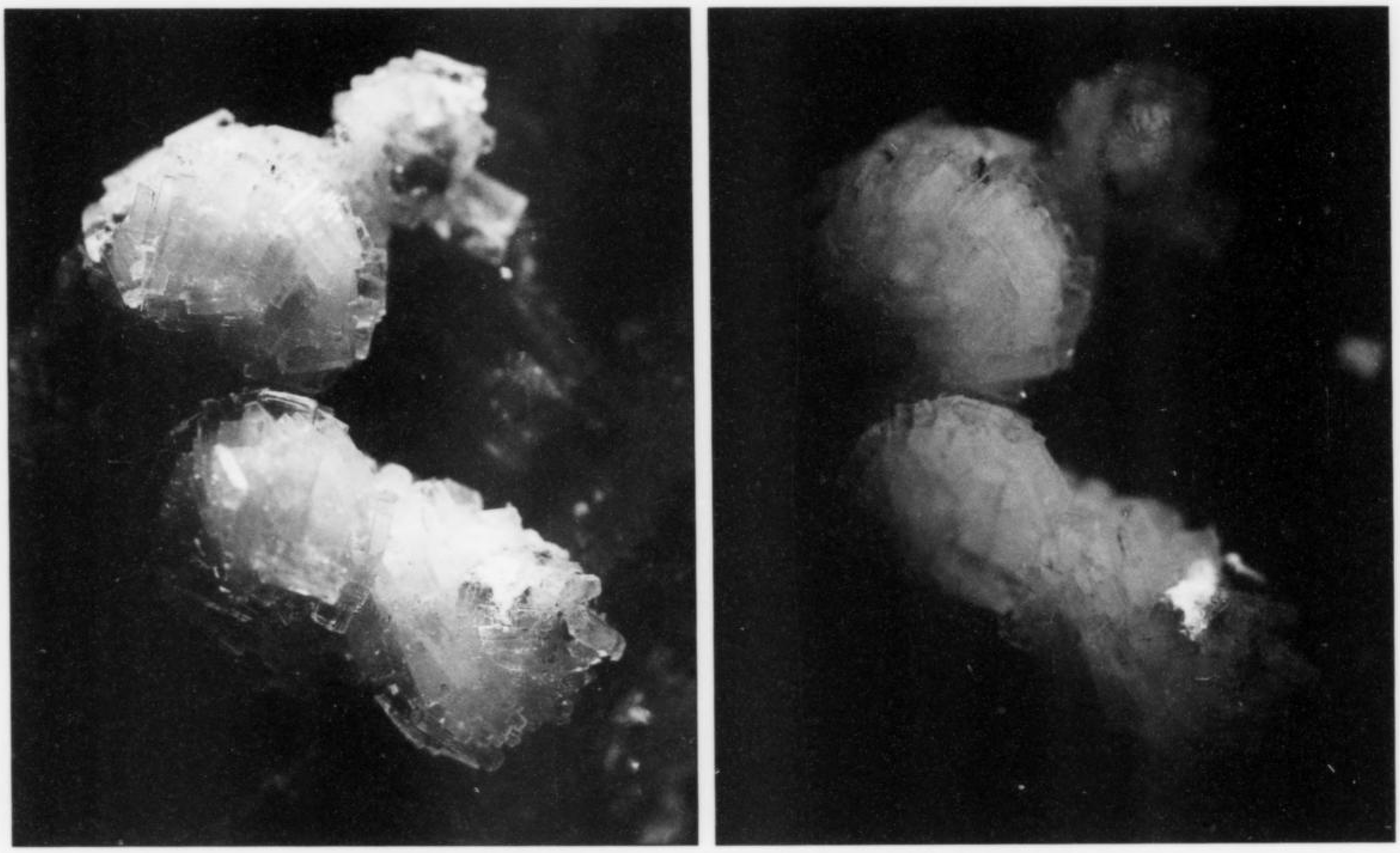

Figure 8. **Podlesnoite spherules (the largest is 5 mm in diameter) consisting of a variety II radial core and a crust of variety I crystals, on natrolite: (*a*) in ordinary light, (*b*) in shortwave ultraviolet light. A. S. Podlesnyi collection; N. A. Pekova photo. The difference in the fluorescence color of podlesnoite varieties I and II is well-demonstrated on a broken combined spherule.**

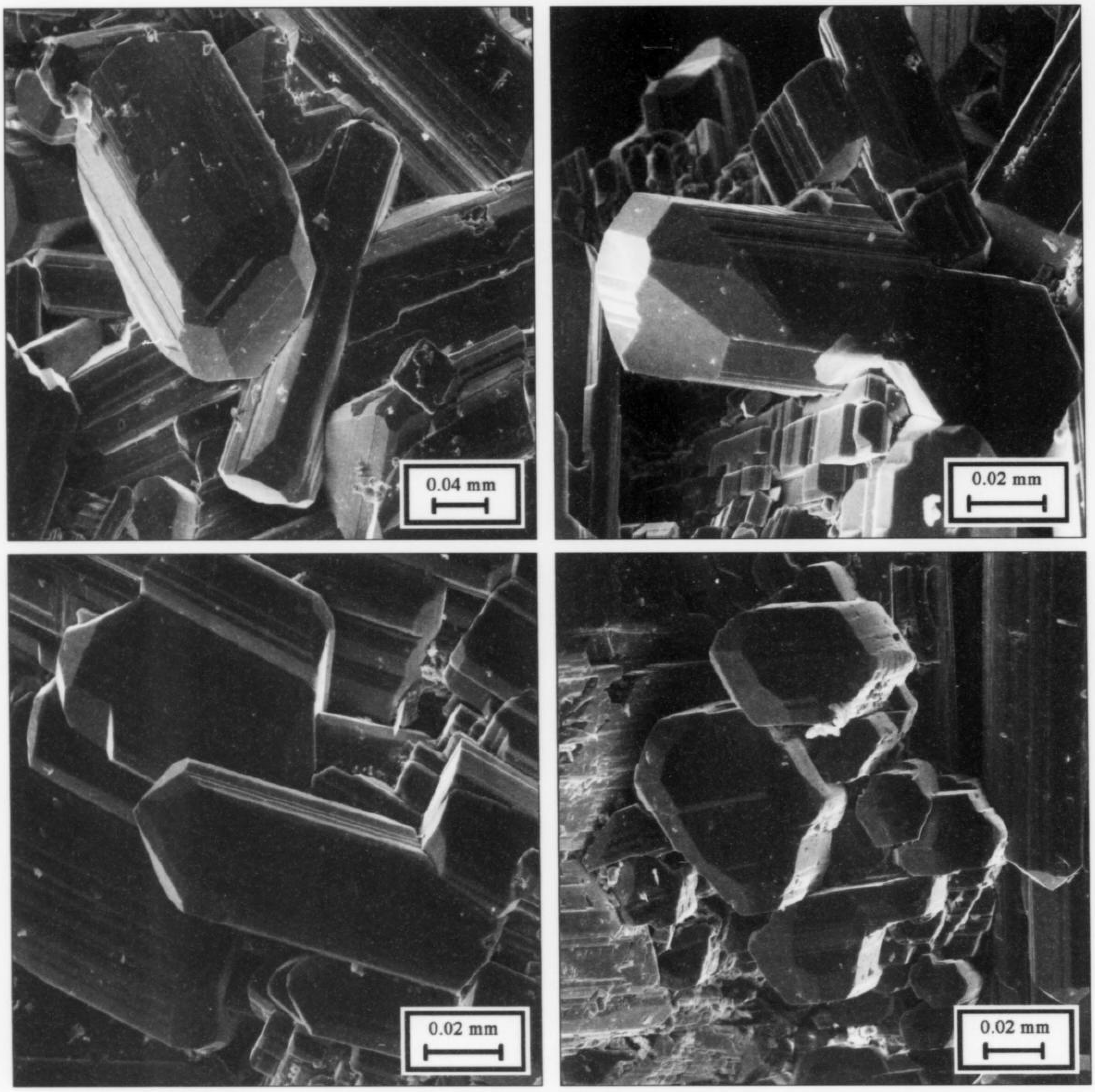

Figure 9. **Podlesnoite crystals (*a–c*) and parallel intergrowth (*d*). I. V. Pekov collection and SEM photo.**

The empirical formula of podlesnoite calculated on the basis of six oxygens is:

$$Ba_{1.02}(Ca_{1.98}Fe_{0.01}Na_{0.01}Sr_{0.005})_{\Sigma 2.005}C_{1.99}O_6F_{2.00}.$$

The idealized formula is:

$$BaCa_2(CO_3)_2F_2$$

. . . which requires CaO 29.87, BaO 40.83, CO_2 23.44, F 10.12, $-O = F_2$ 4.26, total 100.00 wt.%. Thus the chemical composition of the new mineral as determined by analysis is very close to the ideal composition. No chemical zoning in the crystals was observed.

Crystals of podlesnoite dissolve slowly in both concentrated and dilute HCl at room temperature with very weak effervescence, whereas a fine powder of the mineral under the same conditions easily dissolves in both concentrated and dilute HCl with strong effervescence.

X-RAY CRYSTALLOGRAPHY AND CRYSTAL STRUCTURE FEATURES

The X-ray single-crystal diffraction data of podlesnoite were obtained using an Xcalibur S diffractometer equipped with a CCD detector and Mo$K\alpha$-radiation. The new mineral is orthorhombic, with space group *Cmcm*. Unit cell dimensions are: a = 12.501(8), b = 5.846(3), c = 9.443(5) Å, V = 690.1(7) Å^3, Z = 4.

The X-ray powder diffraction data (Table 2) were obtained using a STOE STADI MP diffractometer equipped with a PSD detector and Ge-monochromatized Cu$K\alpha_1$-radiation. Unit cell dimensions refined from powder data are: a = 12.511(5), b = 5.857(2), c = 9.446(4) Å, V = 692.2(8) Å^3, Z = 4.

The axial ratios calculated from unit cell data are: $a : b : c$ = 2.1361 : 1 : 1.6128. These values are close to the ones calculated from goniometric data (Table 1): $a : b : c$ = 2.1290 : 1 : 1.5854.

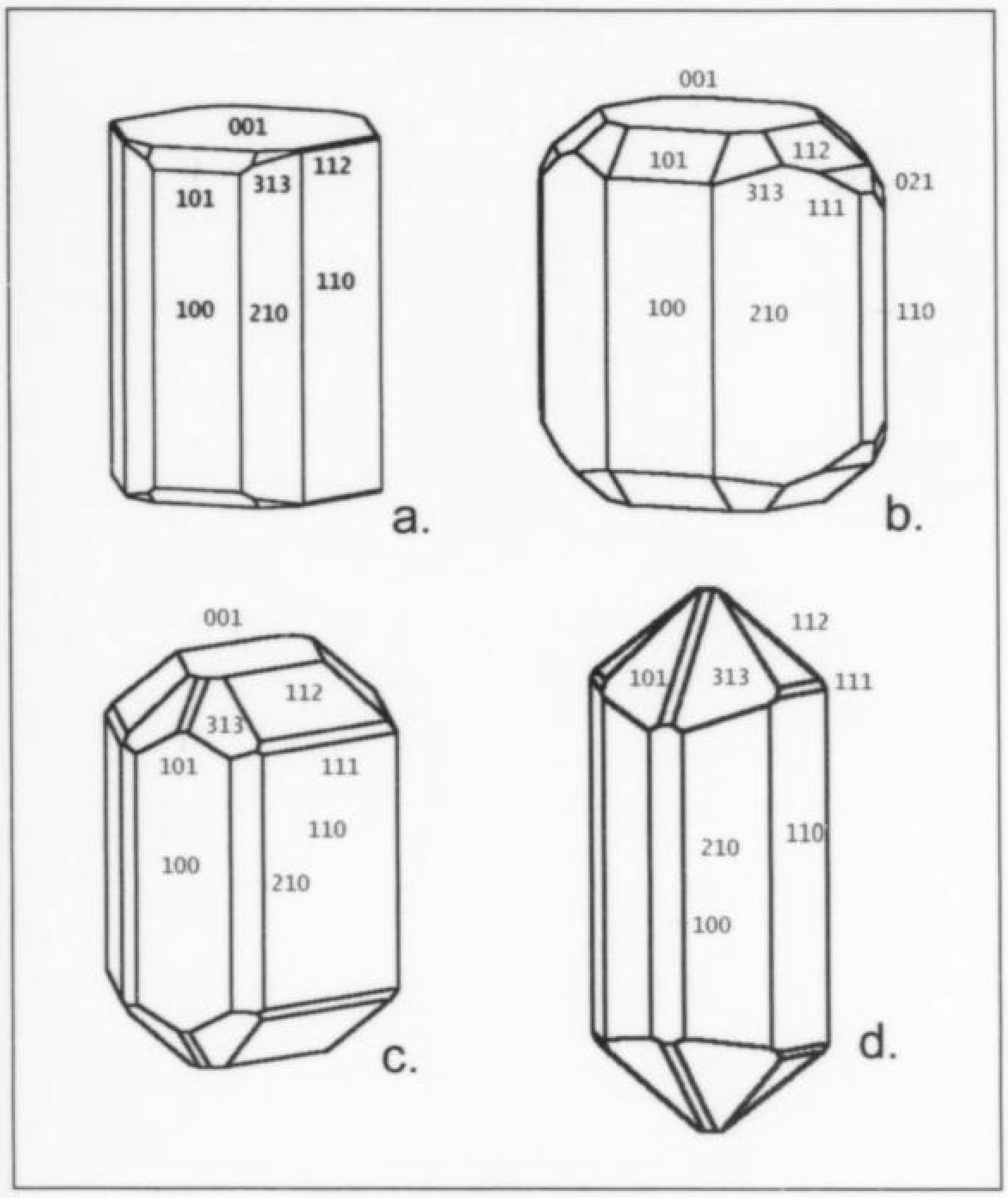

Figure 10. **Podlesnoite crystal drawings: (*a*) typical crystal, (*b–d*) rarely observed crystals.**

Table 1. **Crystal forms of podlesnoite (class *mmm*).**

Forms	*Spherical coordinates*			
	measured		*calculated*	
	φ	ρ	φ	ρ
{001}	—	0.0°	—	0°
{100}	90.0°	90.0°	90°	90°
{110}	25.2°	90.0°	25.09	90°
{210}	43.2°	90.0°	43.12°	90°
{101}	90.0°	36.7°	90°	37.05°
{021}	0.0°	72.6°	0°	72.78°
{111}	25.2°	60.0°	25.09°	60.68°
{112}	25.2°	41.1°	25.09°	41.68°
{313}	54.5°	42.7°	54.55°	42.83°

NOTE: data averaged for 3 crystals. Standard deviations are ±0.1° for faces {001}, {100}, {110}, {210}, {021}, and {313} and ±0.2° for faces {101}, {111}, and {112}.

From goniometric data, $a : b : c = 2.1290 : 1 : 1.5854$.

The X-ray powder diffraction pattern of podlesnoite is unique and constitutes an unambiguous diagnostic characteristic.

The crystal structure of podlesnoite was studied on a single crystal, $R_F = 2.78\%$. It has been described in a separate publication (Zubkova *et al.*, 2007). Podlesnoite is a representative of a new structural type; there are no known closely related minerals or synthetic compounds.

The base of the crystal structure of podlesnoite (Fig. 13) is a condensed framework consisting of columns of Ca-centered 8-fold polyhedra (CaO_6F_2) stretched along [001]. (CO_3) groups, coplanar to the *ac* plane, and large Ba atoms are located in cavities of the framework. Ba atoms center the 10-fold polyhedra (BaO_6F_4); F atoms center the tetrahedra (FCa_2Ba_2).

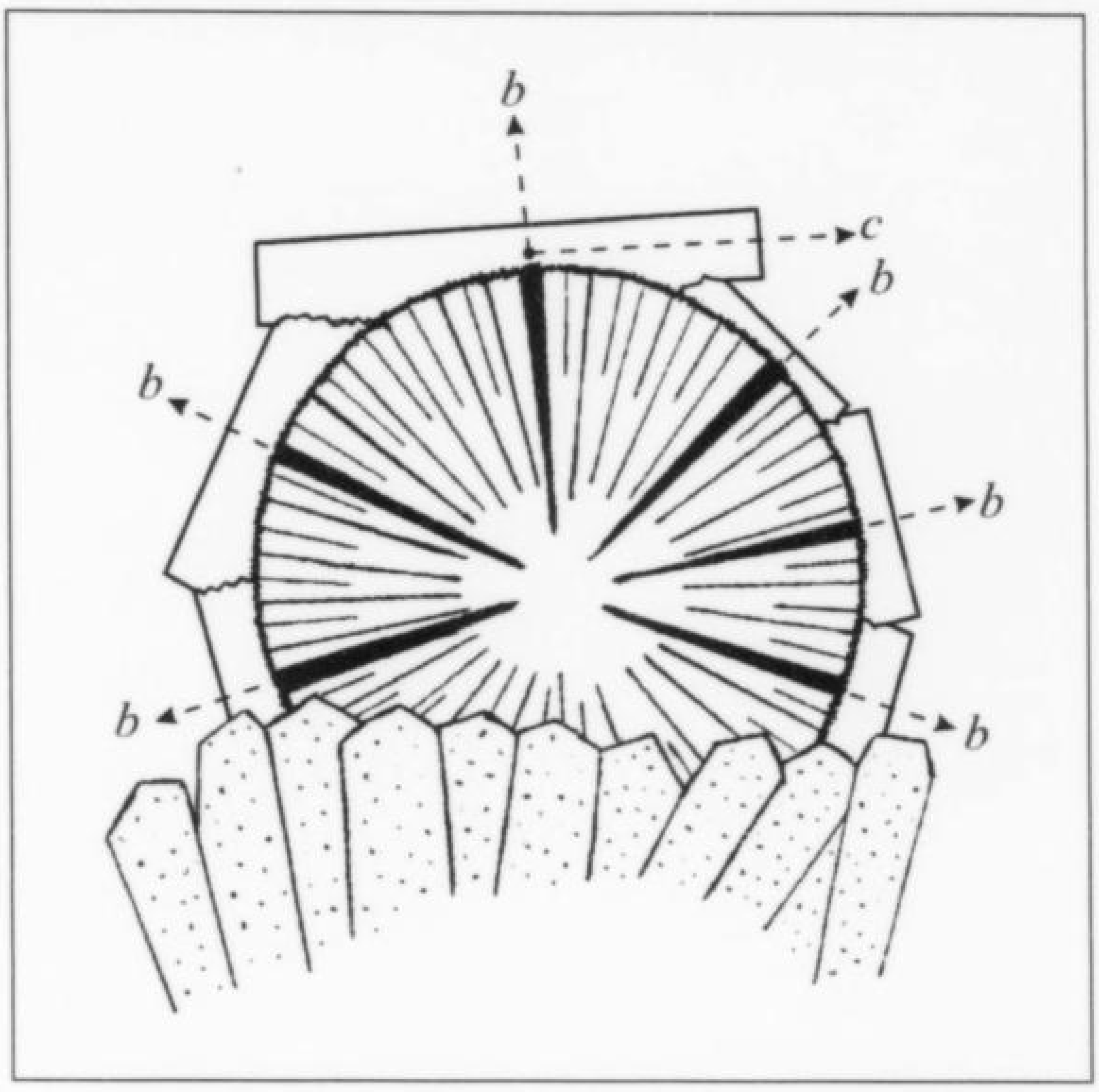

Figure 11. **Schematic drawing of an auto-epitactic intergrowth of two morphological varieties of podlesnoite: prismatic crystals of variety I overgrowing a radial spherulite of variety II with the same crystallographic orientation as the fibers of variety II. Underlying natrolite crystals are speckled.**

The podlesnoite structure is remotely related to that of minerals of the aragonite group, and can be regarded as a derivative of the aragonite-type structure. Transition from aragonite to podlesnoite can be described as an ordered substitution of ⅓ Ca cations by larger Ba cations and ⅓ (CO_3) groups by pairs of F atoms: $[3Ca] + [3(CO_3)] \rightarrow [2Ca + Ba] + [2(CO_3) + 2F]$. This transformation means a change of the cation-to-anion ratio (from 1 : 1 in aragonite to 3 : 4 in podlesnoite) and leads to very significant structural changes (Fig. 14). As a result, aragonite-group minerals and podlesnoite strongly differ in symmetry, unit cell dimensions and X-ray powder diffraction patterns. However, short-range order interactions between (CO_3) groups and cations in podlesnoite and aragonite-group minerals are not so different, resulting in the close similarity of their IR spectra.

DISCUSSION

Previous to this description of podlesnoite, 27 fluorocarbonate minerals were known. Nineteen of them contain essential rare-earth elements (*REE*), *i.e.* lanthanides or yttrium. Among them, members of the vaterite $CaCO_3$—bastnäsite *REE*(CO_3)F polysomatic family and topologically related Ba,*REE* and Na,*REE* carbonates prevail (17 species); there are minerals without the M^{2+} cations: bastnäsite-(Ce), bastnäsite-(La), bastnäsite-(Y); Ca,*REE* minerals: synchysite-(Ce), synchysite-(La), synchysite-(Y), parisite-(Ce), parisite-(Nd), röntgenite-(Ce); Ba,*REE* minerals: cordylite-(Ce), huanghoite-(Ce), cebaite-(Ce), zhonghuacerite-(Ce), kukharenkoite-(Ce), kukharenkoite-(La), qaqarssukite-(Ce); and an Na,*REE* mineral: lukechangite-(Ce). Horváthite-(Y) and mineevite-(Y) have different structures. The Ca-Th-fluorocarbonate thorbastnäsite is structurally related to the vaterite-bastnäsite family of minerals. Other natural fluorocarbonates include hydrous minerals with uranyl cations (schröckingerite and albrechtschraufite), sodium minerals with Ca (sheldrickite and rouvilleite) or Al (barentsite), a Ca-Bi mineral (kettnerite) and the Ca mineral brenkite. Podlesnoite is

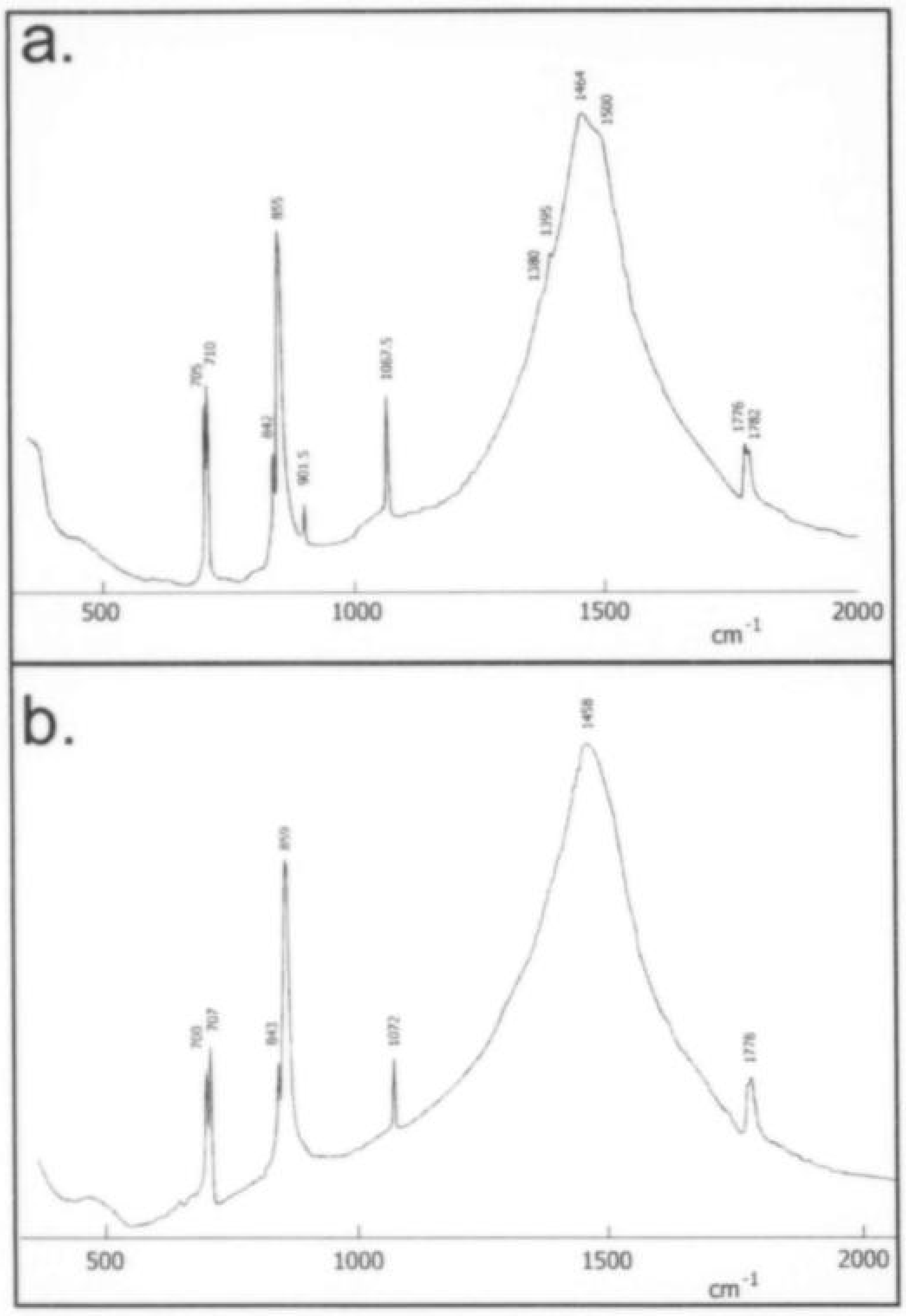

***Figure 12.* Infrared spectrum of podlesnoite from the Kirovskii mine (*a*) and strontianite from Vishnevye Gory, South Urals, Russia (*b*).**

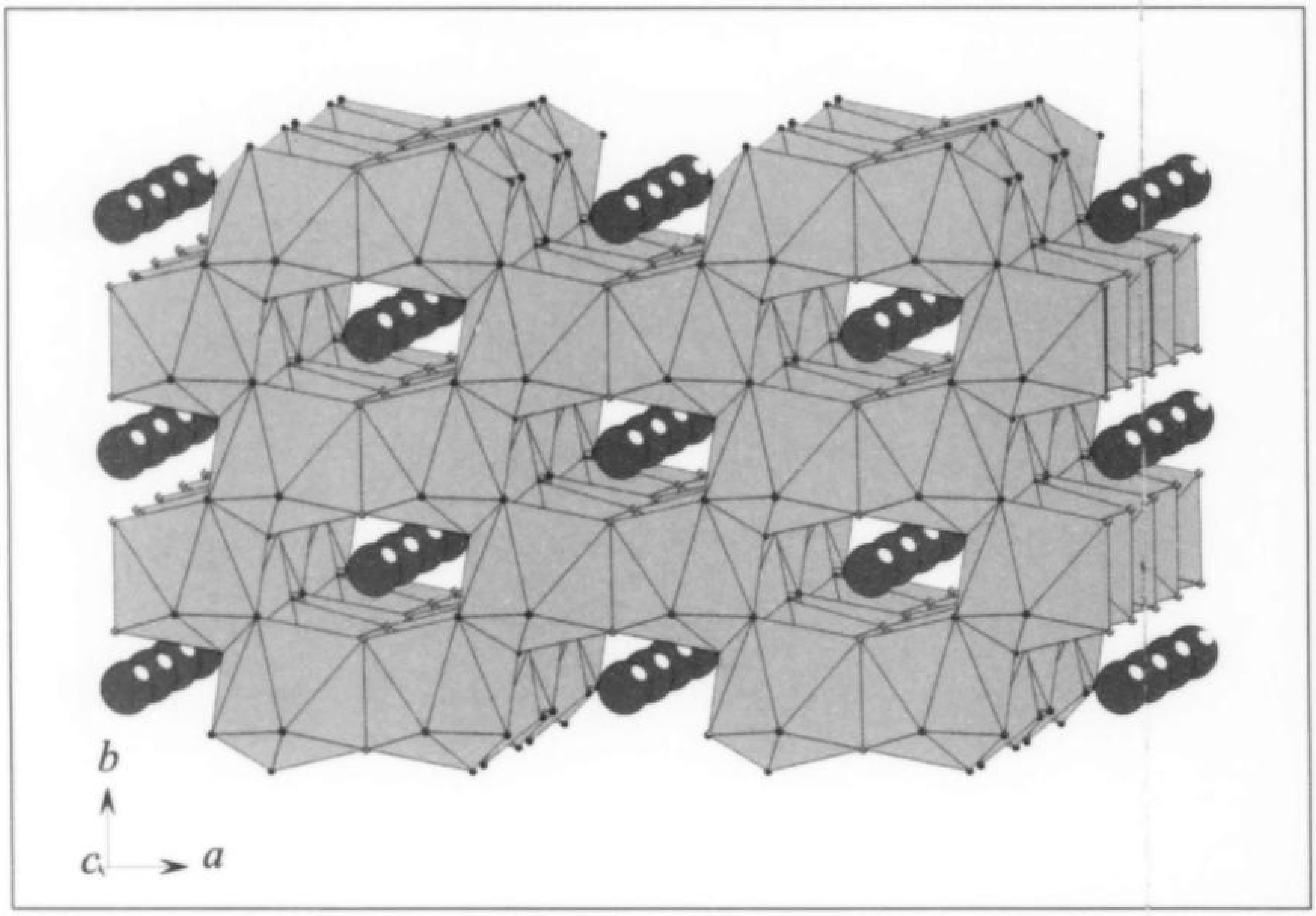

***Figure 13.* A condensed framework, consisting of (CaO_6F_2) polyhedra, and chains of Ba atoms in the crystal structure of podlesnoite. Ca-centered polyhedra are blue, Ba atoms are large red circles, F atoms are small green circles, and O atoms are small black circles.**

only the second (after brenkite, $Ca_2(CO_3)F_2$) natural fluorocarbonate containing only alkaline-earth cations.

Thus, the majority of the known natural fluorocarbonates contain essential *REE* and have hexagonal (trigonal) or pseudo-hexagonal layered structures related to the structure of vaterite, a hexagonal modification of $CaCO_3$. Some of these minerals are widespread; in particular, bastnäsite-(Ce) is the main ore mineral of the world's largest rare-earth deposits at Bayan Obo (Inner Mongolia, China) and Mountain Pass (California, U.S.A.). The crystal structures of these minerals are based on regularly interstratified vaterite-like MCO_3 (M = Ca, Ba or Na_2) and bastnäsite-like $REE(CO_3)(F,OH)$ layer modules (polysomes) (Donnay and Donnay, 1953; Ni *et al.*, 1993; Yang *et al.*, 1996; Grice and Chao, 1997). The ratio of different modules (layers) generates the *c* parameter of the hexagonal unit cell (or pseudo-cell) and, correspondingly, determines the mineral species or series. Diversity and wide distribution of vaterite-bastnäsite family members in nature show that these minerals easily "adapt" to different mineral-forming conditions, primarily driven by the chemistry of the crystallizing fluid; polysomatism is likely the most important factor in this adaptive behavior.

Carbonates with structures related to that of aragonite, an orthorhombic modification of $CaCO_3$, are already known in nature. These are ancylite-group members: orthorhombic and monoclinic minerals with general formula: $M^{2+}_{2-x}REE_x(CO_3)_2(OH)_x{\cdot}nH_2O$ (M = Sr, Ca, Pb, x = 0.9–2, n = 0–1). It was considered even recently that only ancylites with the M^{2+} cations [Sr: ancylite-(Ce), -(La); Ca: calcio-ancylite-(Ce), -(Nd); Pb: gysinite-(Nd)] exist in nature. However, several years ago the *REE* representatives of the ancylite group without the M^{2+} cations, namely kozoite-(Nd) and kozoite-(La), were discovered (Miyawaki *et al.*, 2003). They are natural analogs of earlier known (Sawyer *et al.*, 1973) synthetic ancylite-like compounds $REE(CO_3)(OH)$. Unlike vaterite-bastnäsite polysomatic family minerals with strictly ordered M^{2+} and REE^{3+} cations, ancylite-group members show disorder (Dal Negro *et al.*, 1975; Belovitskaya *et al.*, 2002) or weak order (Orlandi *et al.*, 1990) of M^{2+} and REE^{3+} cations. Thus, ancylites, calcio-ancylites and gysinite can be presented as intermediate members of the solid-solution series with the end-members $M^{2+}CO_3$ (aragonite-group minerals with M = Ca, Sr, Pb) and $REE(CO_3)(OH)$ (kozoite).

The path of transition from aragonite to podlesnoite is quite different from that of aragonite to ancylite (Fig. 14). Unlike ancylite, the cation/anion ratio in podlesnoite is 3:4, Ca and Ba cations are strictly ordered, and all (CO_3) triangular groups are coplanar with the *ac* plane. The geometric characteristics of both cation and anion sub-lattices in aragonite, podlesnoite and ancylite are different (Fig. 14).

Ca,*REE* members of the vaterite-bastnäsite polysomatic family are represented by parisites, $CaREE_2(CO_3)_3F_2$, röntgenite, $Ca_2REE_3(CO_3)_5F_3$, and synchysites, $CaREE(CO_3)_2F$. Ca/*REE* ratios in them are 0.5, 0.67 and 1.0 respectively, *i.e.* cation compositions

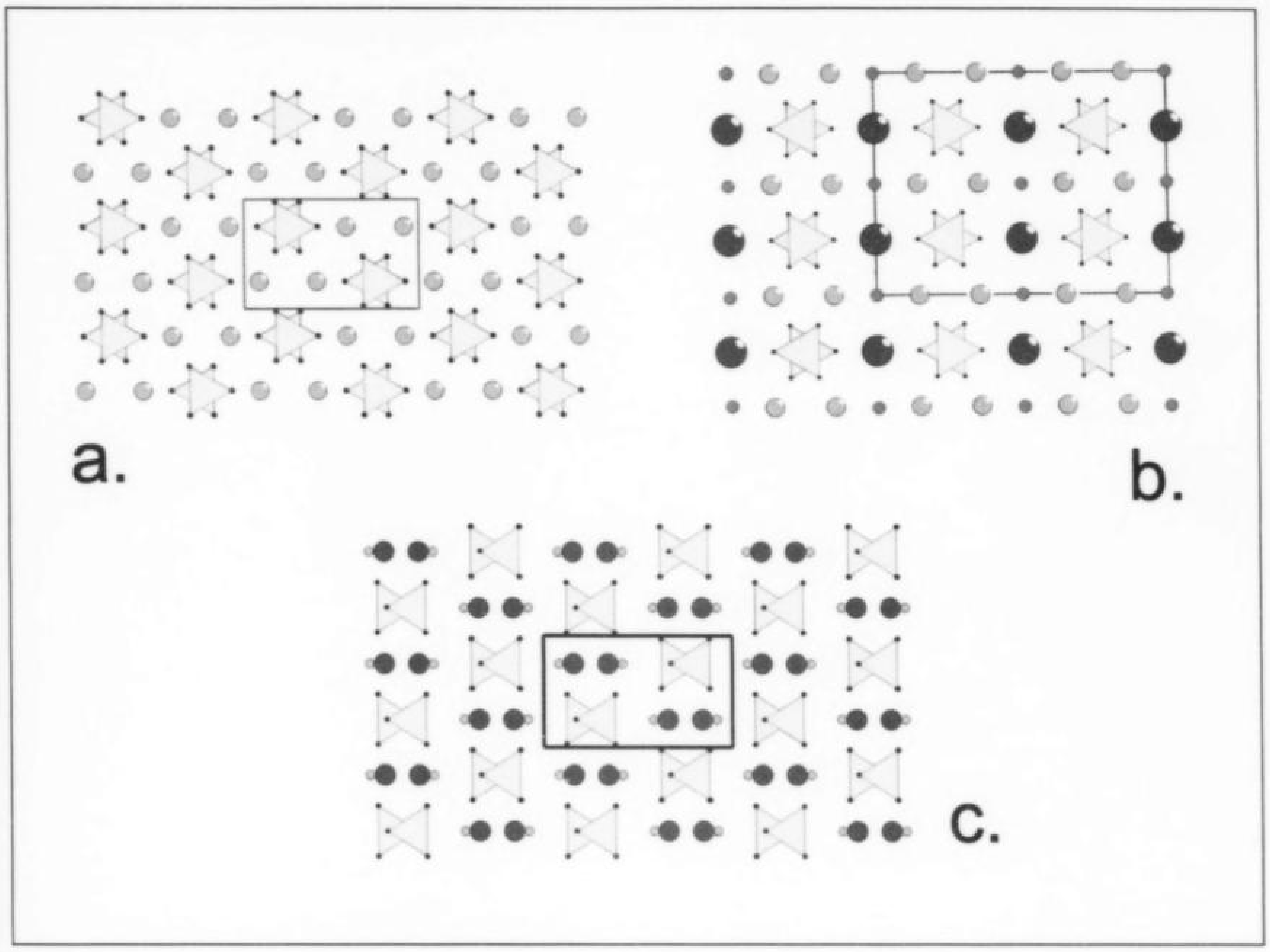

Figure 14. **Crystal structures of aragonite (*a*), podlesnoite (*b*) and ancylite (*c*). (CO_3) groups are yellow triangles, other atoms and groups are circles: Ca–blue, Ba–red, F–green, (Sr,*REE*)–magenta, (OH,H_2O)–gray, O–small black. Podlesnoite data from this study; aragonite data from Jarosch and Heger (1986); ancylite data from Belovitskaya *et al.* (2002).**

Table 2. **X-ray powder diffraction data for podlesnoite.**

NOTE: I_{calc} values were calculated from structural data.

I_{meas}	d_{meas}, Å	I_{calc}	d_{calc}, Å	*hkl*
11	6.250	9	6.255	200
21	5.303	20	5.304	110
13	4.733	8	4.723	002
16	3.771	11	3.769	202
100	3.527	100	3.527	112
71	3.397	61	3.397	310
10	3.125	8	3.128	400
9	2.928	9	2.928	020
10	2.797	9	2.797	021
11	2.757	8	2.758	312
9	2.653	8	2.652	220
20	2.609	18	2.608	402
3	2.552	5	2.553	221
5	2.492	3	2.489	022
15	2.364	16	2.362	004
43	2.313	41	2.313	222
22	2.302	15	2.301	510
2	2.234	2	2.236	511
20	2.211	12	2.209	204
4	2.160	2	2.157	114
12	2.085	11	2.085	600
15	2.069	12	2.069	512
39	1.948	32	1.948	422
40	1.940	35	1.939	314
4	1.927	2	1.929	130
10	1.839	9	1.838	024
18	1.786	15	1.786	132
11	1.768	12	1.768	330
5	1.698	4	1.699	620
3	1.651	1	1.651	315
6	1.649	4	1.648	514
12	1.607	11	1.607	712
7	1.598	3	1.598	622
10	1.564	3, 6	1.564, 1.563	800, 604
4	1.527	2	1.527	206
9	1.510	7	1.509	116
7	1.4638	2, 2	1.4642, 1.4635	040, 532
3	1.4252	1	1.4284	316
5	1.4159	5	1.4154	334
3	1.4073	2	1.4062	406
6	1.3793	2, 5	1.3795, 1.3789	820, 624
2	1.3653	3	1.3649	242
7	1.3537	5	1.3538	226
5	1.3042	5	1.3039	804
4	1.3003	1, 2	1.3003, 1.2993	912, 516
6	1.2898	5	1.2895	534
5	1.2770	4	1.2768	442
10	1.2692	6, 6	1.2698, 1.2677	732, 426
4	1.2441	3	1.2444	044
6	1.2205	2, 4	1.2205, 1.2197	244, 136
7	1.1589	4	1.1581	716
7	1.1174	4, 2, 3	1.1178, 1.1165, 1.1153	10.2.2, 11.1.0, 318

of all these minerals lie inside the M^{2+}/REE interval typical for ancylite-group members (Pekov *et al.*, 1997). Thus, hypothetical hydroxyl-dominant analogs of these minerals can be considered as cation-ordered dimorphs of calcio-ancylite with different cation compositions. OH-dominant analogs of synchysite, parisite and röntgenite are not known for certain in nature, whereas OH>F in all ancylite-group minerals; fluorine is a minor admixture, but not an essential constituent in them (Pekov *et al.*, 1997). This constraint is likely caused by the fact that (OH) groups form strong hydrogen bonds in ancylites (see Belovitskaya *et al.*, 2002) that hampers their substitution by F atoms. Thus, cation-ordered modifications are more stable for Ca,*REE* fluorocarbonates unlike Ca,*REE* and Sr,*REE* hydroxycarbonates for which cation-disordered modifications are more stable. This is confirmed by the existence of close paragenetic associations of ancylite-group minerals with synchysite, as demonstrated at Khibiny, Vuoriyarvi (North Karelia, Russia), Narssarssuk (South Greenland) and some other alkaline complexes.

Barium, the largest of the alkaline-earth cations (except Ra), is known in ancylite-group minerals as only a minor admixture, probably the result of the large difference in ionic radii of Ba^{2+} and REE^{3+}. However, seven natural Ba,*REE* fluorocarbonates with layered bastnäsite-like structures (see above) are known in nature. In these minerals, the Ba and *REE* cations are ordered, like Ca and *REE* in parisite, synchysite and röntgenite, whereas Sr,*REE* carbonates with bastnäsite-like structures are unknown.

Podlesnoite, like Ba,*REE* and Ca,*REE* fluorocarbonates, demonstrates strict cation ordering, a strong affinity to fluorine, and insignificant isomorphism of both barium and calcium with strontium.

The chemical formula of podlesnoite, $BaCa_2(CO_3)_2F_2$, can be rendered as $BaCa(CO_3)_2 \cdot CaF_2$. Barytocalcite, $BaCa(CO_3)_2$, and fluorite, CaF_2, are closely associated with podlesnoite. Barytocalcite was formed earlier than the new mineral, whereas fluorite was formed later. The crystallization of podlesnoite probably took place in conjunction with a decrease of Ba concentration in the hydrothermal solution and a corresponding increase in F concentration. Association of barytocalcite and its polymorphous modifications, alstonite and paralstonite, with fluorite is well-known at numerous localities, whereas the first known barium-calcium fluorocarbonate in nature is podlesnoite, and its synthetic analog has yet to be produced. This is probably an indication that the stability field of podlesnoite is quite narrow, and that its formation is possible only under very restricted conditions.

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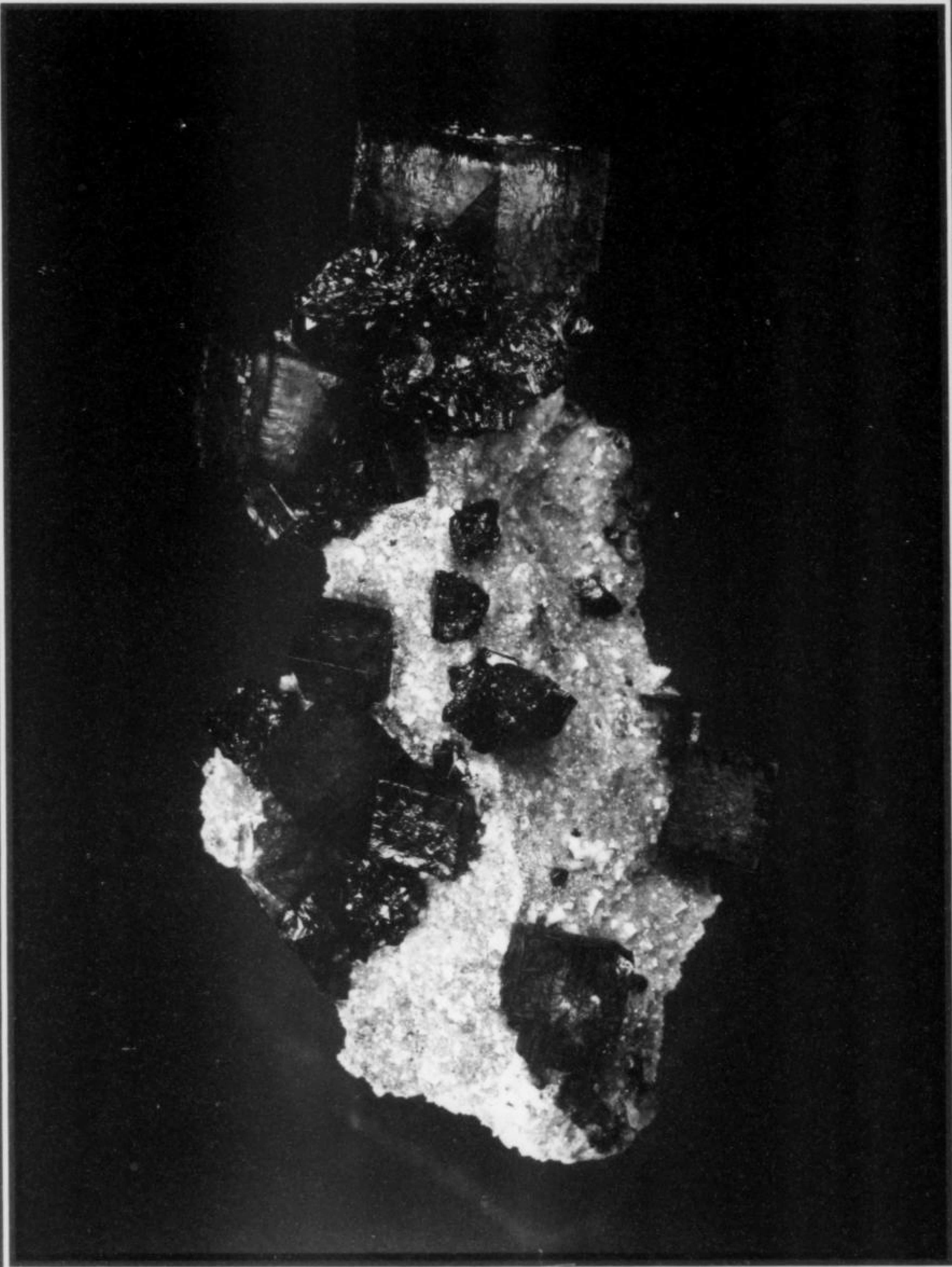

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Fragile Minerals and the TSA

Crocoite, scolecite, mesolite, cerussite—such specimens and other fragile delicacies are highly desired by avid mineral collectors. Yet, they strike fear in the hearts of the stoutest among us when we contemplate how to get them home intact. We have all come across a superb specimen, attractively priced, but have nonetheless refrained because there was no easy way to get it home damage-free.

What if, however, you do decide to take that specimen home with you on a plane? And what if you carefully wrap it and loosely seal it in a box, with the intent of treating it as carry-on luggage? Of course, from the moment you embark on this course, your mind is dwelling on one thought, and one thought alone—those folks you will encounter at the airport with the badges and patches that say "Transportation Security Administration" or "TSA." And, in your darkest moments, perhaps you wonder what would happen if those friendly TSA folks accidentally gouged a hole smack in the middle of your prized crocoite. It has happened to people before, and it can happen again.

Of course, in the law, as in other walks of life, avoidance of a problem is often the best course. In this regard, the TSA website (www.tsa.gov) provides some helpful advice. It states that "[i]f you are carrying valuable items . . . we recommend that you ask Security Officers to screen you and your carry-on luggage in private," adding that this process may be initiated by contacting the TSA screening supervisor. Using this procedure also probably lessens the likelihood that a TSA security officer will view your specimen as a dangerous "projectile" that cannot be taken on the plane. By the way, the TSA website also contains a detailed list of prohibited carry-on items.

Perish the thought, but what if your specimen, in fact, is damaged during the inspection process? At this point, you will discover that pursuing a monetary claim against the United States Government is not quite like pursuing one against the corner grocer. The reason is that the United States is protected from lawsuits except to the extent that the Congress consents for it to be sued. That doctrine, known in the law as "sovereign immunity," dates back to the English monarchy. Yet, despite its monarchial roots, the doctirne was viewed as so well-established by the Founding Fathers as not to be debated, even for a moment, at the Constitutional Convention.

But, all is not lost. There is, in fact, a statute that potentially waives the sovereign immunity of the United States in a case involving your negligently damaged mineral specimen. It is the Federal Torts Claims Act (found in various provisions of Title 28 of the U.S. Code), a law with an interesting history. This statute was passed in 1946, approximately a year after a B-25 "Mitchell" bomber—the type of twin-engine plane used for the Doolittle raid on Tokyo—got lost in a blinding fog and crashed into the Empire State Building, 915 feet above street level, killing and injuring a number of individuals. Responding to this disaster, Congress passed a statute generally making the United States liable "for injury or loss of property" that is "caused by the negligent or wrongful act or omission of any employee of the Government," where "the United States, if a private person, would be liable to the claimant in accordance with the law of the place where the act or omission occurred."

So, what does this law mean? Under the statute, the United States is generally liable for the negligent acts of its employees to the same extent that a private person would be liable for those same acts under the law of the State in which the negligence occurred. So, if you are in the airport in Tucson, it is Arizona law that will preliminarily control whether the government is liable for negligence in gouging your crocoite.

Of course, nothing in the law, particularly when you are dealing with the United States, is that simple. For one thing, to recover under this statute, you have to file a written claim with the TSA, stating the circumstances of your loss and the exact amount you are claiming. And you must file this claim within two years of the incident. A copy of the claim form is available on the TSA website. Pay careful attention to the filing instructions, particularly the requirement that you claim a sum certain—that is, a specific dollar amount. With very limited exceptions, the figure you list on the form represents the maximum amount you can recover under the law, even if you are forced to pursue the matter in litigation. For this and other reasons, if your claim is going to be substantial, you may want to consult an attorney well-versed in the Federal Tort Claims Act to make sure that your claim is filed correctly. Mess up this preliminary step and you may later find, to your horror and chagrin, that you cannot recover at all.

The TSA has a Claims Management Office that processes these claims. The hope (and the reason why Congress established the claim procedure) is that this agency will either grant your claim or negotiate a reasonable settlement. If, however, TSA denies your claim or does not decide your claim within six months, then you have the right to file suit against the United States in the U.S. District Court for the district in which you live. If you get to this point, you should definitely consider hiring an attorney, as the United States will be defended in that lawsuit by attorneys from the U.S. Department of Justice that specialize in handling tort cases.

There are a variety of other statutory twists and turns that might affect your ability to recover here. For one thing, it is possible that the Justice Department will argue that the TSA's actions are covered by a statutory exception to the Federal Tort Claims Act, perhaps the one that exempts from coverage claims arising from the detention of goods by a law-enforcement officer. However, a "Dear Traveler" message posted on the TSA website from the Director of the TSA's Claims Management Office appears to admit that the agency is responsible if loss or damage to your property is directly caused by the negligence of a TSA employee. (The lawyers among you might want to read *Kosak v. United States*, 465 U.S. 848 (1984), in which the Supreme Court held that the U.S. Customs Service could be liable for damaging artworks.) Remember also that your recovery may be affected by nuances in the law of the state in which the negligence occurred (in our example above, Arizona). Finally, recognize that the Federal Tort Claims Act does not allow for the recovery of certain types of damages, among them punitive damages and pre-judgment interest on the amount of your loss. So do not expect a bonanza at the government's expense.

The bottom line is that Congress has created a potential legal path for you to recover damages against the United States if, despite your best efforts to avoid the problem, the TSA folks convert your cabinet specimen into hundreds of micromounts. Happy flying.

NOTE: ***This column is for educational purposes only and is not legal advice, or a substitute for such advice. Readers who have questions on this topic should consult with a qualified lawyer.***

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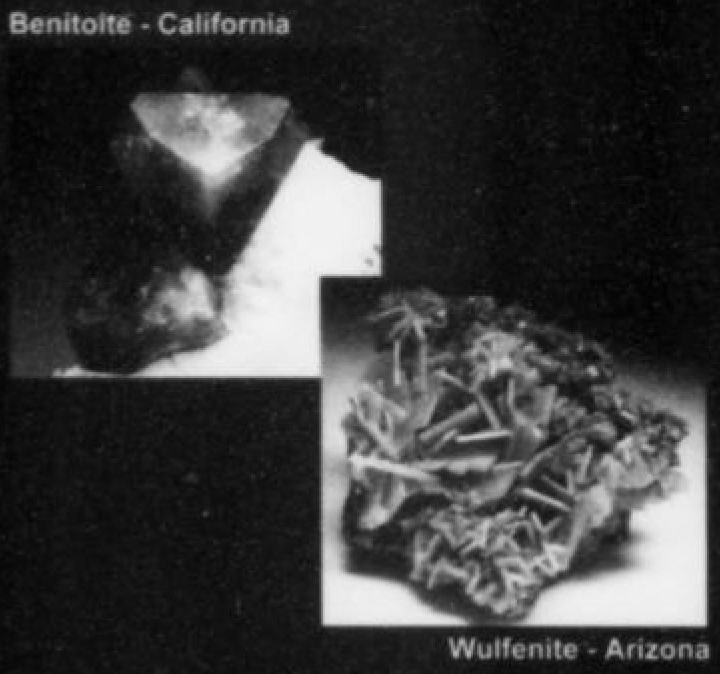
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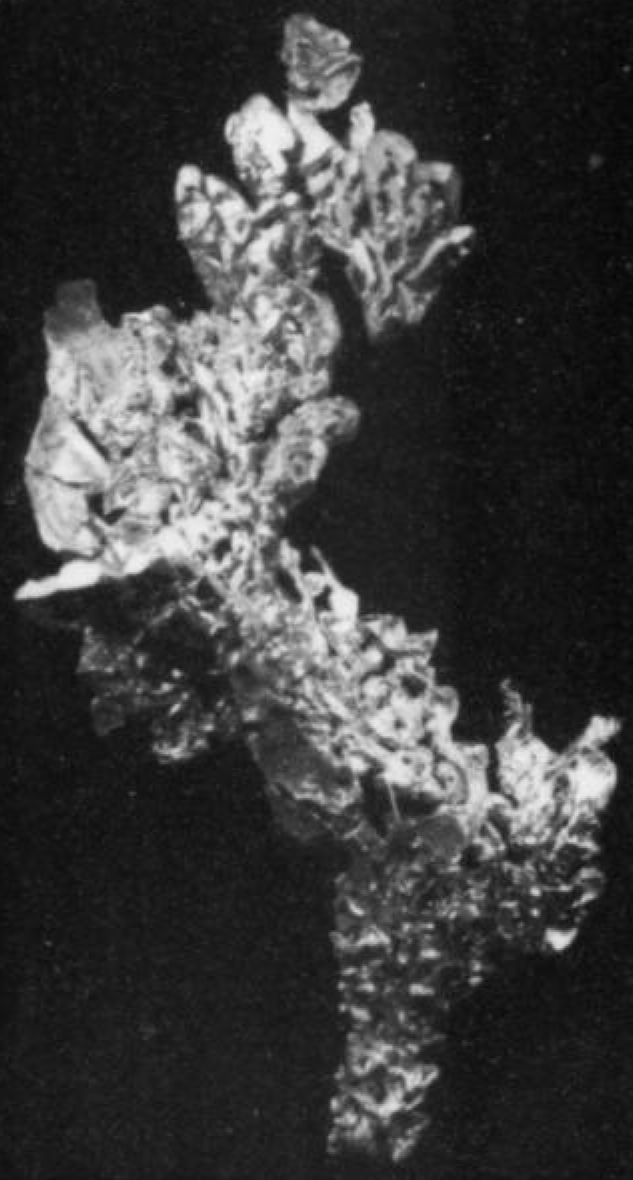

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Golden, Colorado 80401
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E-mail: robinson@mtu.edu
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Hours: 9–4 Tues.–Fri., 11–4 Sat. (Daylight Savings Time)
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Website: http://mines.unr/edu/museum
Mackay School of Earth Science & Engineering
University of Nevada, **Reno,** NV 89557
Hours: 9–4 Mon.–Fri. (closed university holidays) and by appointment
Specialty: Comstock ores, worldwide minerals, mining artifacts, Mackay silver

New Mexico Bureau of Mines & Mineral Resources—Mineral Museum

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E-mail: vwlueth@nmt.edu
Fax: (505) 835-6333
Associate Curator: Robert Eveleth
Tel: (505) 835-5325
E-mail: beveleth@gis.nmt.edu
New Mexico Tech,
801 Leroy Place
Socorro, NM 87801
Hours: 8–5 M–F, 10–3 Sat., Sun
Specialties: New Mexico minerals, mining artifacts, worldwide minerals

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Fax: (520) 883-2500
Website: http://www.desertmuseum.org
Curator, Mineralogy: Anna M. Domitrovic
Tel: (520) 883-3033
E-mail: adomitrovic@desertmuseum.org
2021 N. Kinney Road
Tucson, AZ 85743-8918
Hours: 8:30-5 Daily (Oct.-Feb.)
7:30-5 Daily (Mar.-Sept.)
Specialty: Arizona minerals

U.S. National Museum of Natural History (Smithsonian Institution)

Curator: Dr. Jeffrey E. Post
E-mail: minerals@nmnh.si.edu
Collection Managers: Paul Pohwat and Russell Feather
(Dept. of Mineral Sciences)
Washington, DC 20560-0119
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Fax: +39 02 8846 3281
E-Mail: Federico.Pezzotta@comune.miland.it
Department of Mineralogy and Petrography
Corso Venezia, 55
I-20121 **Milano,** Italy
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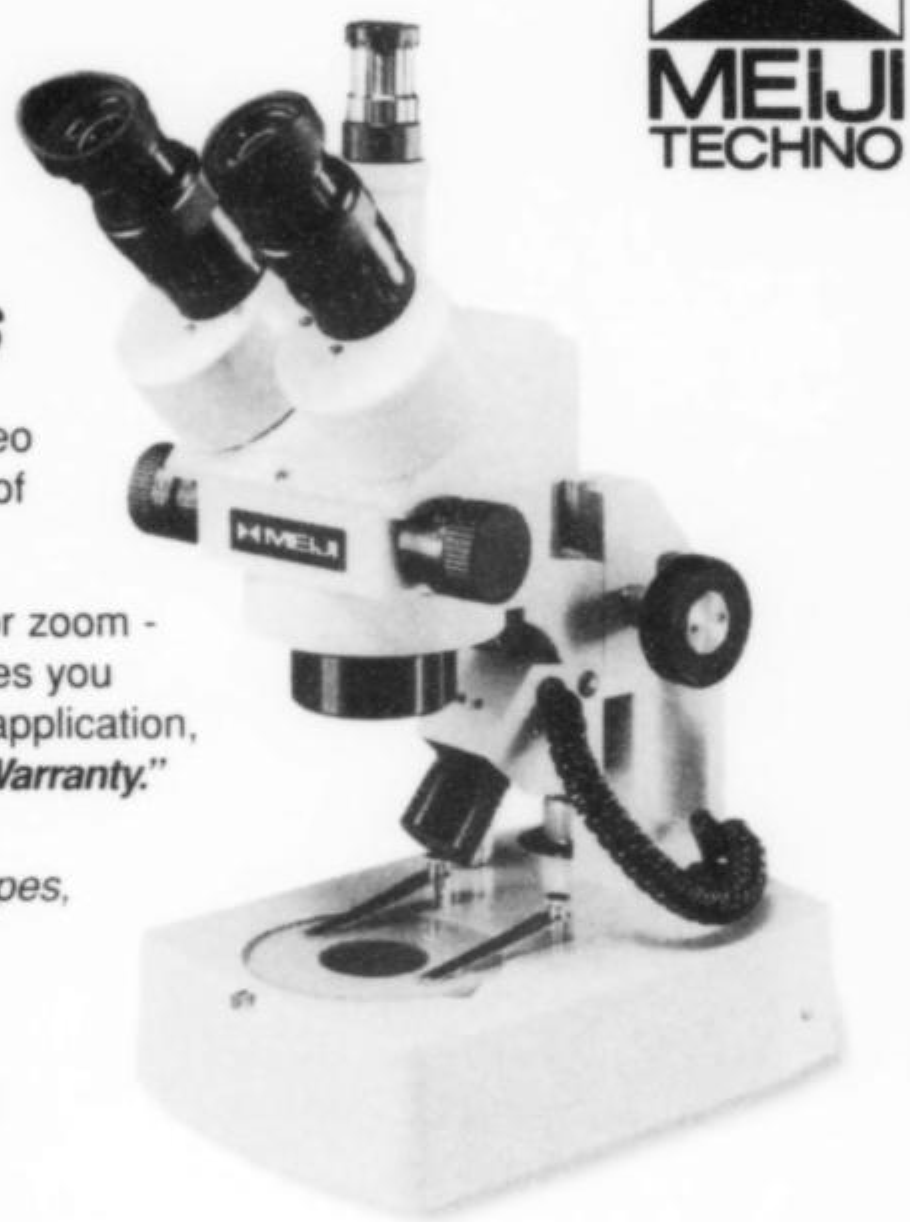
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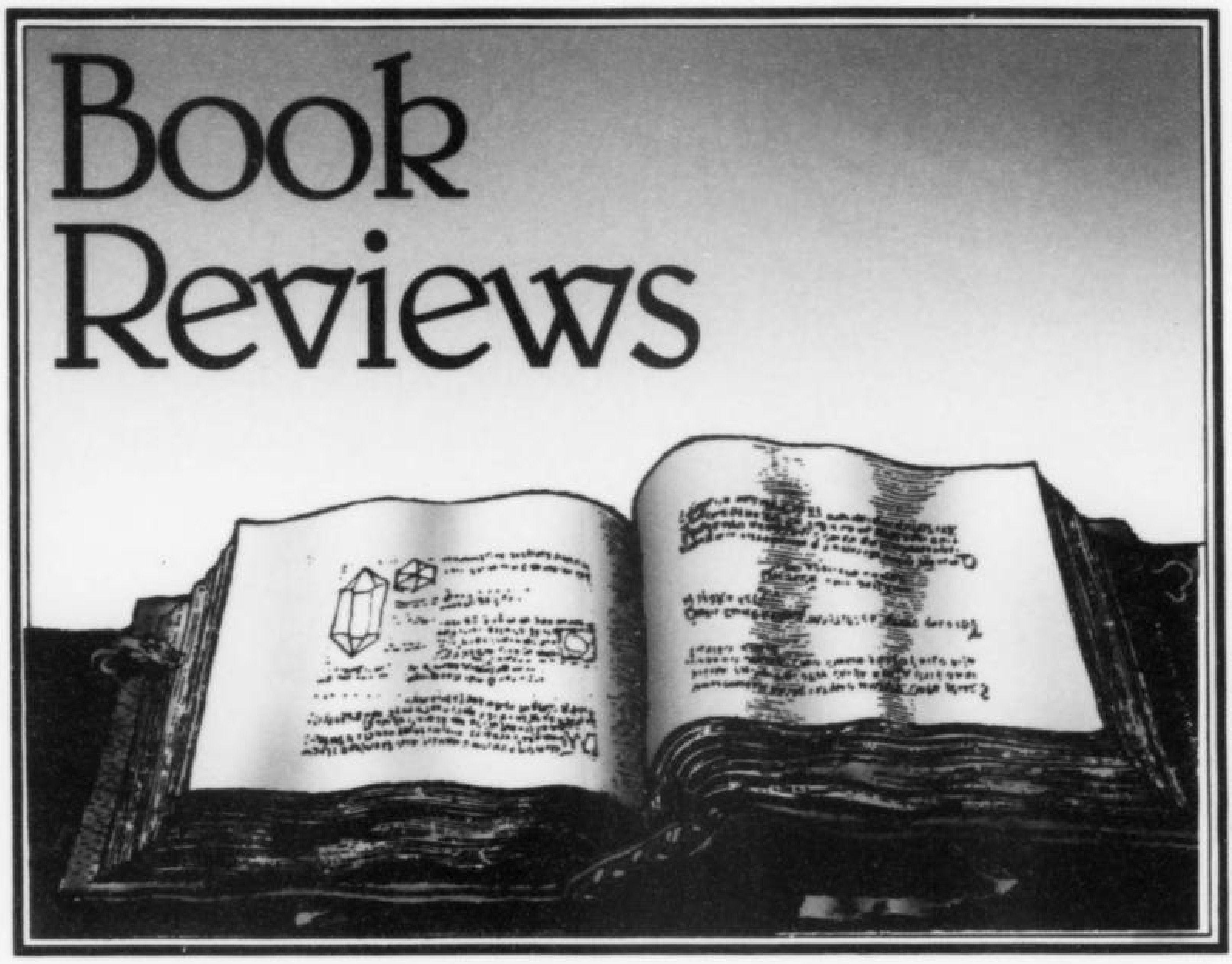

Book Reviews

Mineral Identification

A Practical Guide for the Amateur Mineralogist
by Donald B. Peck

Mineral Identification: A Practical Guide for the Amateur Mineralogist

By Donald B. Peck, published (2007) by Mineralogical Record, Inc., P.O. Box 35565, Tucson, AZ 85740; stiff-cover, spiral-bound, 8.5 x 11 inches, 262 pages plus CD. Price: $35 plus shipping. Order online at www .MineralogicalRecord.com.

My first mineral book was an old, pocket-sized edition of Herbert S. Zim's popular *Golden Guide to Rocks and Minerals* (1957). I read that black-covered little guide voraciously, hoping (no, believing!) that I could actually identify most minerals by careful observation and determination of a few simple physical properties like hardness, streak, etc. Equipped with pennies, steel files, pieces of glass, unglazed porcelain, a magnet and much enthusiasm, I set up my first "laboratory" on a small wooden desk in the bedroom I shared with my older brother. Disappointment came early and often. When I later studied mineralogy in college, I scoffed at the notion of "simple tests." How I wish Donald Peck's book had been written at least four decades earlier!

This new publication is a 262-page, soft-covered and spiral-bound 8.5 × 11-inch work that is a gem of careful, concise, methodical presentation. It will coax collectors beyond the usual beginner's methods of mineral identification, seductively raising their awareness, appreciation and skill for conducting such fearsome tasks as simple chemical analysis and optically based identification methods. Joe Mandarino's forward hints at the excitement this work will generate, but I was not prepared for the delight it kindled as I read through it.

Like many of its predecessors, the book begins with the basics: Part I: Mineral Identification Using Physical Properties. Twenty-five pages are devoted to color, streak, luster, hardness, specific gravity, fracture, cleavage, fusibility, luminescence, magnetism and radioactivity. Peck explains the phenomena that contribute to physical properties, clearly discusses how the tests should be undertaken, and even suggests excellent methods when dealing with microcrystals instead of massive chunks. In many cases, he suggests how to build apparatus that will make the task easier if not downright fun. His treatment of specific gravity, for example, not only provides details on the various balances and the respective methods to be employed with them, but he also discusses construction of a simple beam balance, offers useful hints like crushing and observing the sample for apparent impurities, repetition of tests, note-taking etc. I found numerous tips and hints throughout this section, realizing that my early days attempting such things as fusibility tests with a blowpipe would have been greatly improved had I read a clear "how to" book like this one!

Each section ends with a Case Study, a cogent example of how a carefully orchestrated attack on an unknown can be successfully launched. Using an early collecting experience at Roxbury, Connecticut, the author takes us through a very straightforward process-of-elimination exercise that reduces an unknown's identity from 2000 possibilities, to 372, to 178, to 35, to 6, then 2 and finally, the answer! And then, a check of the answer! While all challenges (and mineral unknowns) are not so simple to overcome, the methodology of the process is powerful. And when an answer is lacking, there is Part II to consider . . . .

In this section, Peck approaches identification techniques that rely on crystal morphology. Covered in 45 pages, he deals with crystallographic terminology, constants such as interfacial angles, and a wonderful approach to "analyzing crystals" that utilizes a seven-step decision tree to arrive at proper identification of the crystal system. For each crystal system, he describes its unique features, crystallographic axes, common special forms, what to look for and more. Representative minerals are noted so that one can build a small collection of reference specimens for each of the classes within each system. Miller Indices are clearly explained, as is the critical observation of interfacial angles, the goniometer (and how to make one), axial ratios and more. A closing Case Study, also from Peck's long experience as a collector, provides a good example of how his crystallographic protocol can successfully identify an unknown. And should that fail, there is always Part III, Chemical Analysis . . . .

I admit to being completely spoiled in this area. I have my own Scanning Electron Microscope that is equipped with a modern Energy Dispersive Spectroscopy unit that makes most basic chemical determinations quite simple (but quite expensive as well). But I remember the days before such luxury (and the huge cost to obtain and maintain it!) was available to me. The author devotes some 60 pages to chemical principles, safety precautions and the chemical techniques themselves. He discusses sublimates, flame tests, bead tests, spot tests, reagents and reactions, the ring furnace and more. The techniques described reminded me of my college days, of Curt Segeler's remarkable abilities with a handful of chemicals, of the magic Carlos Barbosa could perform at a kitchen table. And lest we forget, wet chemistry can be amazingly accurate, and it is actually more useful for detection of light elements such as lithium and boron which my EDS unit cannot handle. I had forgotten how interesting it was to take an unknown through a "wet chemistry" process, and the author's third Case Study at the end of the section was a solid example of how to tie together the many techniques at one's disposal. The presentation here was cogent and convincing, and as Peck states: "You can do it, too!"

And so we come to the most feared topic of all in Part IV: Optical Mineralogy. In just 30 pages, the author covers polarized light, pleochroism and birefringence, extinction, elongation, optic sign, index of refraction and relief, the spindle stage and more. Daunting as it may seem, Peck provides concise, step by step instructions for the various techniques, sprinkled with hints, observations and several very useful protocols for basic steps to follow in each subsection. Adding these protocols to your identification arsenal would make a huge improvement over the "eyeball technique" many of us have developed! As the author cites in his Case Study here, "If you are serious about mineral identification, the time and effort will be well spent."

I agree, but with a small caveat. It has been nearly 40 years since my first college course that dealt with optical mineralogy. I had a tough time with it then, and I have stayed away from it as a result until only recently. Last year, I had the great opportunity to spend a few days with a well-known mineralogist in his lab where he tried to refresh my memory and revive my interest in optics. I had a rewarding experience, but I also realized how little I remembered, how much there is to learn, and what time and patience it took to practice and become proficient. Trying to cram all that knowledge into a short learning period will likely be discouraging for most. The message: take your time, absorb the individual techniques, practice them with known minerals.

In Part V, the author introduces the concept of "Putting It All Together" through the use of a CD that is included with the book. And what a CD it is! It contains MinSearch, a search engine and database of more than 4000 minerals and their physical properties, optics and chemistry, including more than 3000 worldwide localities. The program allows searching of the database by any number and combination of 20 different properties. It essentially has taken the traditional reference tables of determinative mineralogy books of old and made them accessible in any combination or sequence. Simple instructions for installation and use are provided in the hardcopy book, and the CD also includes a Mineral ID Calculator that can perform all suggested calculations based on observations in the manual, including specific gravity, symmetry, axial ratio, position in series based on density or refractive index, and optic axial angle (2V). The program **Excalibr W** is also included for automating the processing of data from the detent spindle stage. A comprehensive number of pdf files are also included in a staggering Resource Guide on the CD.

Following Part V are six comprehensive appendices covering 70 pages: Annotated Bibliography, a dozen Instruments You Can Make, 20 exhaustive Reference Tables, five sections of Chemical Equipment and Reagents, Crystal Models, and Suppliers of various items mentioned in the book. A Glossary, Index and Quick Index to Reference Tables complete the work.

Peck's nearly 50 years as a teacher of chemistry, physics and earth science are clearly demonstrated in this wonderful undertaking. His explanations, hints and caveats are obviously built on years of careful use and experience, and one can envision the renaissance man of early mineral science at work here, with Peck's manual at his side. I genuinely enjoyed this gem, longing for a time before XRD, EDS and other "black box" technologies spoiled my ingenuity and patient curiosity.

I heartily recommend this comfortable and informative book for any collector interested in careful mineral identification by classical methods. Those few Luddites among you without a computer will miss a wonderfully flexible database, but the techniques carefully offered here will be invaluable nonetheless. The book lies flat on the desk, is ridiculously affordable at just $35.00 plus shipping, and it can be obtained (retail only) exclusively from the publisher, Mineralogical Record, via their online bookstore at www.Mineralogical Record.com.

Tony Nikischer
Excalibur Mineral Corp.

The Friends of Mineralogy, Inc.

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FM's objectives are to promote, support, protect, and expand the collection of mineral specimens and to further the recognition of the scientific, economic, and aesthetic value of minerals and collecting mineral specimens.

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PUBLICATIONS AND WORKSHOPS

Antero Aquamarines by Mark Jacobson (1993), Friends of Mineralogy, Colorado Chapter, P.O. Box 5276, Golden, CO 80401-5276. Price: $15.00 (tax and postage included).

Reminiscences of a Mineralogist by Arthur Montgomery. Order from: Friends of Mineralogy, Pennsylvania Chapter, Arnold Mogel, 15 Oak Road, Schuykill Haven, PA 17972; Tel: 570-739-4034; Emailo: pioche@losch,net.

Minerals of California on-line. Friends of Mineralogy, Southern California Chapter; Website: http://www.mineralsocal.org/scfm.

"Mineral Collectors' Workshops" in March and October, sponsored by Friends of Mineralogy, Southern California Chapter. Contact: Bob Housley, RHousley@its.caltech.edu.

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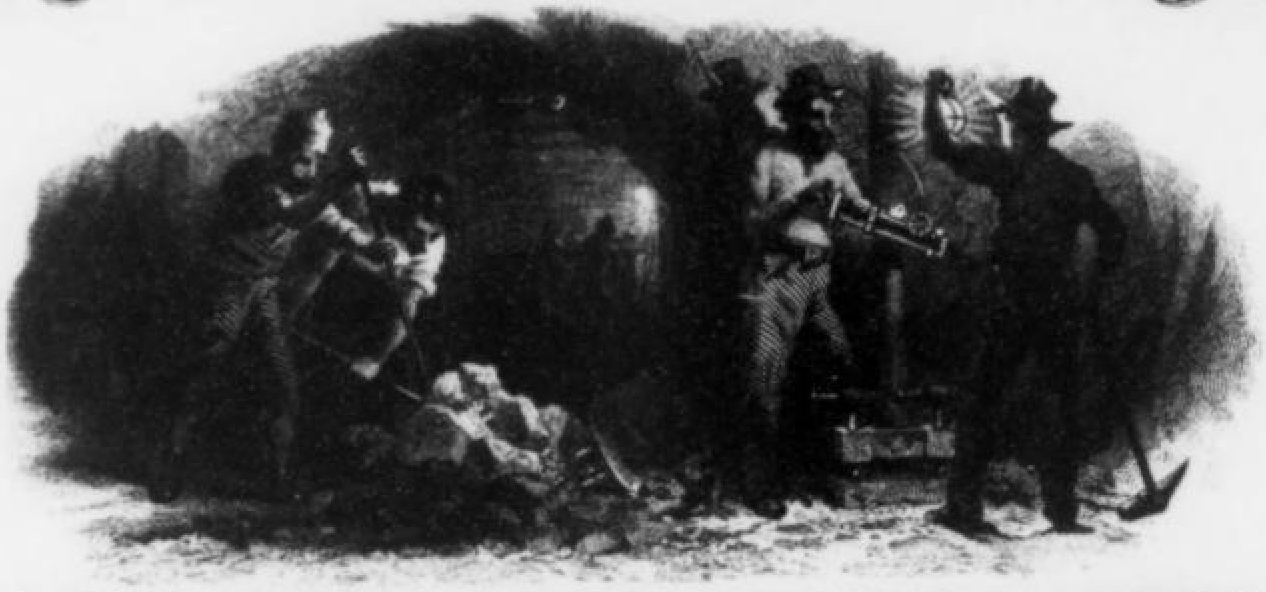

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