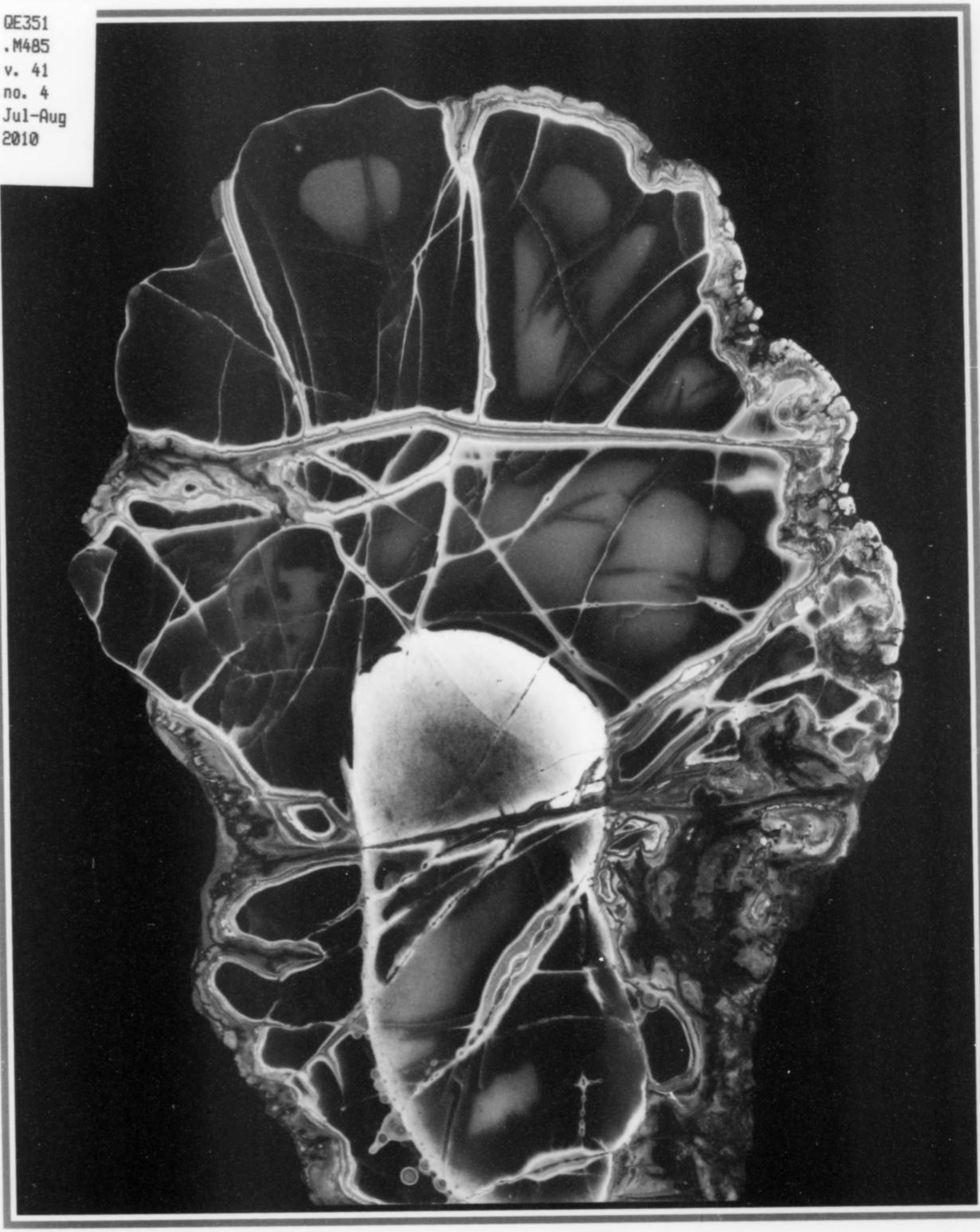
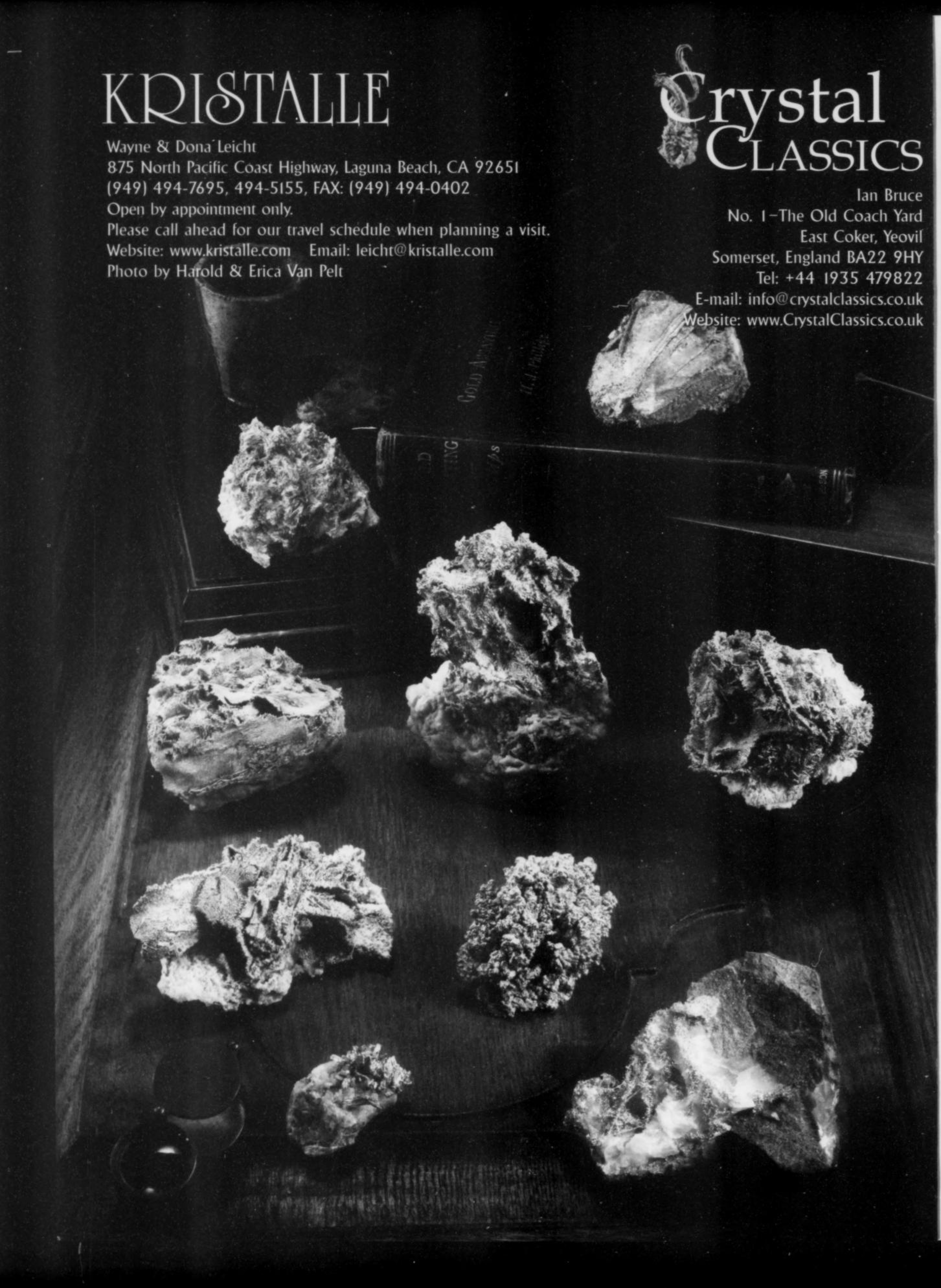
THE MINERALOGICAL RECORD

JULY–AUGUST 2010 • VOLUME 41 • NUMBER 4 $15

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The

Mineralogical Record

The International Magazine for Mineral Collectors

VOLUME 41 • NUMBER 4 JULY–AUGUST 2010

Continued on page facing inside back cover

Articles

Columns

This issue was made possible in part by contributions from Philip G. Rust and the Fellows of the Mineralogical Record

COVER: VARISCITE nodule, 28 cm, collected by John Hutchings at the Clay Canyon mine near Fairfield, Utah, ca. 1919. Photo courtesy of the John Hutchings Museum of Natural History, Lehi, Utah. (See the article on this famous locality beginning on page 321.)

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Notes from the Editors

Mineral Name/Formula Hybrids

In recent decades there has been an unfortunate (in this writer's opinion) trend in mineral nomenclature: the hybridizing of mineral names with formulas. The philosophical root of this practice has been the Levinson suffixes. A. A. Levinson's 1966 article ("A system of nomenclature for rare-earth minerals," *American Mineralogist*, **51**, 152–158) introduced the concept that, instead of coming up with a new name in the traditional way for a new chemical analog of an existing mineral, the *chemical symbol* for the element substituted in the formula could be tacked on with a hyphen to the back end of the original mineral name. He reasoned that, with so many rare-earth elements to choose from, each having relatively little effect on the properties of the mineral (and thus requiring detailed chemical analysis for identification of the species), it would be more convenient to use suffixes to distinguish each rare-earth analog and then use the root name (e.g. monazite) when the dominant REE is not known. The idea appealed to other mineralogists, who then applied it to the naming of non-REE minerals as well.

But this merger blurred the line between what constitutes a mineral *name* and a mineral *formula*. The result has been nomenclatural cross-breeds such as stilbite-Ca, florencite-(Ce), and donnayite-(Y), and real nomenclatural monstrosities such as whiteite-(CaFeMg) and whiteite-(CaMnMg).

Crystallographers have also succumbed to the temptation, resulting in structurally hybridized names with code letters and numbers added at the end, such as ferronigerite-6*N*6*S*. Then *that* approach was hybridized to include both chemical *and* structural symbols in the same name, e.g. apatite-(CaOH)-*M*. In fact, many perfectly good names that have long been entrenched in the literature were overturned by Burke (2008, in this journal, with approval of the International Mineralogical Association) in the name of "tidying up," and were given new hybrid names instead.

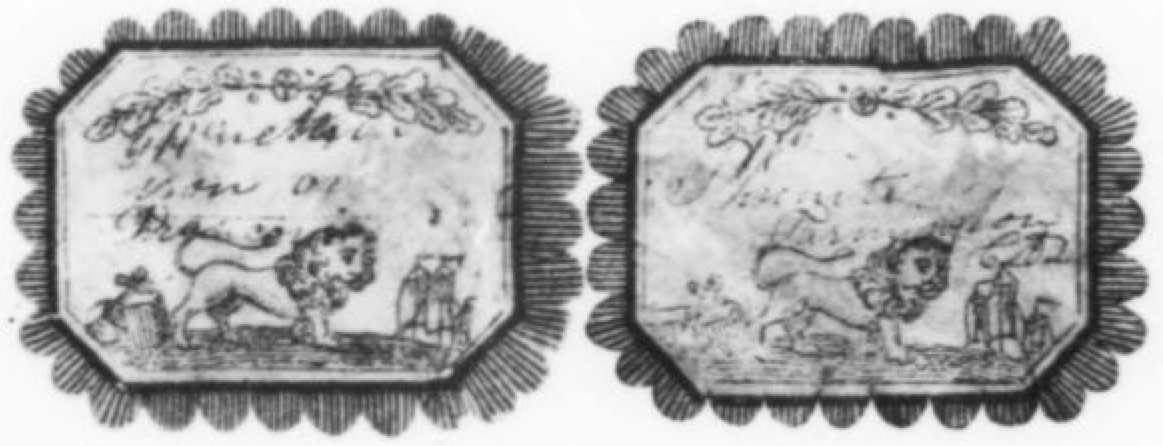
Convenience notwithstanding, I personally wish that mineralogists would keep in mind what a "name" is and what it is not. Chemical formulas are not names. Structural formulas are not names. Why would one want to *rename* a perfectly good mineral such as fluorapatite with the new name apatite-(CaF)? How does this help anyone? It's not even shorter. Is it too much work to remember that the species contains some calcium? Is it too much work to remember that there are four other chemically similar species distinguished by various substitutions; must they instead all have to come out together in an alphabetical list, as a memory aid?

Some common sense is finally beginning to creep back in. An IMA committee chaired by Marco Pasero and Anthony Kampf recently published a revision of the nomenclature of minerals in the apatite supergroup (*European Journal of Mineralogy*). Among other changes, they specify:

> The use of adjectival prefixes for anions is to be preferred instead of modified Levinson suffixes; accordingly, six minerals should be renamed as follows: apatite-(CaF) to fluorapatite, apatite-(CaOH) to hydroxylapatite, apatite-(CaCl) to chlorapatite, ellestadite-(F) to fluorellestadite, ellestadite-(OH) to hydroxylellestadite, phosphohedyphane-(F) to fluorphosphohedyphane. For the apatite group species these changes restore the names that have been used in thousands of scientific papers, treatises and museum catalogues over the last 150 years.

Bravo to Drs. Pasero and Kampf, and the other members of the committee: Cristiano Ferraris, Igor Pekov, John Rakovan and Timothy White.

WEW



Lion Labels

Can anyone solve the mystery of whose collection these labels represent? The left label shown here is from the Mineralogical Record Label Archive (from Ron Bentley's collection), and the one on the right (still attached to a prehnite specimen) was recently shown to us by Kelly Nash. Kelly's specimen came with a label from the collection of E. B. Underhill (1809-1888), though it probably predates Underhill. The labels are 3.3 cm wide and obviously designed to be glued onto specimens. They depict a lion flanked by a ship's anchor and shipping boxes on the left, and a three-masted sailing ship on the right, surmounted by oak-leaf clusters. "No" is printed in the upper-left corner, and there are two faint guidelines for writing. Minor details show that each of these labels (as well as a third in our collection) was printed from a different engraving; most likely engravings of several labels were prepared and ganged together to be printed at one time on the same sheet, then die-cut.

The writing on the three known labels appears to read:

(Left)	[illegible] "iron or" "France(s)"
(Right)	"Phrenite" "Farmington, CT"
(not shown)	"Bismuth" and "11/4" written sideways

"Phrenite" was and remains a common misnomer for prehnite. The Underhill label confirms that the specimen to which the label on the right is affixed is a prehnite from Farmington, Connecticut. Prehnite was named by Werner in 1790, and Underhill died in 1888, so the time period is bracketed. Does anyone recognize these labels?

Rhodochrosite, Sweet Home mine *Jeff Scovil photo*

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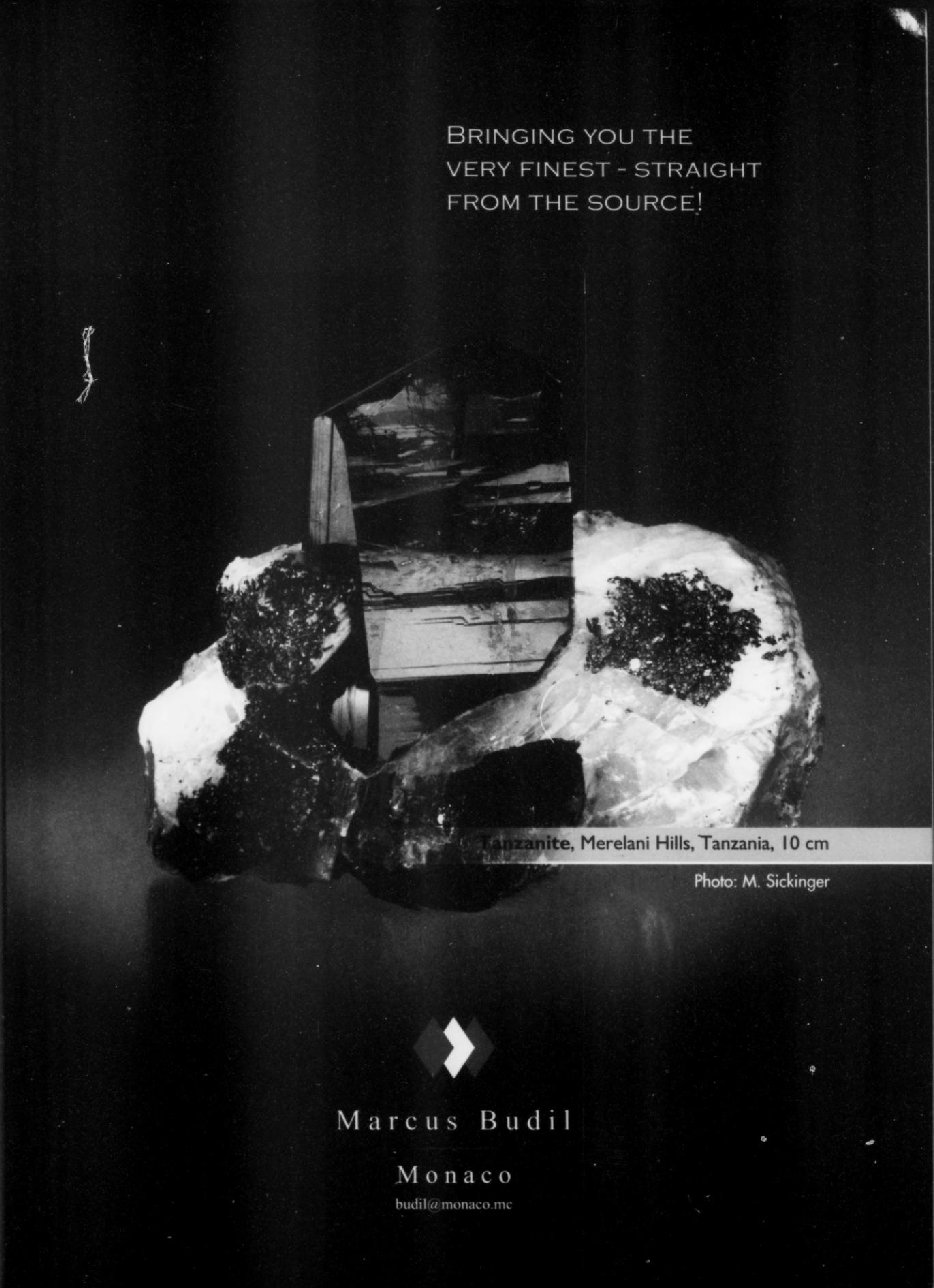
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Tanzanite, Merelani Hills, Tanzania, 10 cm
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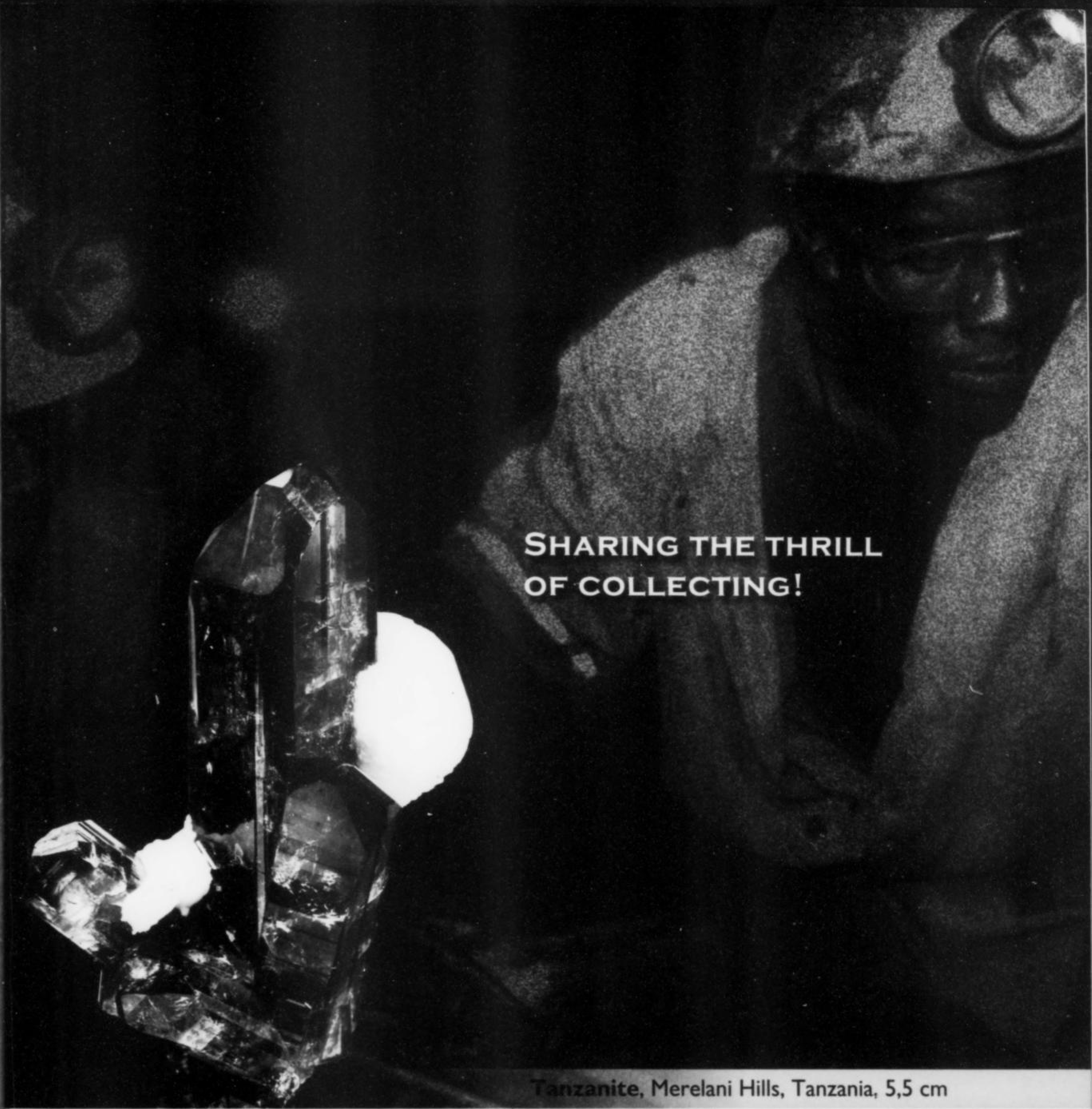
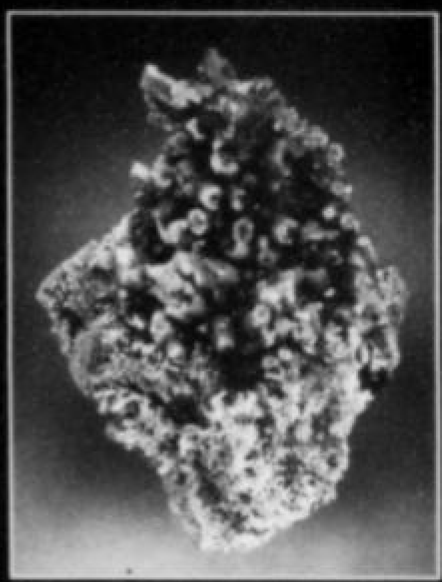


Tanzanite, Merelani Hills, Tanzania, 5,5 cm

Photo: M. Sickinger

Fluorite with Calcite, 4 cm, Gordonsville mine, Smith County, Tennessee




from the Collection of
Steve Neely

PHOTOS BY JEFF SCOVIL

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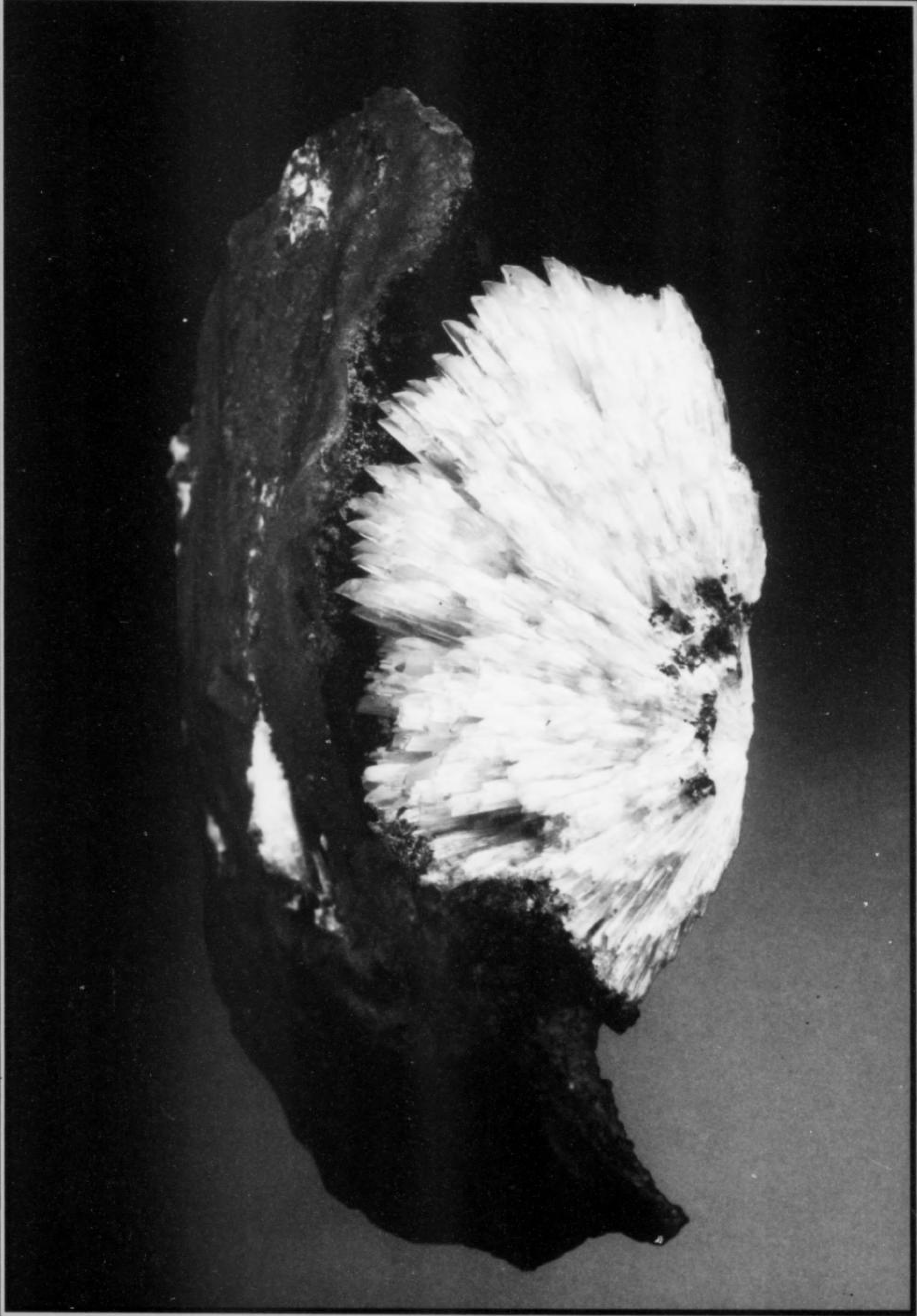
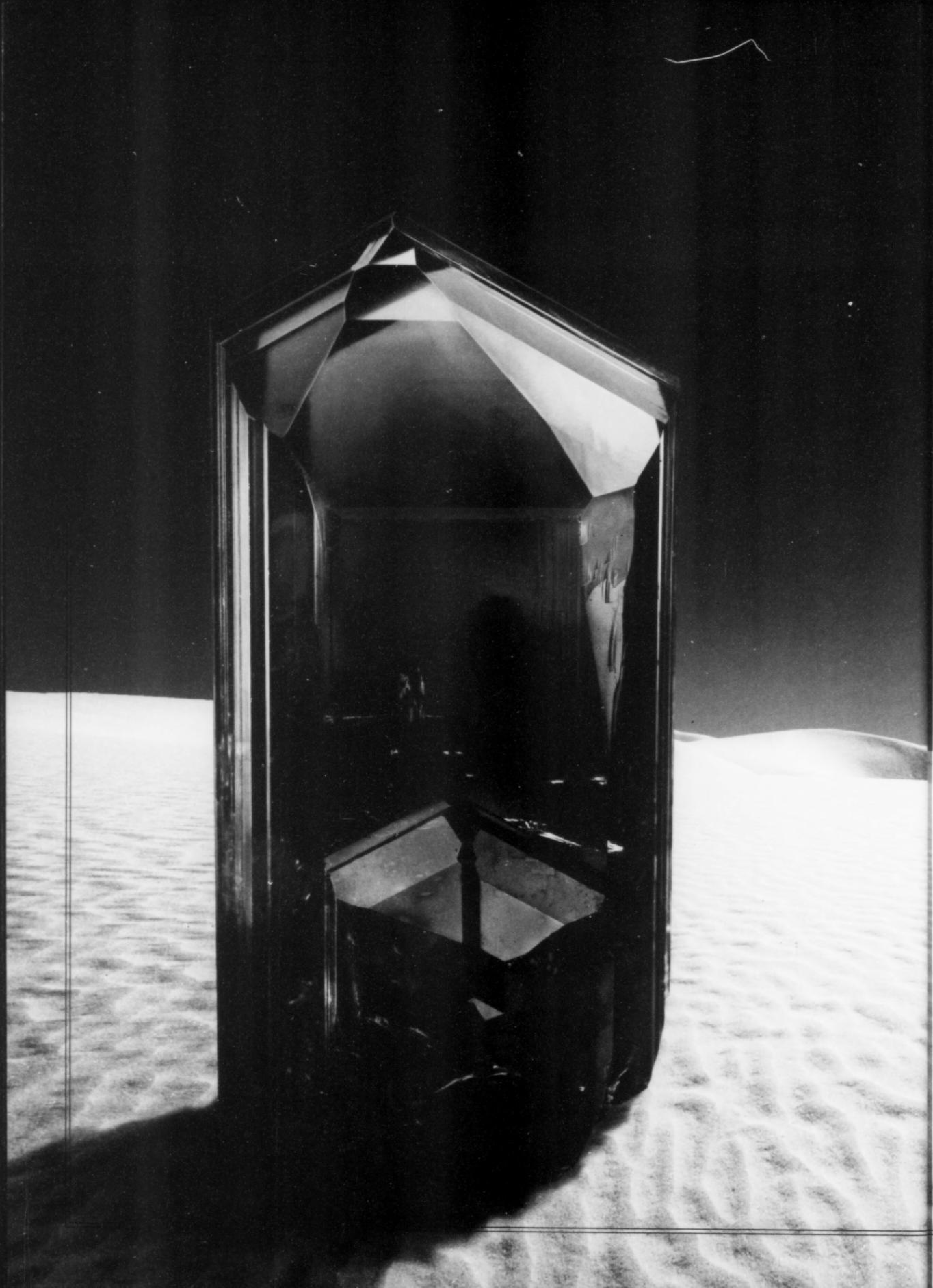
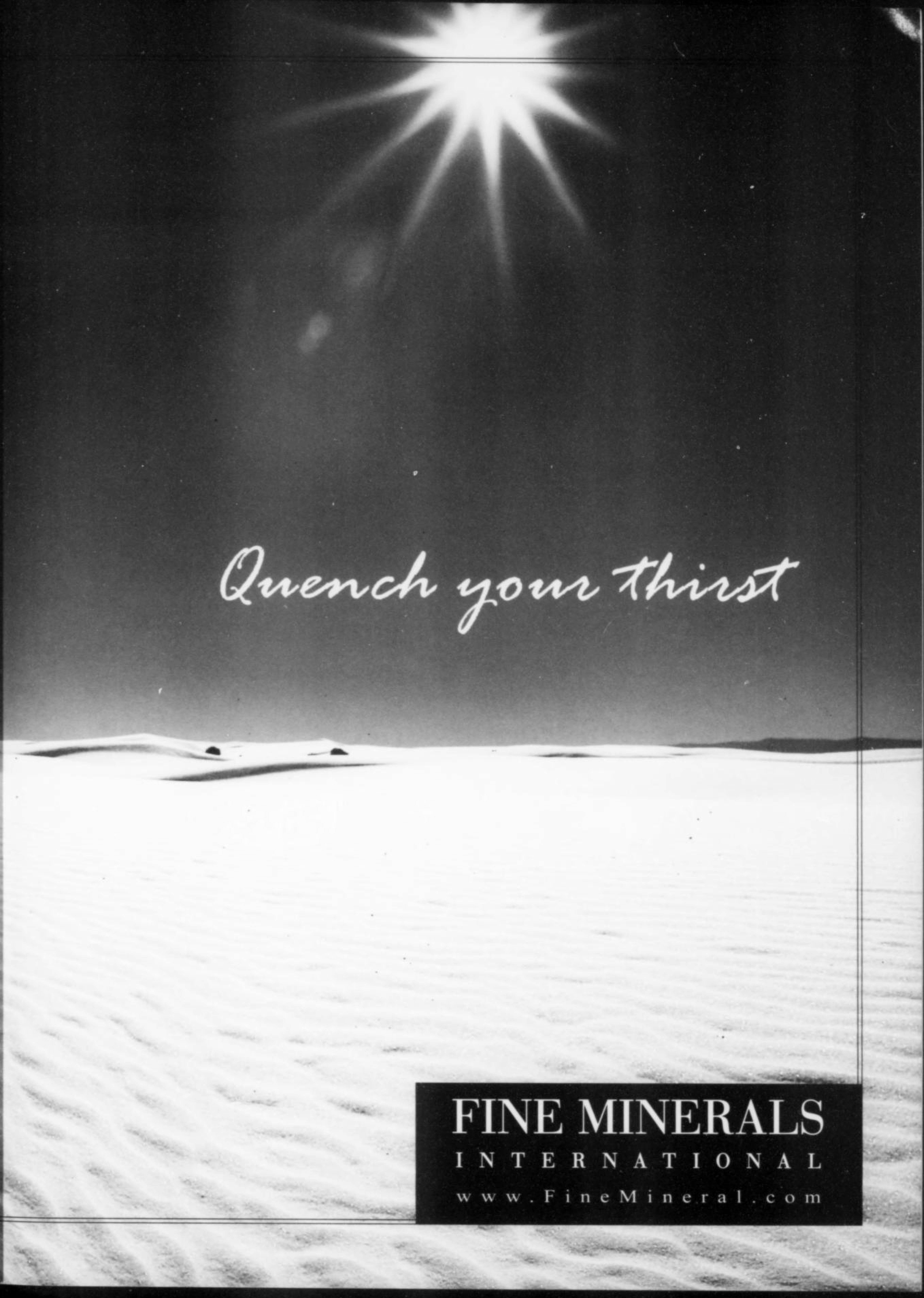


LEGRANDITE, 8.8 CM, OJUELA MINE, MAPIMI, DURANGO, MEXICO. FROM STUART WILENSKY, SEPT. 16, 2007

EX COLLECTIONS OF WILBER, PROCTOR, BARLOW, & SEAN FINNEGAN. PICTURED IN THE BARLOW BOOK

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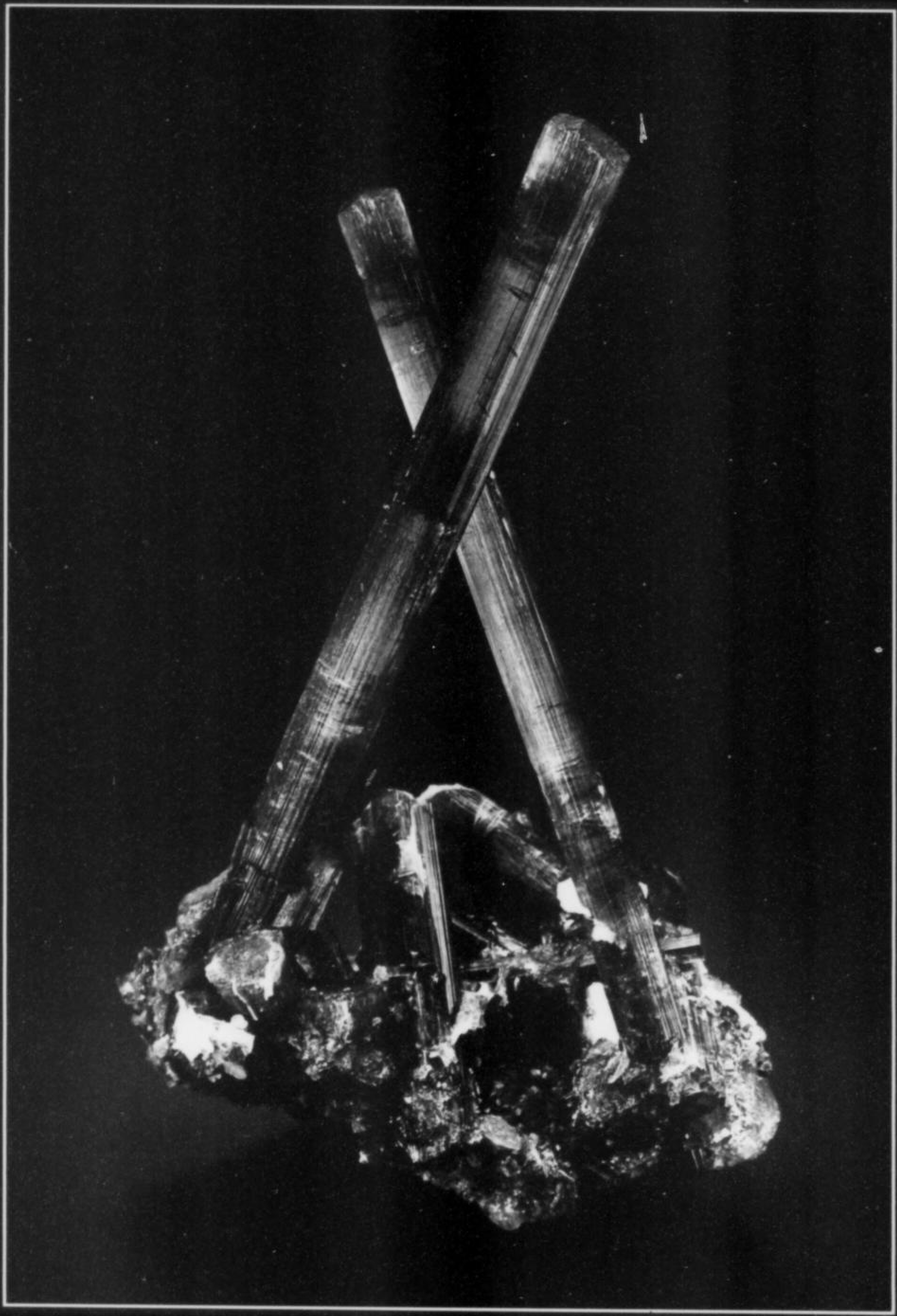


SCOTT RUDOLPH

Collection

THE Clay Canyon Variscite Mine

FAIRFIELD, UTAH

Wendell E. Wilson
The Mineralogical Record
4631 Paseo Tubutama
Tucson, Arizona 85750
minrecord@comcast.net

Fairfield, Utah has been famous among mineral collectors for well over a century as the source of the world's finest specimens of variscite. The chrome-green nodules, riddled with veins of various other phosphates, make splendid display specimens when slabbed and polished. The mine is also the type locality for the phosphates englishite, gordonite, millisite, montgomeryite, overite and wardite.

INTRODUCTION

Fairfield variscite enjoys a special status in the mineral world. Nearly all specimens are slabbed and polished—a situation that would normally preclude much interest on the part of mineral collectors. Nevertheless, polished slabs are collected and traded among mineral collectors as if they were crystal specimens. They sell for substantial prices and are coveted display items in mineral cabinets that may contain no other polished specimens. Fine variscite nodules and suites of nodules can be found in mineral museums around the world, particularly the Harvard Mineralogical Museum, the Smithsonian Institution, the Seaman Mineral Museum in Michigan, the John Hutchings Museum of Natural History in Lehi, Utah, and the Crater Rock Museum in Oregon. The six micromineral species for which Clay Canyon is the type locality are likewise highly valued by species collectors and by micromounters.

LOCATION

The Clay Canyon variscite occurrence (named the Little Green Monster claim by Montgomery and Over in 1937) is located primarily in the southeast quarter of the southwest quarter of Section 22, T6S, R3W, in the Oquirrh Mountains, western Utah County, Utah, about 50 miles south of Salt Lake City. The claim is part of the Camp Floyd mining district about 2 miles south of the Mercur townsite and 5.5 miles northwest of Fairfield, at an altitude of about 5,800 feet. The original adit entrance to the mine (currently buried and reclaimed) is situated near the foot of a hill a short distance north of the south fork of Clay Canyon, near the confluence of the north and south forks. Access is via State Highway 73 west from the town of Lehi, then south through Cedar Fort and Fairfield. The turnoff to Clay Canyon is 1.5 miles past Fairfield, where a dirt road leads northwest into the mountains for another 3 miles to the mine.

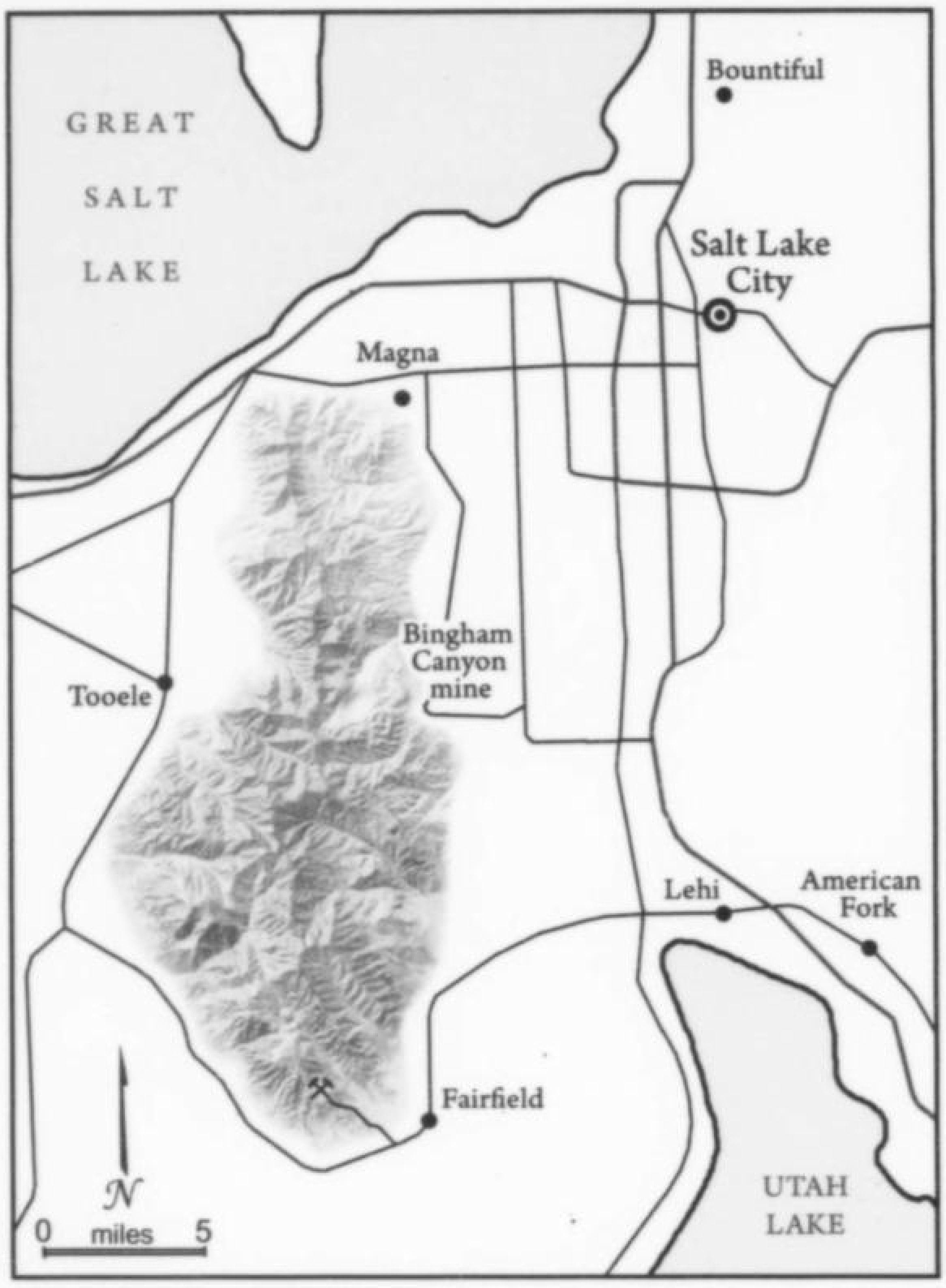


Figure 1. Location map showing the Oquirrh Mountains southwest of Salt Lake City, and the road leading into the southern end of the mountains from Fairfield to the mine.

HISTORY

The first variscite[1] specimens from the Clay Canyon occurrence were sent for identification to George P. Merrill, Curator of Geology at the Smithsonian, in December 1893 by F. T. Millis of Lehi, Utah. Millis stated that the variscite was found in the form of "nuggets" (nodules) in a vein near "Lewiston," Utah about 20 miles west of Lehi. The present-day town of Lewiston is far to the north in another county; however, the old mining ghost town of Mercur in the Oquirrh Mountains was originally known as Lewiston, and is the place to which Millis was referring.

F. T. Millis himself remains a mystery. There is no one with the surname Millis in the 1870–1900 Federal Censuses for any town in Utah, he is not listed in any Utah city directories of the time, nor is his correspondence preserved at the Smithsonian in the archive of curator George P. Merrill. The lack of knowledge about F. T. Millis is frustrating considering that he is the discoverer of the deposit, and that the mineral *millisite* was later named in his honor (Larsen and Shannon, 1930) and remains a valid species. At least his existence is confirmed by his registration of other mining claims in the area in 1892 and 1893.

At Merrill's request, a resident chemist in Washington, R. L. Packard, made the actual identification on the 18-cm nodule sent to Merrill and published his results in the *American Journal of Science* (Packard, 1894). The specimen is made up mostly of yellow material (crandallite) in which are embedded several small nodules of green variscite (Larsen and Shannon, 1930). Unfortunately the original Millis specimen in the Smithsonian cannot now be found (Paul Pohwat, personal communication, 2010).

Millis appears not to have followed up on his discovery. According to Bennion (1967), the first people to actually work the deposit were Frank Butt and his brother—that is, William Francis "Frank" Butt (1857–1940) and his brother, J. Newbern Butt (1862–1939)—who had discovered the Sunshine mine deposit over the ridge to the west in Sunshine Canyon (Kantner, 1896). They were hoping to find gold in Clay Canyon but were unsuccessful and soon gave up.

Shortly thereafter, Dominick "Don" McGuire (or Maguire) (1852–1933) of Ogden, Utah, who was at that time working the Sunshine mine, took an interest in the Clay Canyon locality. Perhaps having heard about it from the Butt brothers, or having read Packard's article about Millis's find in the *American Journal of Science*'s April 1894 issue, McGuire visited the locality and collected specimens which he circulated to potentially interested parties. Kunz's note in the 16th Annual Report of the U.S. Geological Survey (1895) on the mineral resources of the United States for 1894 reads as follows:

Figure 2. Dominick "Don" McGuire (1852–1933), the first person to stake a claim on the Clay Canyon variscite occurrence (October 1894) and work it. Courtesy Utah Historical Society.

> An interesting discovery has been made of compact nodular variscite in Cedar Valley, near old Camp Floyd, Utah, by Mr. Don Maguire. The rock [matrix] is a crystalline limestone, with layers of black pyritiferous siliceous slate. In the latter occur the nodules, varying in size from that of a walnut to that of a coconut. They are covered with a thin, lamellar, ferruginous crust, beneath which lies the compact variscite in various

[1] Variscite was originally described from Vogtland (ancient name: Variscia) in Saxony by Breithaupt in 1837.

shades of rich green. This is a new form of occurrence for this species and has attracted considerable attention abroad, both as a novel mineral and as an ornamental stone of quaint beauty. The locality, which is a spur of the Oquirrh Mountains, has been visited and examined by Mr. Maguire. He finds that it [the variscite] is somewhat abundant, but that only careful hand work can be used to extract the pieces from the rock. The writer [Kunz] suggests that the name utahlite would not be inappropriate for it.

In October 1894, McGuire staked a claim on the Clay Canyon deposit and worked it periodically during the following years, reporting production through 1914 (Kunz, 1904, 1906; Sterrett, 1908, 1909, 1911) and again in 1919, perhaps from lessees (Stoddard, 1920); production was said to be intermittent, whenever McGuire's stock needed replenishing. *The Salt Lake Mining Review* for January 30, 1913, reported:

> Don Maguire of Ogden, one of the noted metallurgists and engineers of the West, who was in Salt Lake last week, informs *The Mining Review* that, in Camp Floyd district he has uncovered one of the finest bodies of chlor-utahlite [variscite] ever disclosed in the West. This is a gem stone, emerald-green in color, and is used quite extensively in the manufacture of jewelry. From this point Mr. Maguire has already taken 1,000 to 1,500 ounces.

McGuire led a very industrious and active life, and was famous in Utah mining circles. Born in Vermont to Irish immigrants, he had moved with his family to Utah in the 1870s after his father had become wealthy from livestock and land speculation in the Midwest. A graduate of Franciscan College, he had studied mathematics, engineering, French, Spanish and Arabic, then traveled widely, working as a miner, explorer and surveyor (Topping, 1997). According to various city directories, newspaper accounts and census records, McGuire had lived in Ogden since at least 1890, when he served as vice president of the Catholic Knights of America. In 1893 he was serving as Chief of the Department of Mining and Ethnology for the Utah World's Fair Commission (for the Chicago World's Fair of 1893), and again for the St. Louis Exposition of 1904. He became involved in extensive archeological digs around the state, and his essay "Prehistoric Man in Utah" (1894) is the first overview ever written of Utah archeology. He was also Vice President of the Ogden Chamber of Commerce in 1896. He had worked as a traveling salesman in the 1890s and also as a real estate agent with his partner William Campbell; but he listed himself as a "quartz miner" on the 1900 Ogden census and as a "mine owner" on the 1910 census. According to *The Copper Handbook* (Stevens, 1907, 1920), he was General Manager of the Napoleon and Maghera Copper Mining and Reduction Company, and owner of the Eldorado Gold Mining and Milling Company, among others.

McGuire excavated a small pit incorporating a shallow inclined shaft at the discovery site, and dug a tunnel into the hillside, though the tunnel appears not to have intersected productive ground. Apparently all of McGuire's variscite production came from the pit. Some of the variscite was sold to local lapidaries who marketed it under Kunz's suggested trade name of "utahlite" and later as "chlor-utahlite."

In the September 1894 issue of *The Mineral Collector,* field collector and mineral dealer Maynard Bixby (1853–1935) mentioned in his "Utah notes" that "A new mineral of a beautiful green color resembling malachite, but a hydrous phosphate of aluminum containing chromium, has been found near Camp Floyd. It has been named Rosrite" (yet another doomed marketing name for variscite). Nor did other Clay Canyon minerals escape Bixby's notice; he offered variscite cabinet specimens and "fine wardites" for sale in 1897.

Ward's Natural Science Establishment in Rochester, New York purchased a large quantity of the variscite nodules (no doubt from McGuire) in 1895, advertising *"Variscite, Utah, polished slices, deep color, $1 to $10"* (*The Mineral Collector*, July 1895). John M. Davison (1840–1915) at the University of Rochester examined the material and from it extracted a new species, which he named *wardite* after Henry A. Ward (Davison, 1896). By December 1895 George L. English was also advertising specimens in *The Mineral Collector*:

> Variscite from Utah, in gorgeous polished slabs, being sections of nodules of pure variscite, rich green inside, surrounded by yellow agate-like bandings. One of the liveliest minerals now in the market. A few extra fine specimens, $4, $5, $6 and $10.

Figure 3. **Portion of George L. English's ad offering some of the first variscite specimens for sale in the December 1895 issue of *The Mineral Collector.***

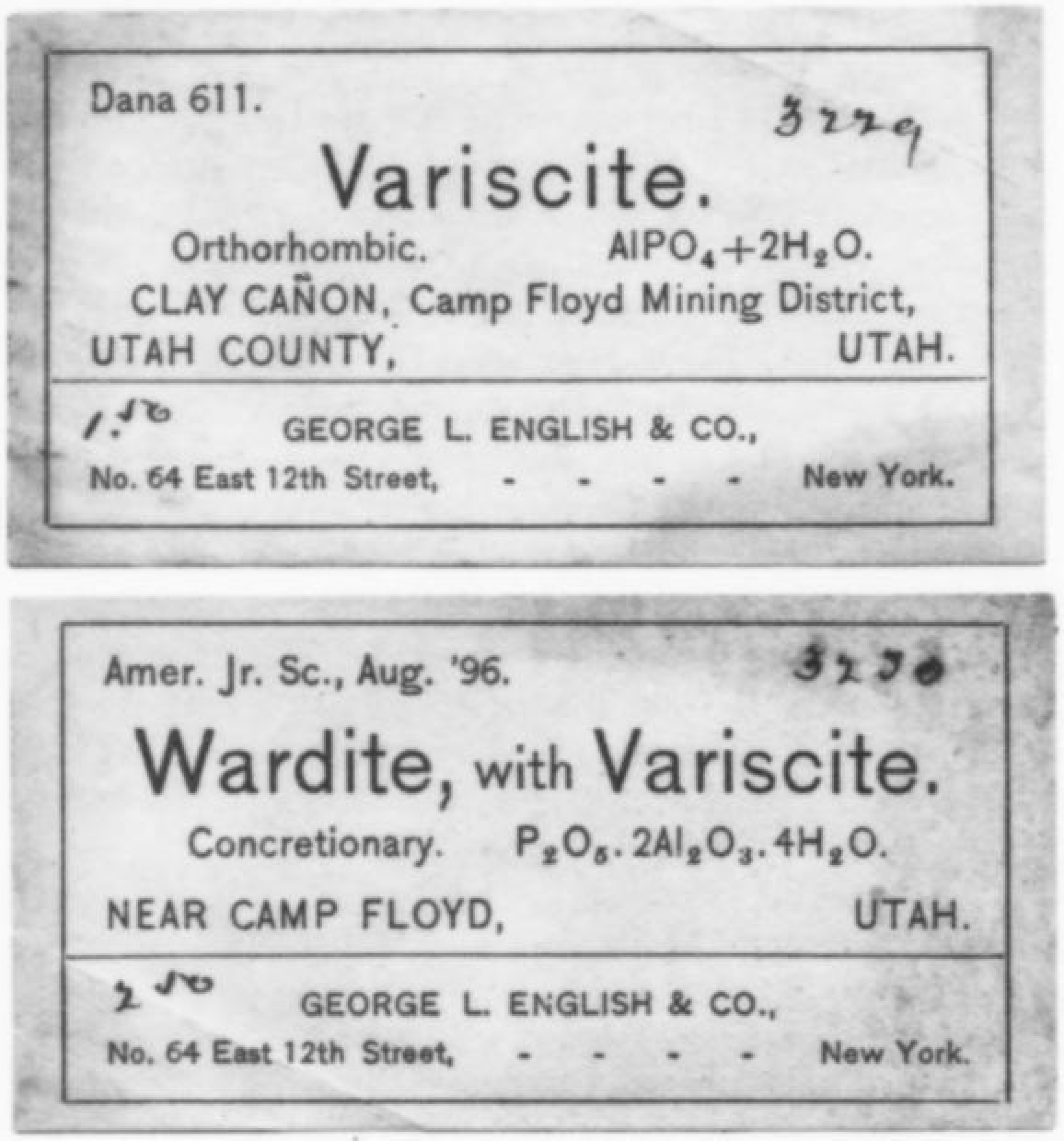


Figure 4. **George L. English labels (1896–1898) for Clay Canyon specimens of variscite and wardite, priced at $1.50 and $2.50, the equivalent of about $40 and $66 today.**

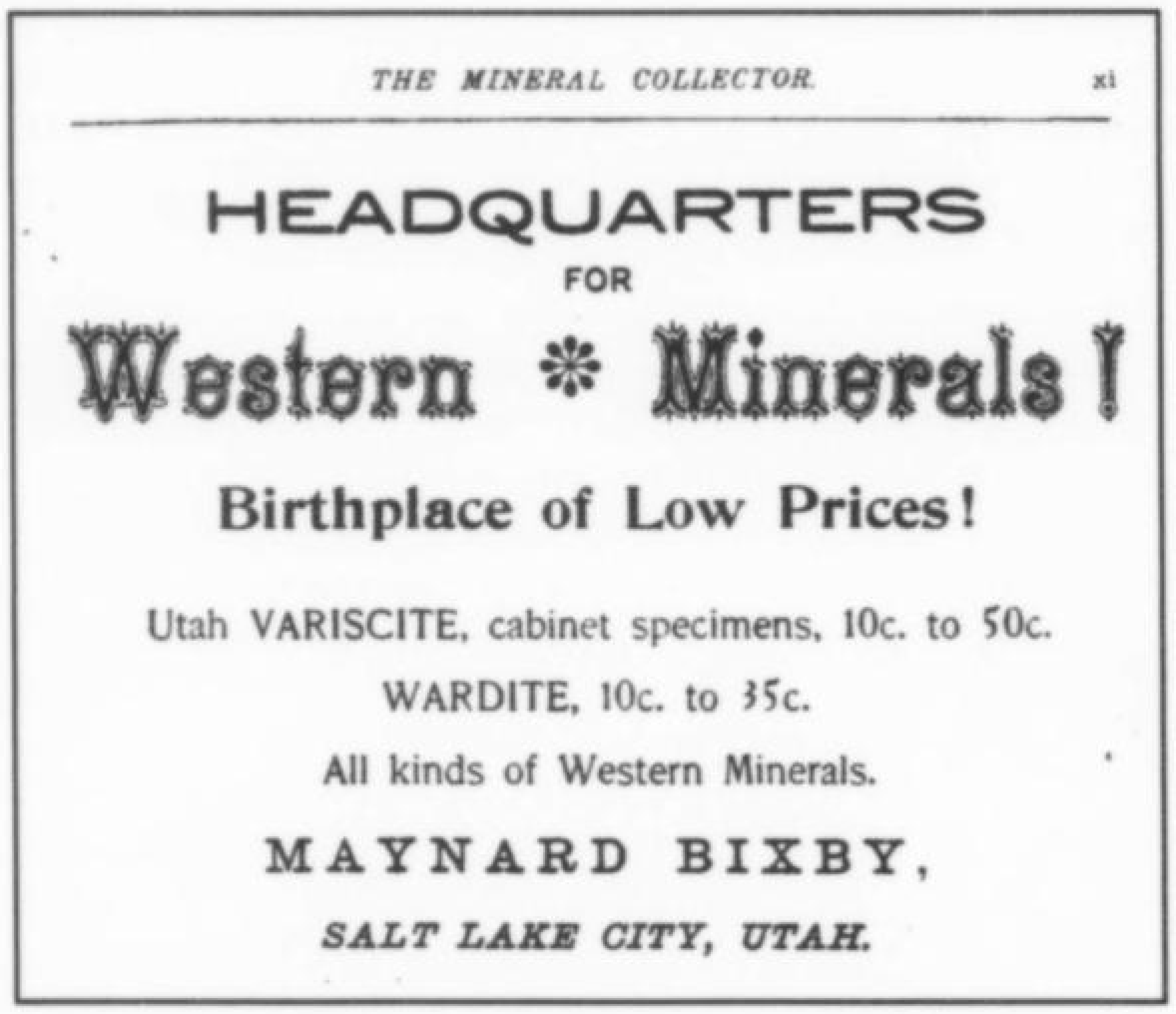


Figure 5. **Maynard Bixby's ad in the August 1897 issue of *The Mineral Collector*.**

Around 1918–1920 the property was worked by Richard Jackson Hutchings (1875–1937) and his younger brother John Hutchings (1889–1977) of Lehi, Nevada—and a one-armed deputy sheriff from Tooele County. Richard listed himself as a "miner" on the 1920 census, and had probably leased the Clay Canyon mine for a while from Don McGuire. John Hutchings had worked in the Eureka silver mines at the age of 12, and then served as a postman for some years in Lehi, but was primarily a collector. He listed himself as a "miner" in 1918 when he registered for the draft, as did his brother Richard; by that time John had already been building his personal museum in his home. During their time at the mine the Hutchings brothers found one of the largest and finest dark green

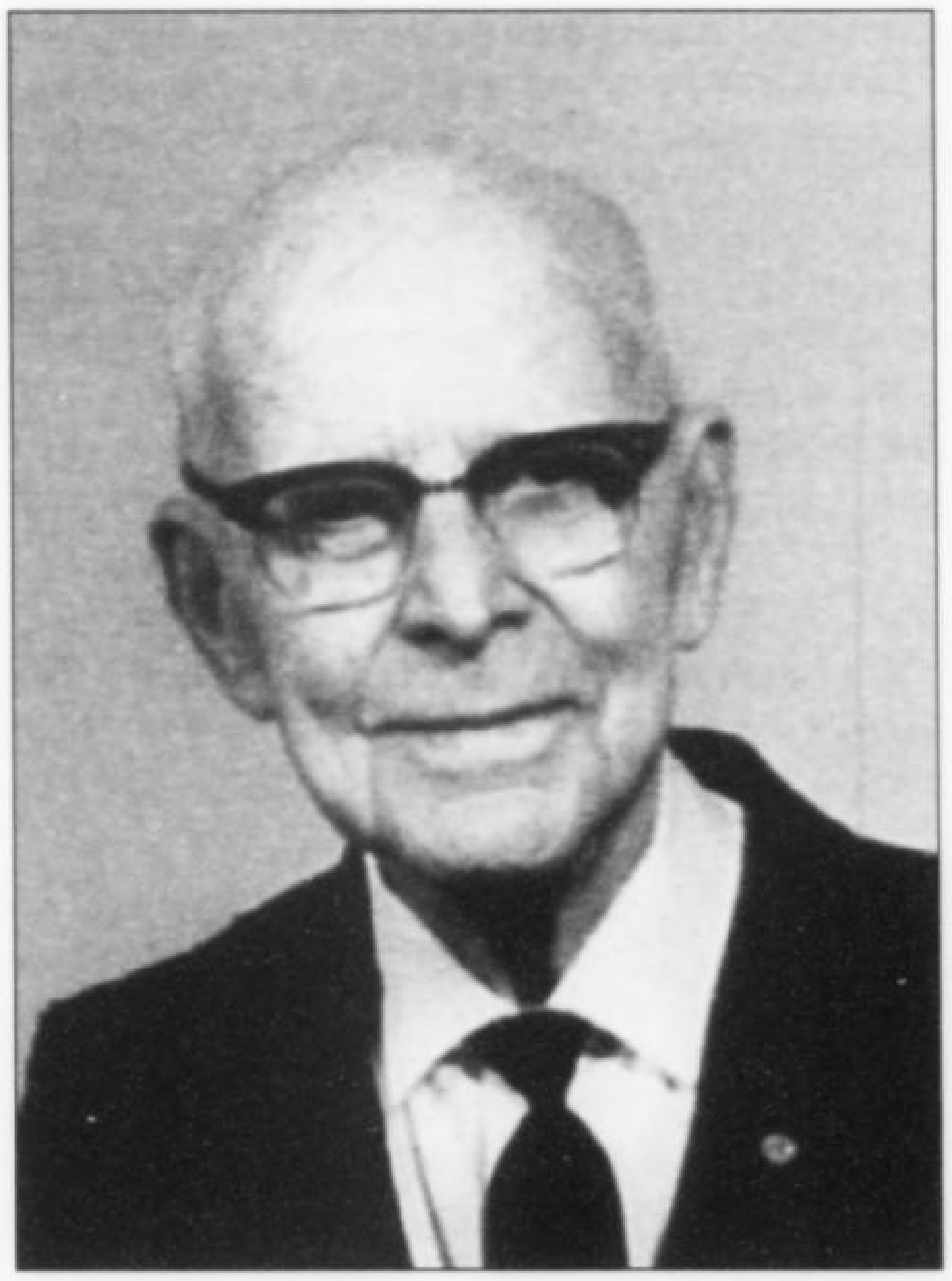


Figure 6. **John Hutchings (1889–1977) of Lehi recovered many variscite nodules in 1918–1920, when he and his brother Richard leased the locality. Photo courtesy of the John Hutchings Museum of Natural History.**

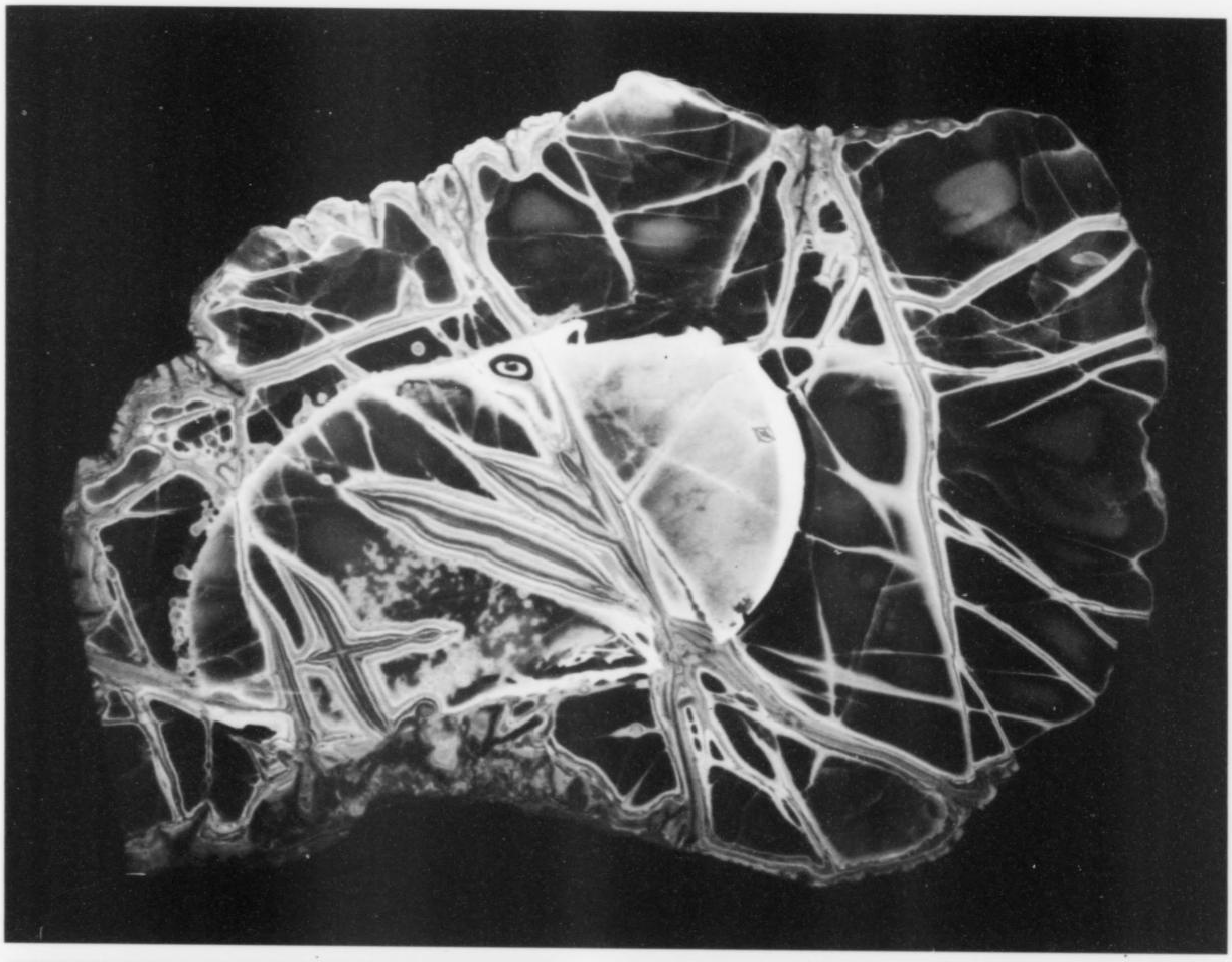
variscite nodules ever recovered there, a 28-cm (11-inch) boulder which John cut and polished himself. In 1955, John Hutchings and his wife Eunice donated their extensive collection of minerals, fossils, shells, stuffed birds, bird eggs, ethnographic artifacts, guns and Western memorabilia to the town of Lehi to formally establish the John Hutchings Museum of Natural History. The big variscite nodule can be seen there today (and is pictured here). Despite their discoveries, the Hutchings brothers were unable to find anyone who actually wanted to buy the variscite they were mining, so they gave up their claim.

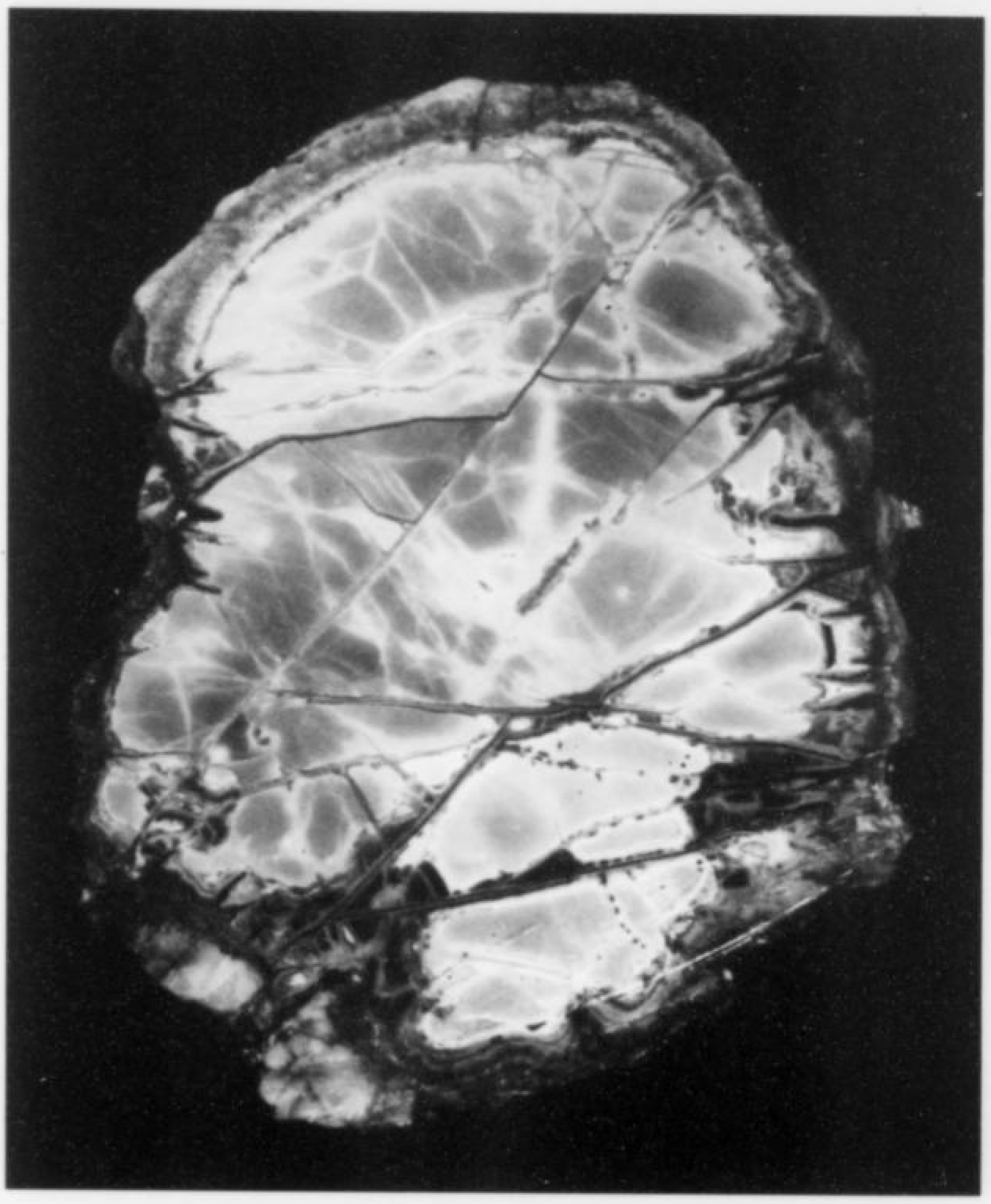
In 1923 George L. English (1864–1944), who was by then managing the mineralogy department at Ward's, supplied specimens of the

Figure 7. (facing page, top) **Variscite nodule, 28 cm (11 inches), one of the finest ever found at the Clay Canyon deposit. The lavender-colored bands are probably hydroxylapatite. Collected by John Hutchings ca. 1919; photo courtesy of the John Hutchings Museum of Natural History.**

Figure 8. (facing page, bottom left) **Variscite nodule, 15 cm, one of the finest ever found at the Clay Canyon deposit. Collected by John Hutchings ca. 1919; photo courtesy of the John Hutchings Museum of Natural History.**

Figure 9. (facing page, bottom right) **Variscite nodule, 19 cm, one of the finest ever found at the Clay Canyon deposit. Collected by John Hutchings ca. 1919; photo courtesy of the John Hutchings Museum of Natural History.**





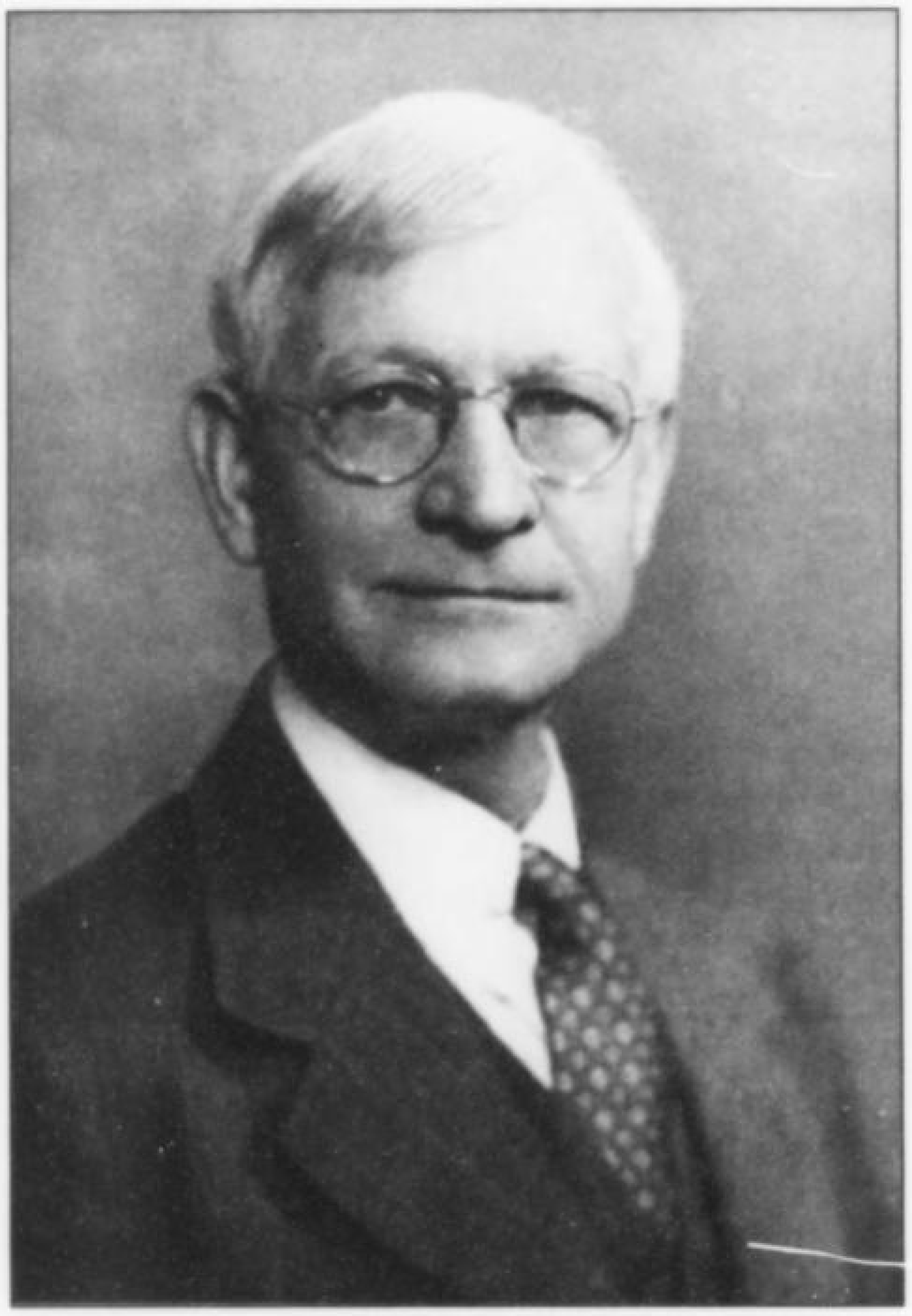


Figure 10. **Esper S. Larsen, Jr. (1879–1961), Harvard mineralogist (with Smithsonian curator Earl V. Shannon) described seven new species from the Fairfield nodules in 1930.**

Figure 11. **Arthur Montgomery (1909–1999) mined the Clay Canyon deposit in 1937 and 1939, with Ed Over, and patented the claim.**

nodules to Harvard mineralogist Esper S. Larsen, Jr. (1879–1961). Larsen made a visit to the locality himself in 1927 and collected a few poor specimens from the dump. Larsen and Smithsonian curator and chemist Earl V. Shannon (1895–1981) then analyzed the material in detail and described seven new species (Larsen and Shannon, 1930).

Bennion (1967), in his somewhat muddled historical sketch, stated that after McGuire, James Chamberlain (1875–1949) of Cedar Fort, just north of Fairfield, had operated the mine, and took out a number of good variscite nodules. He says Chamberlain had done the assessment work on the claim, but had failed to file proof of labor, so the claim lapsed. However, this assertion was later bitterly disputed (Montgomery, 1970b, 1970a).

The best-known collaboration in the mining of variscite nodules was that of Arthur Montgomery (1909–1999) and Ed Over (Edwin Jenkins Over, Jr.; 1905–1963). Montgomery had graduated from Princeton in 1931, spent a year traveling in Europe, and then worked for a while at Ward's Natural Science Establishment in Rochester, New York, learning the mineral business from George English. Perhaps it was there that he saw the remains of the first great variscite discovery at Fairfield. Ed Over had worked in the Colorado mines and attended the Colorado School of Mines for a couple of years before leaving to become a full-time mineral prospector (perhaps with some mentoring in the mineral specimen market by his friend, Colorado Springs mineral dealer Lazard Cahn). Over and Montgomery were introduced to each other by Harvard mineralogist Charles Palache, and immediately became fast friends and collecting partners. By 1934 they were in business together collecting and selling mineral specimens. Sometimes they worked in the field together, but much of the time Over worked alone, shipping specimens back to Montgomery in New York to be marketed. Montgomery's first ad, offering pyrite from Bingham Canyon, Utah appeared in January 1934. Over the next seven years Montgomery and Over were responsible for many spectacular mineral discoveries reaching the market, including red wulfenite from the Red Cloud mine in Arizona, and epidote from the Green Monster mine on Prince of Wales Island in Alaska.

Montgomery and Over returned from their Alaska collecting trip in September of 1936. On the drive back to Colorado Springs they passed through Utah and, taking the advice of Esper Larsen, decided to search out the old Fairfield variscite locality. Montgomery (1970a,b) described their work there as follows:

> We had trouble finding the old mine, for it was hidden away in rather inaccessible hilly country a couple of miles northwest of Fairfield, a farming village clearly marked on the road map but almost unrecognizable as a center of human habitation otherwise. We finally found the locality up a small westerly trending canyon (Clay Canyon, as we found out later) which we negotiated with our car by following old tracks around clumps of sagebrush and along the bed of a sandy wash. The small mine dumps lay close to the canyon bottom on its northerly side. Close above these in the hillside loomed the square opening of a mine tunnel. There was no evidence of anyone having been there for a long time.
>
> We lighted our carbide lamps and began an exploration of the underground workings. The tunnel was dry, musty and quite cool, and led straight into the hillside for a hundred feet northward. There it ended in a large, high chamber, one wall of which exposed a zone of brecciated rock. Angular chunks of iron-stained limestone, from small fragments up to boulder size, were embedded in a soft, powdery grayish matrix. Within the brecciated matrix we noted a scattering of round gray shapes something like large potatoes in appearance. These were concretionary nodules of highly altered phosphate minerals. Their interiors, when broken open, revealed porous,

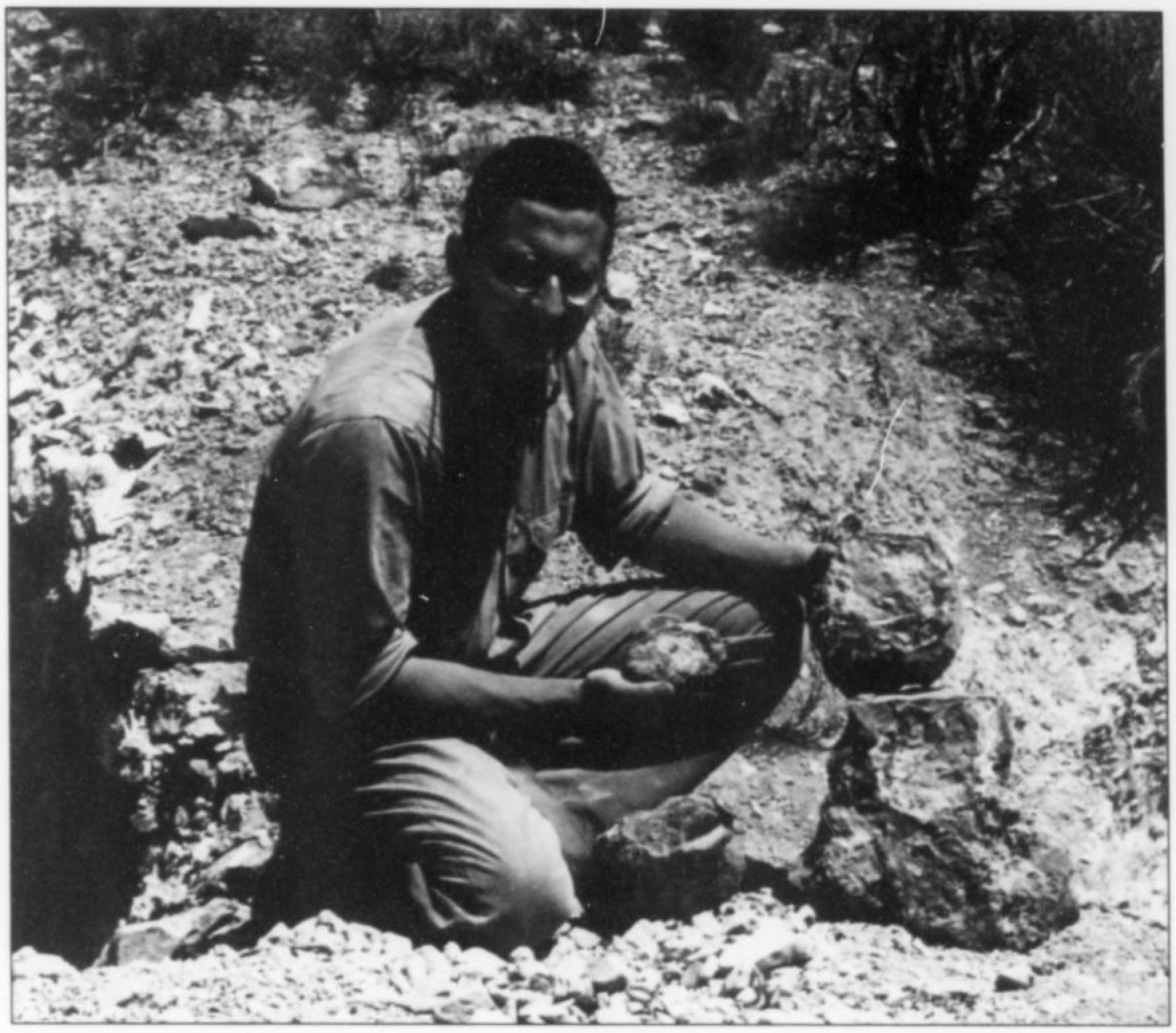


***Figure 12.* Arthur Montgomery with variscite nodules at the adit to the Little Green Monster mine, 1937. Photo by Ed Over, courtesy of Terry Szenics.**

earthy masses of whitish material we guessed to be crandallite (known at that time as pseudowavellite). This occurrence of abundant concretions of altered phosphates suggested an obvious relationship to other nodular phosphates such as variscite. However, there was not a trace of greenish variscite present in this breccia zone. No wonder the miner who drove that long tunnel had stopped here, and discontinued his search for variscite in this section of the mine.

Up on the hillside above there was a small-sized, partly caved-in pit, with adjacent waste dumps, some distance upslope from the tunnel entrance. That was probably where the first discovery of variscite had been made. It looked as if the tunnel had been run in such a way as to try to intersect at depth this phosphate-bearing breccia zone cropping out at the surface.

Thirty or forty feet back from the tunnel's ending at the breccia zone there was an opening into a side-drift running off in an easterly direction roughly perpendicular to the trend of the tunnel. We followed that drift for about 30 feet, at which point it turned sharply northward, parallel to the main tunnel. Ten or 15 feet more and it ended abruptly in a face of earthy brownish material. The soft, broken-up appearance of the material, suggesting fault gouge, made it a promising place to start digging.

We dug with sharp drift picks into that blank wall. After several hours of hard pick-and-shovel work, made more difficult by the close quarters, insufficient air and increasingly dust-laden atmosphere, we had extended the drift face a foot or two farther to the north. All at once a pick stroke hit something, and partly exposed in the middle of the face a little brownish curving shape. It was a hard, solid nodule looking just like a small potato. We pried it out of its earthy matrix, examined it, and noted that it felt heavy. One of us struck it with a geological hammer and broke it in two. The honeycombed interior showed a partial filling of glassy, pale bluish material which sparkled with light reflected from the faces of tiny crystals lining the walls of small cavities. We had discovered a well-crystallized specimen of a quite rare phosphate mineral, wardite. I had first seen the mineral on display in the Morgan Hall in the American Museum of Natural History, where it stood out as bluish veinlets and small, spherical eye-like shapes within two beautiful polished slabs of variscite that had come from the original mining at Fairfield. But I had never seen a distinctly crystallized specimen of wardite until we had broken open that first small nodule.

Greatly encouraged by our find, we continued vigorous pick-and-shovel mining in the north face of the drift. Every once in a while we uncovered a small nodule in the soft, ground-up rock material we were digging out and throwing behind us. We accumulated a good number of them during several days of work while we extended the drift ten or more feet farther north. Most of the nodules contained nothing but powdery, whitish or yellowish crandallite; but one or two more showed wardite, and several, when split open, revealed solid cores of deep green variscite. We were on the right track!

It was too late in our field collecting season that year to try to commence any serious mining operation. We decided to return early the following summer.

We returned to the variscite mine and staked our own lode claim there on May 27, 1937, naming it the Little Green Monster mine, then resumed our pick-and-shovel mining in the face of the side drift. We advanced another ten feet or so northward. At first we ran into a scattering of small nodules, picking up just enough production of deep green variscite, yellow crandallite and associated rare phosphates in a few nodules to make it worthwhile. Unfortunately, as we dug our way northward,

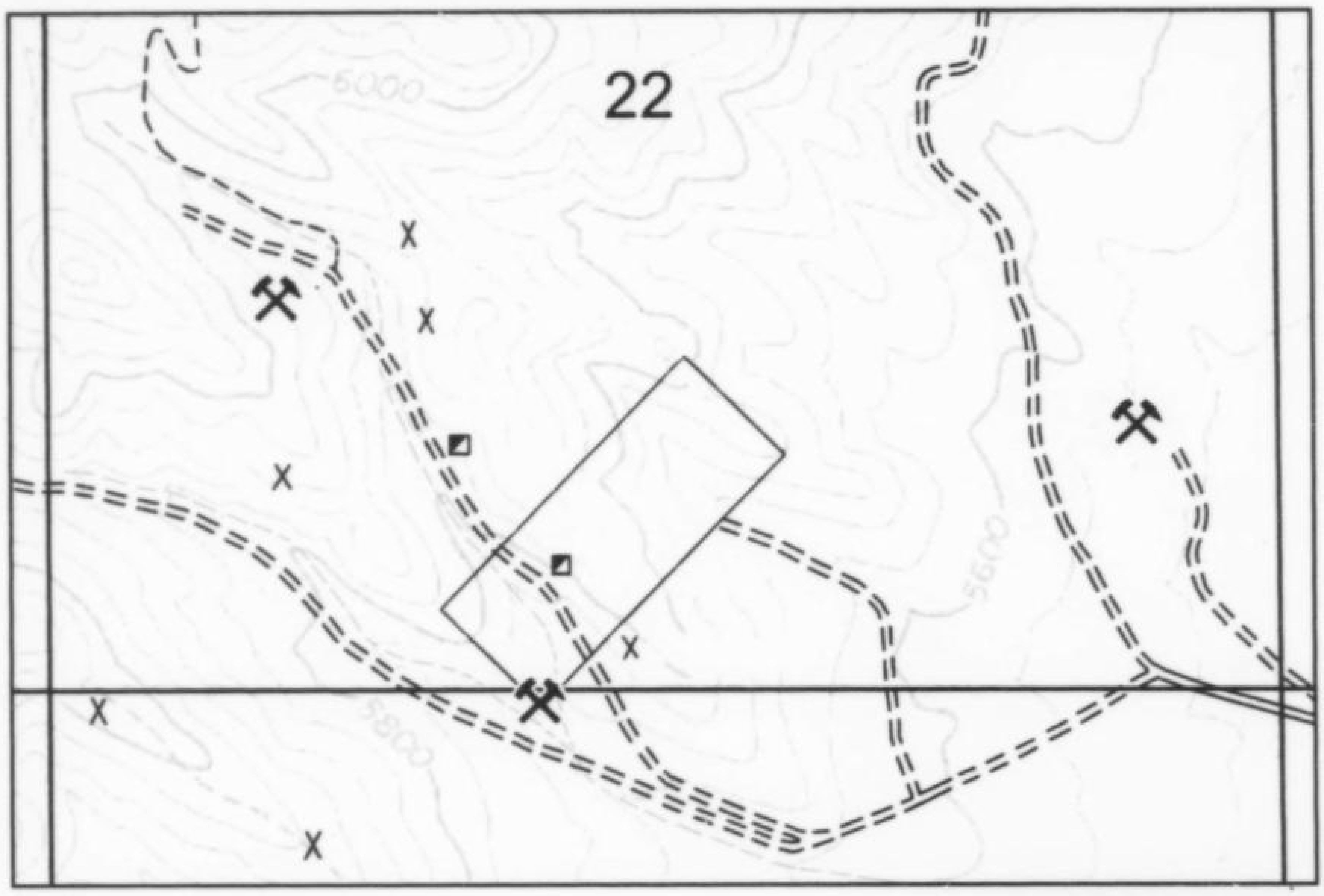


Figure 13. **Location of the Little Green Monster claim in Section 22, patented by Arthur Montgomery, Edwin Over and James Gough in 1948. The section is 1 mile wide. The north and south branches of Clay Canyon are indicated in blue.**

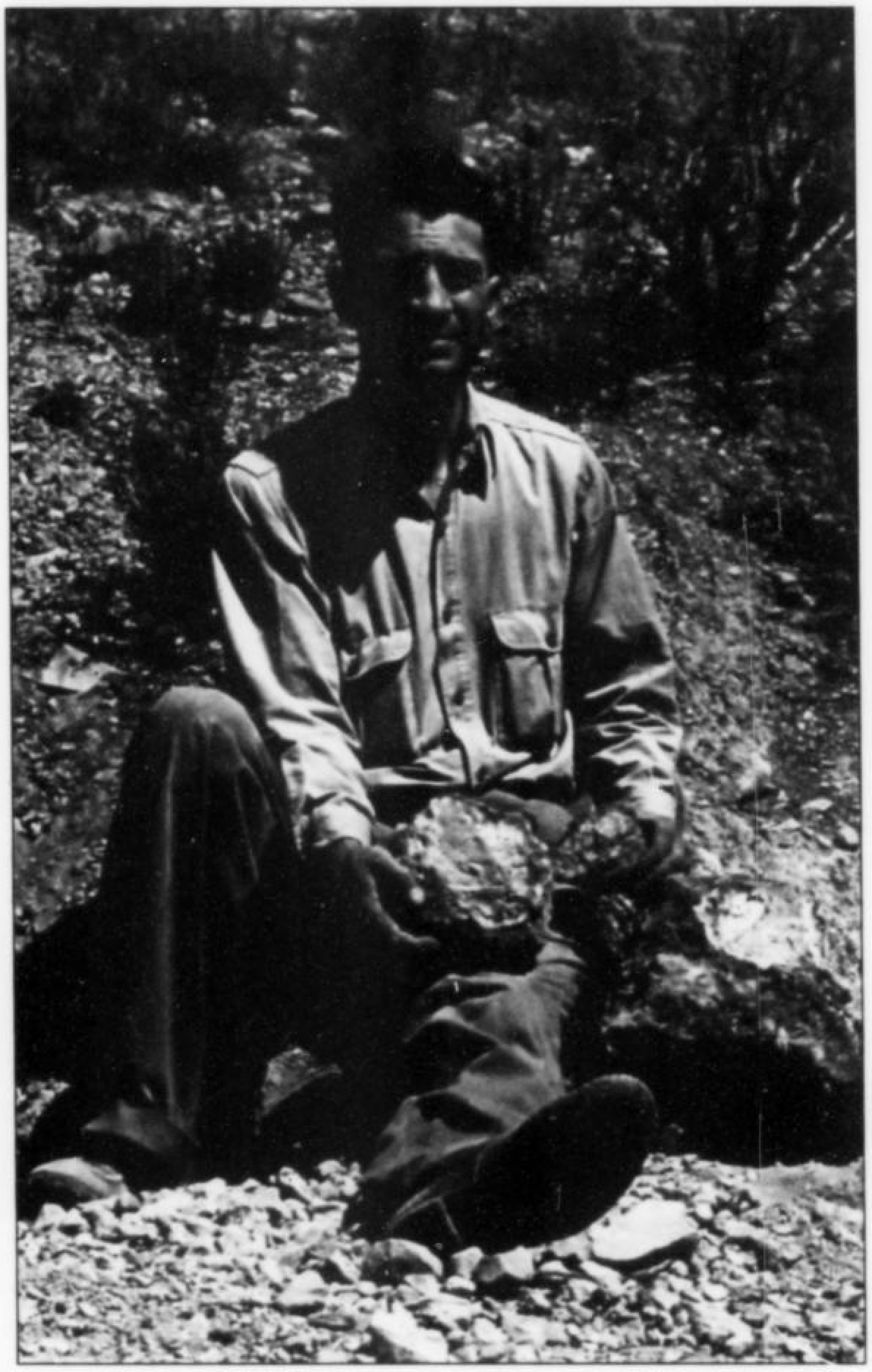


Figure 14. **Ed Over with variscite nodules at the adit to the Little Green Monster mine, 1937. Photo by Arthur Montgomery, courtesy of Terry Szenics.**

the soft ground became harder and rockier, and nodules grew increasingly scarce. Finally they quit on us entirely. We seemed to have passed beyond the nodule-bearing zone.

We went back some feet from the face to that part of our drift extension where we had found the largest number of nodules. By digging into the side walls we uncovered some more. One of us worked to the left (west) and the other to the right (east). Almost at once we noticed a difference in the two sides. While on the west side nodules kept appearing, in fact began to be more numerous; on the east side they gradually petered out after several feet. So we both concentrated our efforts on the west side, excavating a considerable opening into that wall. Not only were nodules growing more abundant, but the ground had become darker brown and extremely soft.

After a few feet of digging we noticed another change. Nodules of a larger size than any we had found before began showing up. By chipping off very carefully a small corner on the nodules we were usually able to learn whether or not variscite was likely to be present in the interior. In the great majority of cases, earthy and porous, pale yellow to whitish crandallite made up the whole nodule. But now and then an outer rind of wholly different character consisting of olive-green to greenish yellow crandallite was exposed. This generally meant variscite underneath. These nodules, rich in variscite, we sacked unbroken, knowing that their ornamental beauty and value would be enhanced through later sawing and polishing.

We started discovering nodules containing crystal cavities. These specimens we could not recognize at first, since they possessed a fair heft, intermediate between the really heavy nodules rich in variscite and the light-weight ones made up of nothing but highly altered porous crandallite. But they broke open rather easily because of their honeycombed internal structure. Not uncommonly, a small kernel of variscite, covered by a whitish coating and surrounded by narrow peripheral openings, was revealed near the center. Glassy, colorless prismatic crystals were sometimes observed implanted upon the curving variscite surface. Some were made up of clusters of sheaf-like sprays of colorless needles (lewistonite). In a few cases we spotted glassy blades, colorless to grayish and arranged in fan-like clusters perched on variscite. These were undoubtedly gordonite crystals, some up to a quarter inch long and of excellent transparent quality.

We enlarged our westerly excavation as we advanced into the wall. We were now digging in very soft, earthy, limonitic-stained material and nodules of all sizes and descriptions were showing up. They were becoming so plentiful, in fact, that we never failed to have a number of their curving shapes exposed in the face. We had broken into a zone of extraordinarily rich nodule-bearing ground.

Soon we had so enlarged our new westerly diggings, with nodule-rich ground on all sides, that we gradually found ourselves engaged in stoping out a large chamber. This stope grew larger until it measured more than 15 feet across. We were even mining nodules out of the roof and from the floor beneath our feet. How well I recall the excitement of those weeks in July and August when we were mining in paydirt! Thousands of pounds of nodules were being extracted each week, of which perhaps a tenth part seemed likely to consist of good quality variscite and could be sacked. The rest were nothing but worthless altered crandallite and were discarded. Best of all, we were slowly accumulating a number of specimens showing various crystallized minerals sparkling within small cavities. Every week we were able to ship back east to our business headquarters hundreds of pounds of variscite nodules. These went in double gunny sacks and were shipped by railway freight from American Fork. The crystallized material, carefully labeled and wrapped in newspaper, went in cartons by railway express.

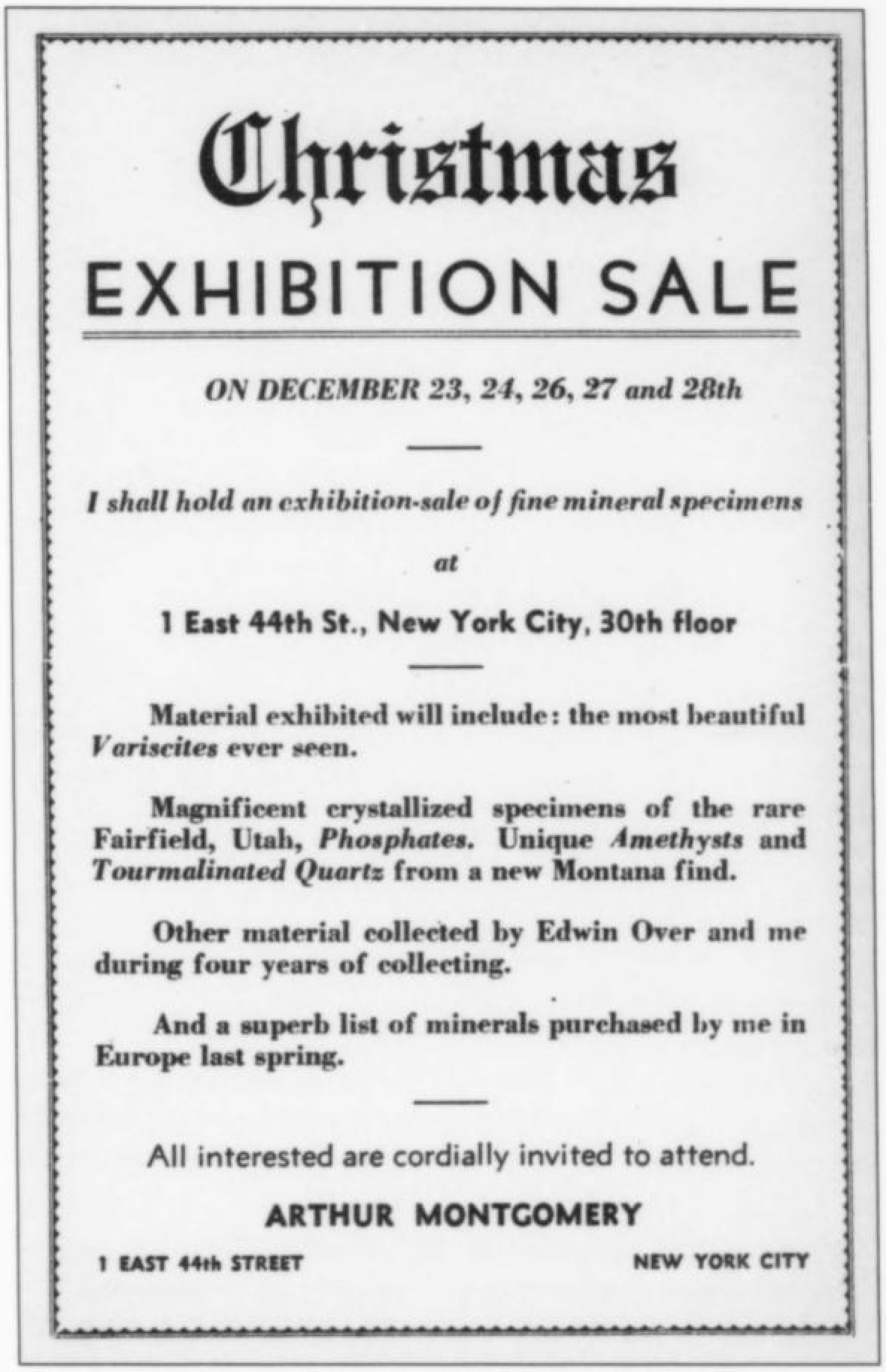
We knew that such phenomenal production could not last forever. Finally the nodules began to thin out in our stope and its surrounding extension galleries. The high roof went into hard, brecciated barren ground; the floor, some feet below tunnel level, at last produced nothing but highly altered crandallite. It was time to stop mining. We had shipped more than a ton of first-class nodules, together with a good number of crystallized specimens.

The situation looked extremely unpromising for future variscite production, but we were not at all sure the deposit was worked out, and felt we might come back sooner or later for more exploratory mining. So we took special pains to record our assessment work covering 1937–1939, in order to maintain our claim.

Back east, the newly mined Fairfield material proved to surpass our highest expectations. Some of the finest specimens, among them nodules of solid variscite measuring up to 8 inches across, went to several of the larger museums and private collections. The best material, as always, ended up at Harvard and the Smithsonian. Ed and I made up our minds to return to Fairfield. We could not return the following summer, for we had planned a three-month expedition to Mount Antero, but the summer after that, of 1939, would be a good time.

When we arrived at the mine in June of 1939 we found that our claim had been jumped by two locals, Jim Chamberlain and his son. [Chamberlain was a South African-born farmer with two sons, William and Charles, living in Cedar Fort just north of Fairfield.] We wasted most of a day putting up new claim notices and checking the mine workings. Fortunately the Chamberlains appeared to have done little digging. But prospects for locating fresh occurrences of nodules looked poor. For some days we carried on exploratory mining within and all around the stoped ground where we had run into the great concentration of nodules. Wherever there was soft ground we dug our drift picks into it and opened it up for a foot or more. Hardly a sign of a nodule anywhere.

Finally one of us, after digging into the south wall of the old drift where it ran eastward just south of our stope, noted some brownish earthy gouge in the roof of the drift at that point. Standing on a pile of freshly mined material, we excavated


Christmas

EXHIBITION SALE

ON DECEMBER 23, 24, 26, 27 and 28th

I shall hold an exhibition-sale of fine mineral specimens

at

1 East 44th St., New York City, 30th floor

Material exhibited will include: the most beautiful *Variscites* ever seen.

Magnificent crystallized specimens of the rare Fairfield, Utah, *Phosphates*. Unique *Amethysts* and *Tourmalinated Quartz* from a new Montana find.

Other material collected by Edwin Over and me during four years of collecting.

And a superb list of minerals purchased by me in Europe last spring.

All interested are cordially invited to attend.

ARTHUR MONTGOMERY

1 EAST 44th STREET NEW YORK CITY

Figure 15. **Ad in the December 1937 issue of *Rocks & Minerals* announcing Montgomery's annual sale of minerals he had collected with Ed Over the previous summer.**

Figure 16. **A wheelbarrow full of freshly dug variscite nodules, 1937. Photo courtesy of Terry Szenics.**

***Figure 17.* Ed Over peeking out of the opening to the surface they had dug following a vein of variscite nodules in 1939. This photo was exhibited at Montgomery's December 1939 sale of specimens they had collected. Photo courtesy of Terry Szenics.**

a hole upward and above the south wall. Suddenly a nodule appeared, then another. We built up a platform of waste rubble in the drift so that we could stand upon it and more easily get at the ground high above our heads, and proceeded to open up the roof area above and south of the drift with great excitement and redoubled energy. As we dug our way upward, out came the nodules, more and more of them, dropping to the floor of the drift with loud thuds. The completely unexpected had happened again! We had broken into another phenomenally rich ore zone.

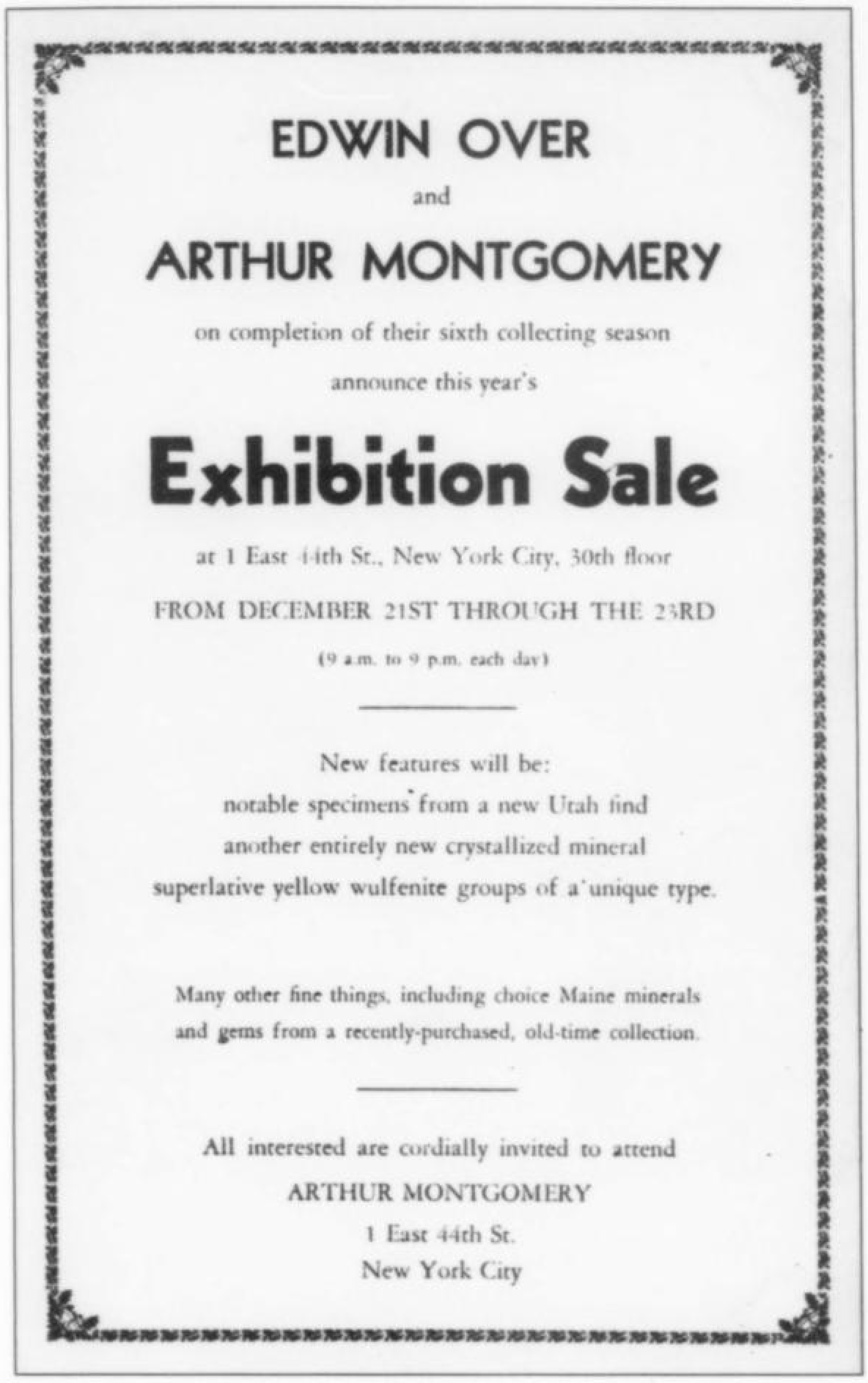
We followed that ore zone upward at a fairly steep angle from the roof of the drift for two months. We were actually running a raise up toward the surface at about a 30° angle, and we were, in nodules continuously. It was clearly an upward-trending continuation of the ore-bearing ground we had stoped out at a deeper level north of the drift. It seemed to be a pipe-like zone of intense brecciation lying within a major fault. Portions of that same fault were seen in the exposures of nodules at the end of the main tunnel and in the discovery pit up on the hillside. But only within certain limited channelways along that fault, it seemed, had variscite nodules formed and been preserved from alteration to crandallite.

Here we were, producing nodules even faster and in greater quantity than in 1937. We followed that rich ore zone in our raise for 70 feet all the way to the surface, eventually breaking through into the sunlight at a spot several tens of feet downslope from the old surface pit on the hillside. A tremendous number of variscite nodules up to 12 inches across came out. We were mining nodules by the thousands. By the time our raise broke out onto the surface we had produced a couple more tons of sacked variscite nodules, most of them first-quality. We also produced a considerable number of crystallized specimens which we turned over to Professor Larsen's son, Esper S. Larsen III, for research.

When our second summer's mining came to an end, we felt we had been responsible for opening up one of the great mineral localities of the world, and bringing to light some of the most beautiful, and also mineralogically rare and interesting, specimens ever seen.

Montgomery advertised his "Christmas Exhibition Sale" for December 23–28, 1937 in New York, offering "the most beautiful variscites ever seen," and "magnificent crystallized specimens of the rare Fairfield, Utah phosphates." Again, in December 1939, he held another sale featuring "notable specimens from a new Utah find." (See Martin Plotkin's 1991 account of attending that sale as a college student.) Although Montgomery's sales included some modestly priced specimens, he really had no interest in selling good minerals at affordable prices or making them available to the most collectors. On October 27, 1937, he wrote as follows to his friend Sam Gordon (namesake of gordonite) at the Academy of Natural Sciences in Philadelphia (quoted by Conklin, 2002):

> None of these minerals will be sold indiscriminately or cheaply enough to flood the market and make them appear as common in the eyes of anyone. Although I have a very great number of superbly crystallized gordonites, for example, it is likely that only a number of the best ones will be sold at all, only as much as for which there is a real demand by the important museums and private collectors. I would rather keep the prices extremely high, and only sell a handful of the finest specimens to places where their excellence and rarity will be fully appreciated, than sell a hundred times as many at low prices [even though] the latter way may be the most successful financially. That is my personal philosophy, as applied to mineral selling.


EDWIN OVER

and

ARTHUR MONTGOMERY

on completion of their sixth collecting season

announce this year's

Exhibition Sale

at 1 East 44th St., New York City, 30th floor

FROM DECEMBER 21ST THROUGH THE 23RD

(9 a.m. to 9 p.m. each day)

New features will be:

notable specimens from a new Utah find

another entirely new crystallized mineral

superlative yellow wulfenite groups of a unique type.

Many other fine things, including choice Maine minerals and gems from a recently-purchased, old-time collection.

All interested are cordially invited to attend

ARTHUR MONTGOMERY

1 East 44th St.

New York City

***Figure 18.* Ad in the December 1939 issue of *Rocks & Minerals* announcing Montgomery's annual sale of minerals he had collected with Ed Over the previous summer.**

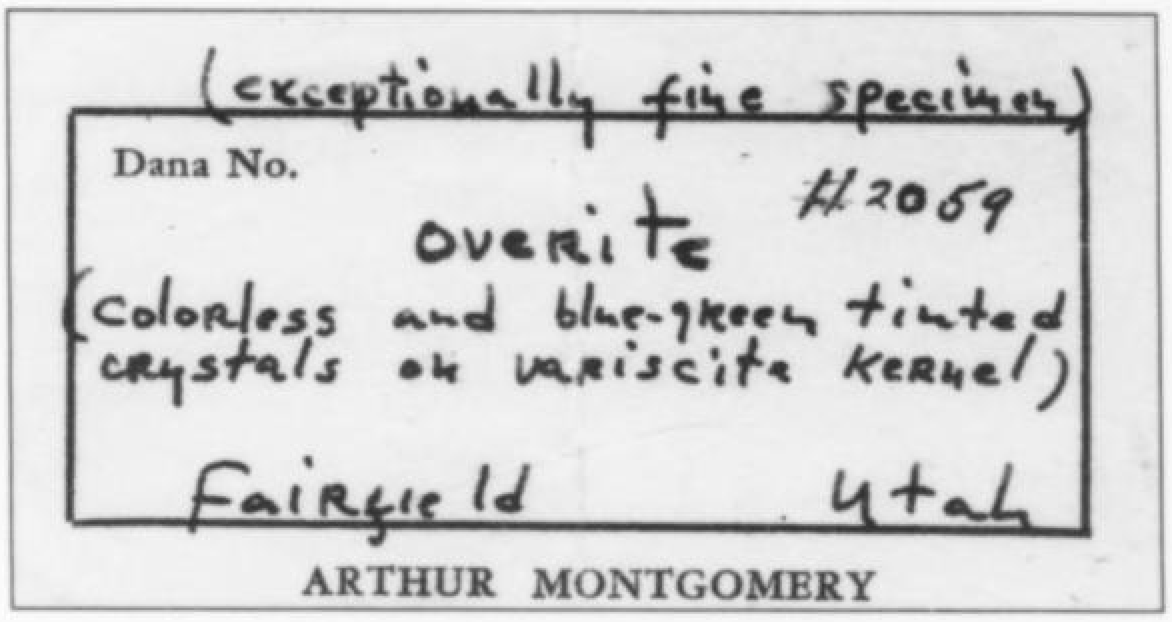
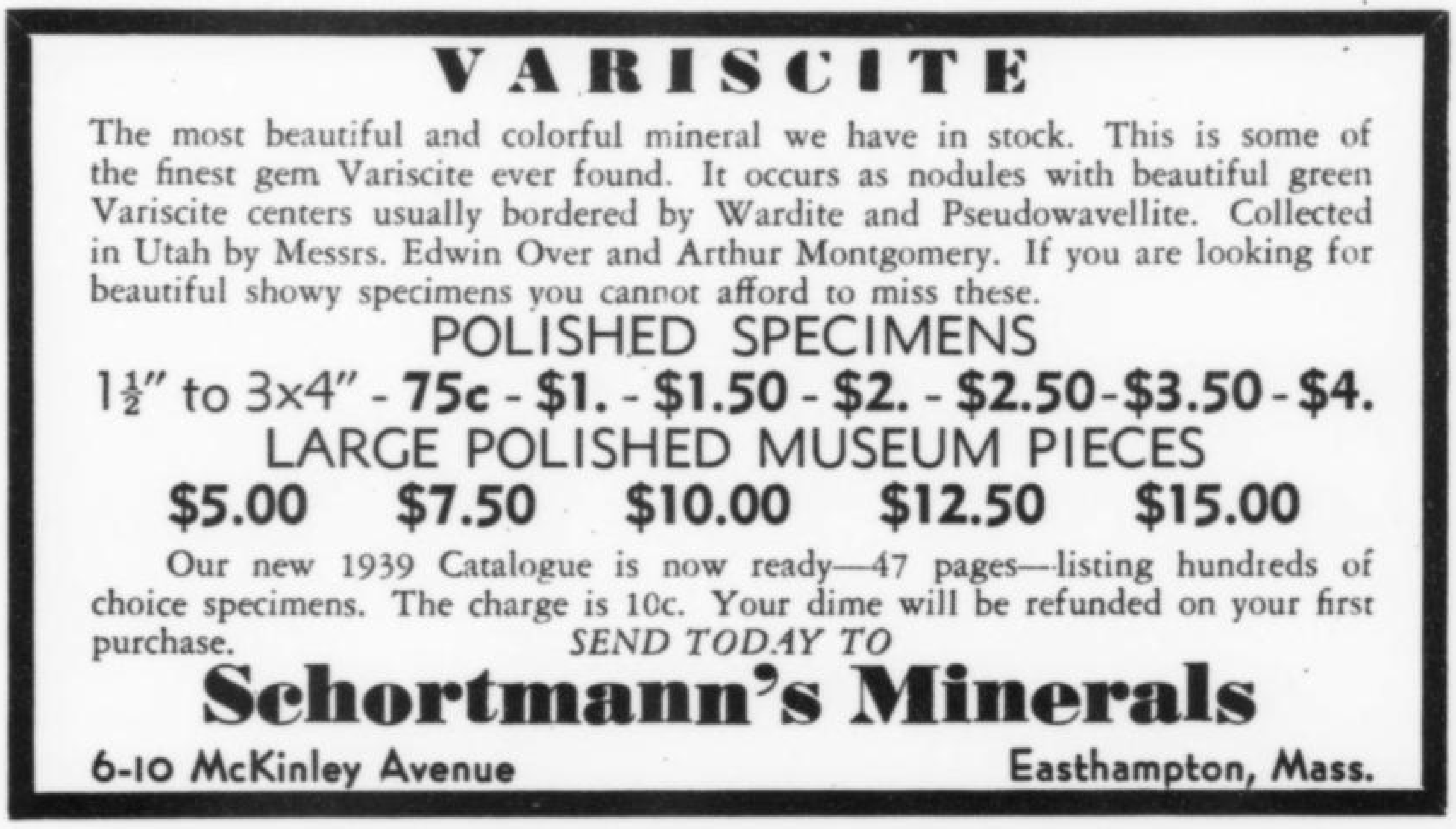


***Figure 19.* A Montgomery label for an exceptionally fine specimen of overite.**

Conklin wonders (as might we all) whether Montgomery destroyed or discarded many Fairfield specimens in order to create artificial rarity—or perhaps sold them for processing as bulk scandium ore, just to keep them off the specimen market. We will never know, but his expressed attitude may explain the rarity of good gordonite specimens today.

After that second summer at the mine, Montgomery and Over enlisted a local man, James William Gough (1897–1986) of Lehi, to continue the assessment work and keep their claim valid; in exchange he could keep whatever minerals he found (Montgomery, 1971b). Ball (1945) reported that the Clay Canyon deposit had been worked for a short time in 1944 and some good variscite nodules were shipped "to the east," possibly to Schortmann's Minerals in Massachusetts—they advertised specimens again that year, including a 9½-inch polished nodule for $30. Warner and Grieger in Pasadena also offered "full complete sawed nodules" of variscite at $2 to $7 per pound in 1944. These may have been mined by Gough, but more likely they all came from Dr. George Bernard Robbe (1884–1963); the vast majority of the 30 fine variscite specimens in the Seaman Mineral Museum came as a bequest from Robbe, a Michigan Tech graduate (1913) who had moved west and worked for the Utah Copper Company's Bingham Canyon mine, where he helped develop techniques for the chemical extraction of copper from ores. According to Seaman Museum records (George Robin-


VARISCITE

The most beautiful and colorful mineral we have in stock. This is some of the finest gem Variscite ever found. It occurs as nodules with beautiful green Variscite centers usually bordered by Wardite and Pseudowavellite. Collected in Utah by Messrs. Edwin Over and Arthur Montgomery. If you are looking for beautiful showy specimens you cannot afford to miss these.

POLISHED SPECIMENS

1½" to 3x4" - **75c - $1. - $1.50 - $2. - $2.50-$3.50 - $4.**

LARGE POLISHED MUSEUM PIECES

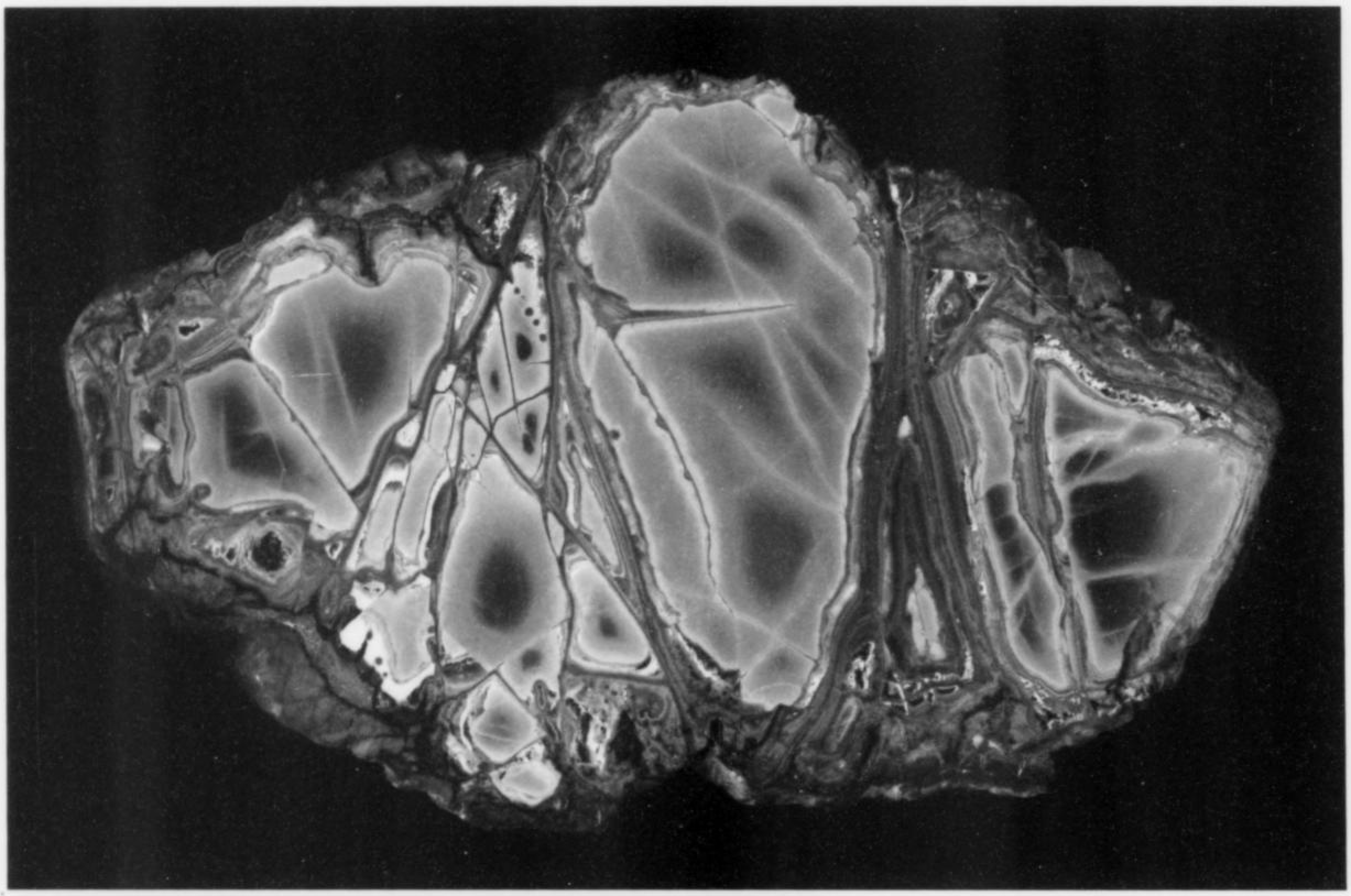
$5.00 $7.50 $10.00 $12.50 $15.00

Our new 1939 Catalogue is now ready—47 pages—listing hundreds of choice specimens. The charge is 10c. Your dime will be refunded on your first purchase. *SEND TODAY TO*

Schortmann's Minerals

6-10 McKinley Avenue **Easthampton, Mass.**

***Figure 20.* Schortmann's ad in the February 1939 issue of *Rocks & Minerals* offering variscite collected by Montgomery and Over, presumably during their first (1937) field season at the Clay Canyon mine.**



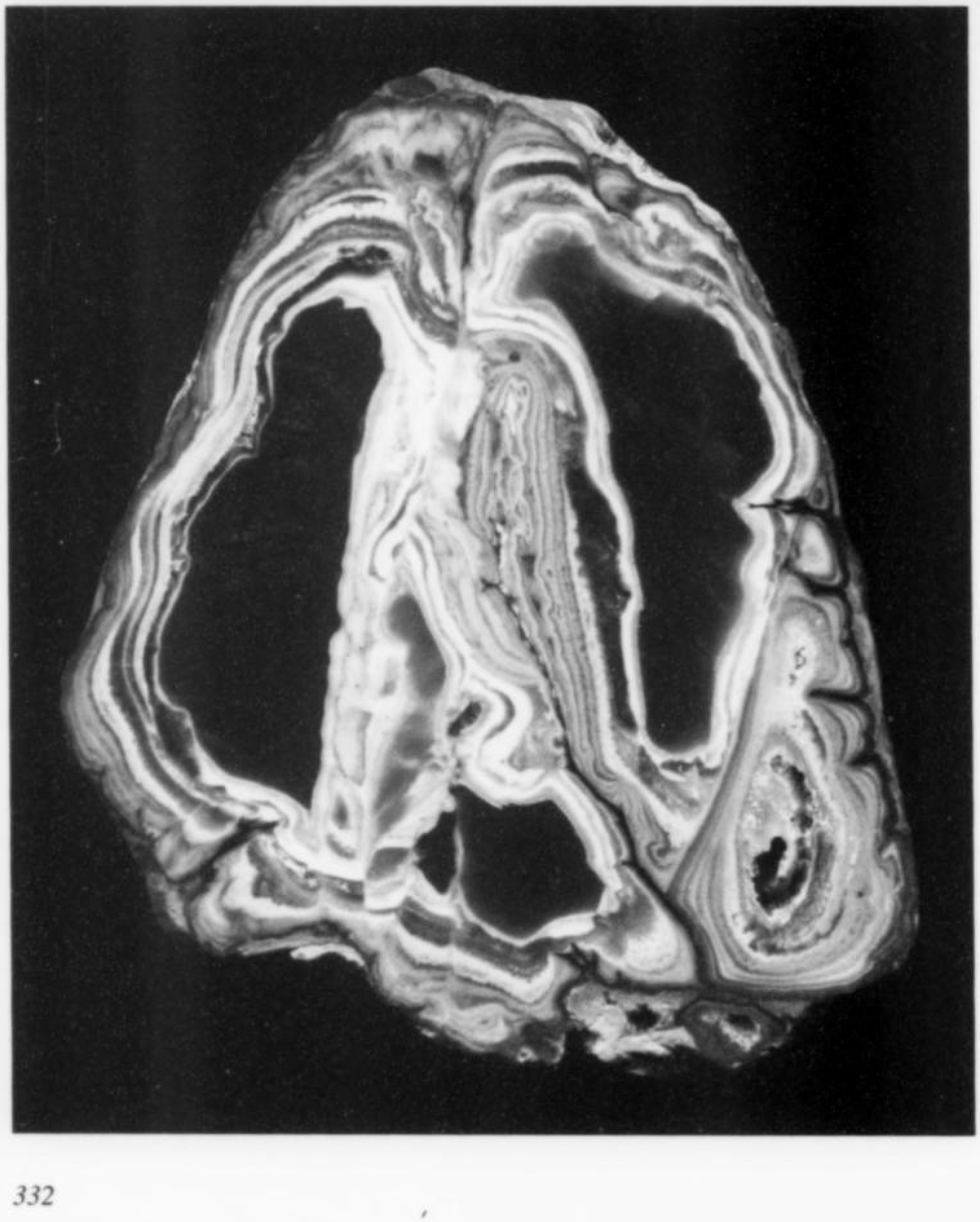
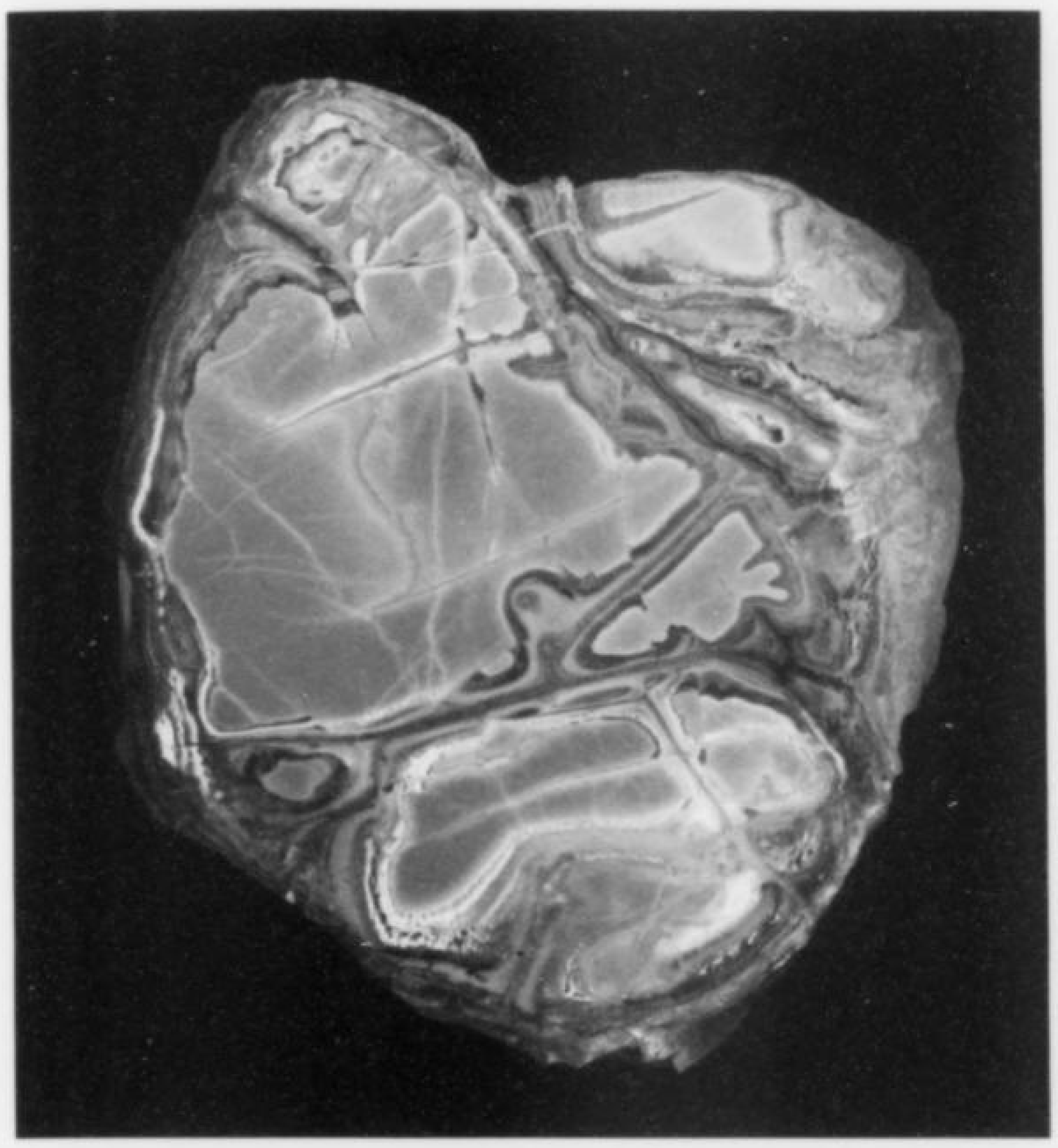
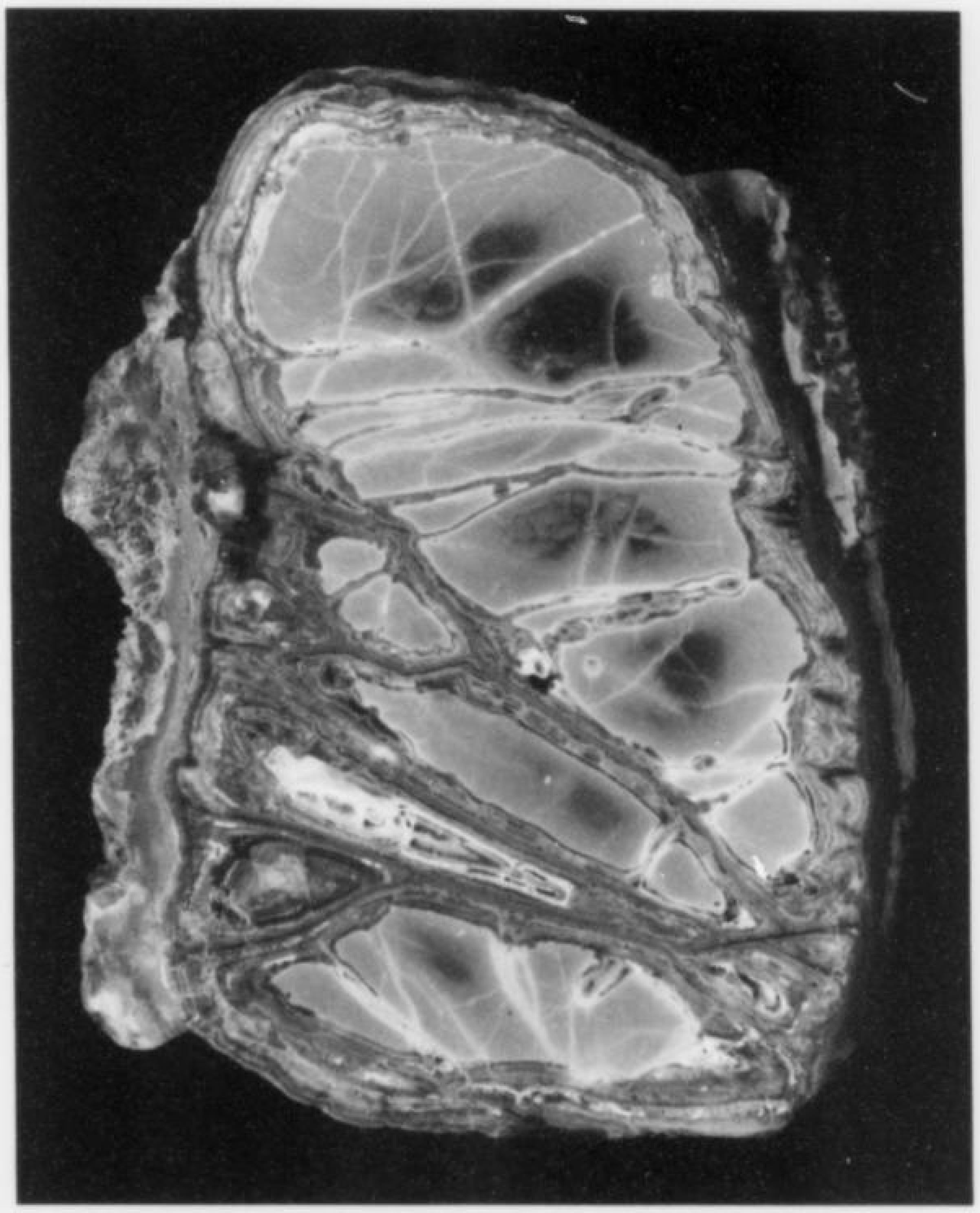


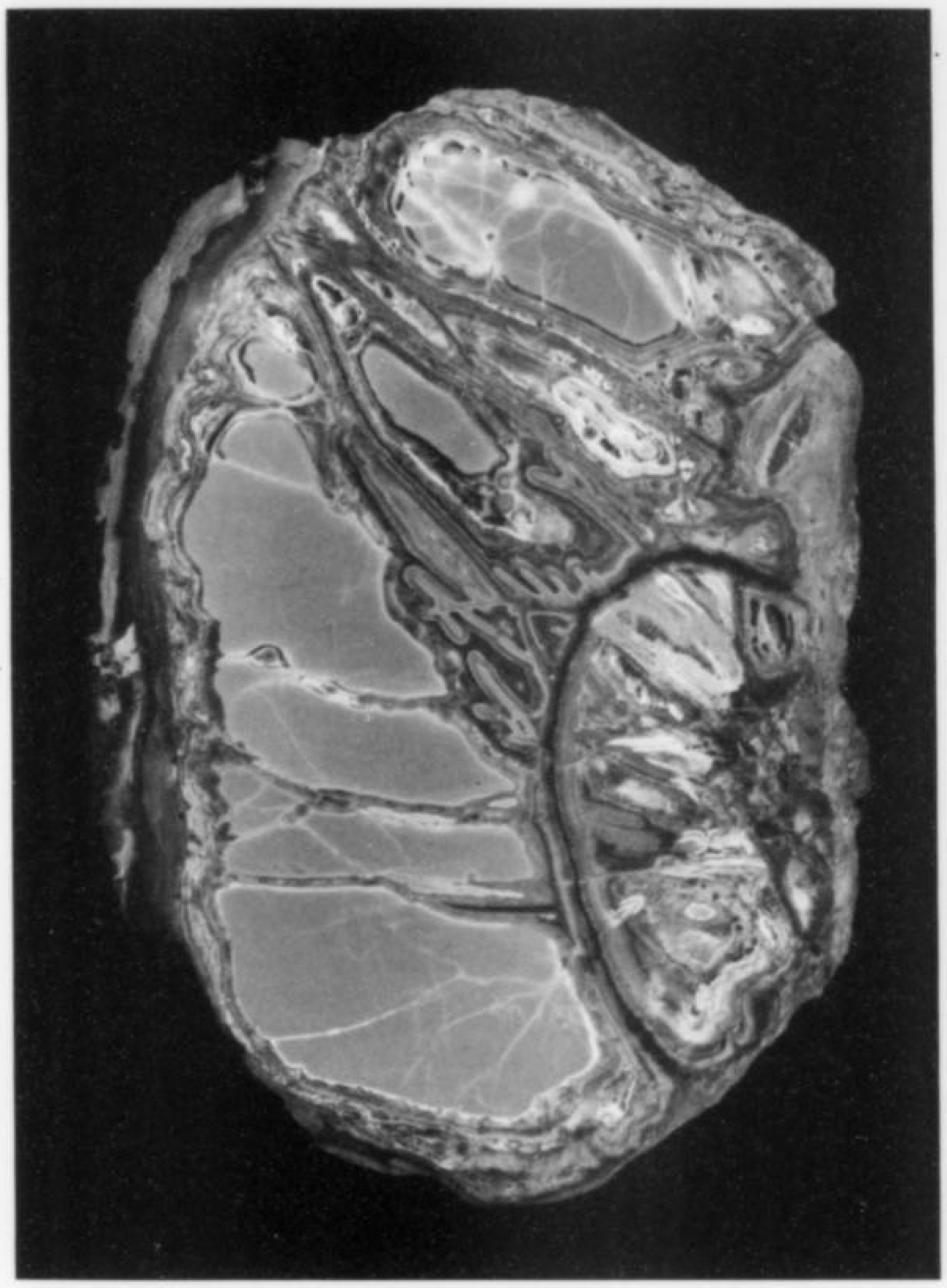
Figure 21. Variscite nodule, 17 cm, collected at Clay Canyon by George Robbe ca. 1944. Seaman Mineral Museum collection (GBR-1436); George Robinson photo.

Figure 22. Variscite nodule rich in yellow crandallite and showing particularly dark green variscite, 7.5 cm, collected at Clay Canyon by George Robbe ca. 1944. Seaman Mineral Museum collection (GBR-1627); George Robinson photo.

Figure 23. Dr. George Robbe (1884–1963), a Michigan Tech graduate, mined the Clay Canyon mine in 1944. Many fine specimens from his personal collection are now in the Seaman Mineral Museum in Houghton, Michigan. (Photo courtesy of George Robinson, Seaman Mineral Museum.)







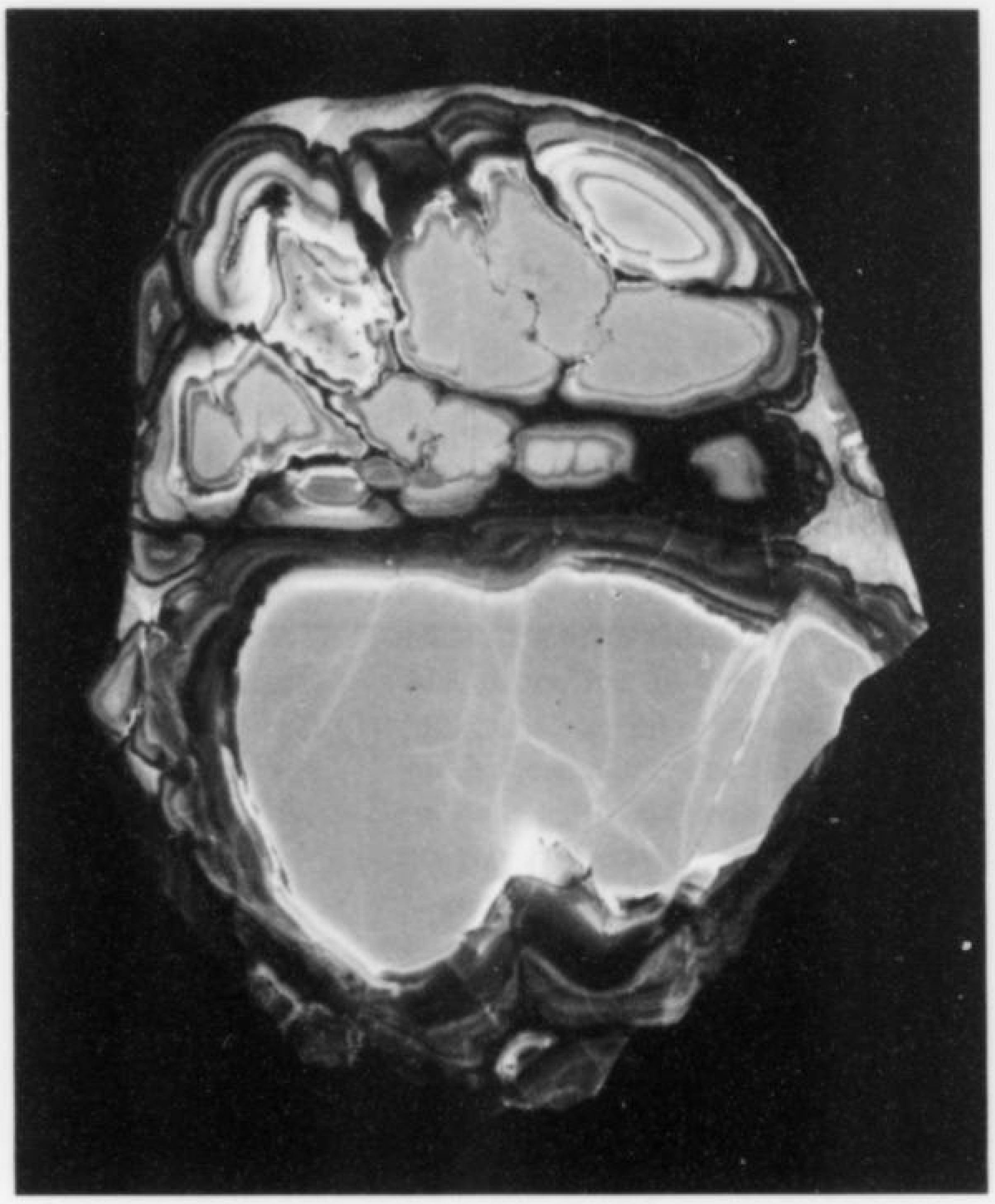


Figure 24 (top left). **Variscite nodule, 9.5 cm, collected at Clay Canyon by George Robbe ca. 1944. Seaman Mineral Museum collection (GBR-1663); George Robinson photo.**

Figure 26 (above left). **Variscite nodule, 15 cm, collected at Clay Canyon by George Robbe ca. 1944. The blue veining is wardite. Seaman Mineral Museum collection (GBR-1613); George Robinson photo.**

Figure 25 (top right). **Variscite nodule, 15 cm, collected at Clay Canyon by George Robbe ca. 1944. Seaman Mineral Museum collection (GBR-1439); George Robinson photo.**

Figure 27 (above right). **Variscite nodule, 8 cm, collected at Clay Canyon by George Robbe ca. 1944. Seaman Mineral Museum collection (GBR-2778); George Robinson photo.**

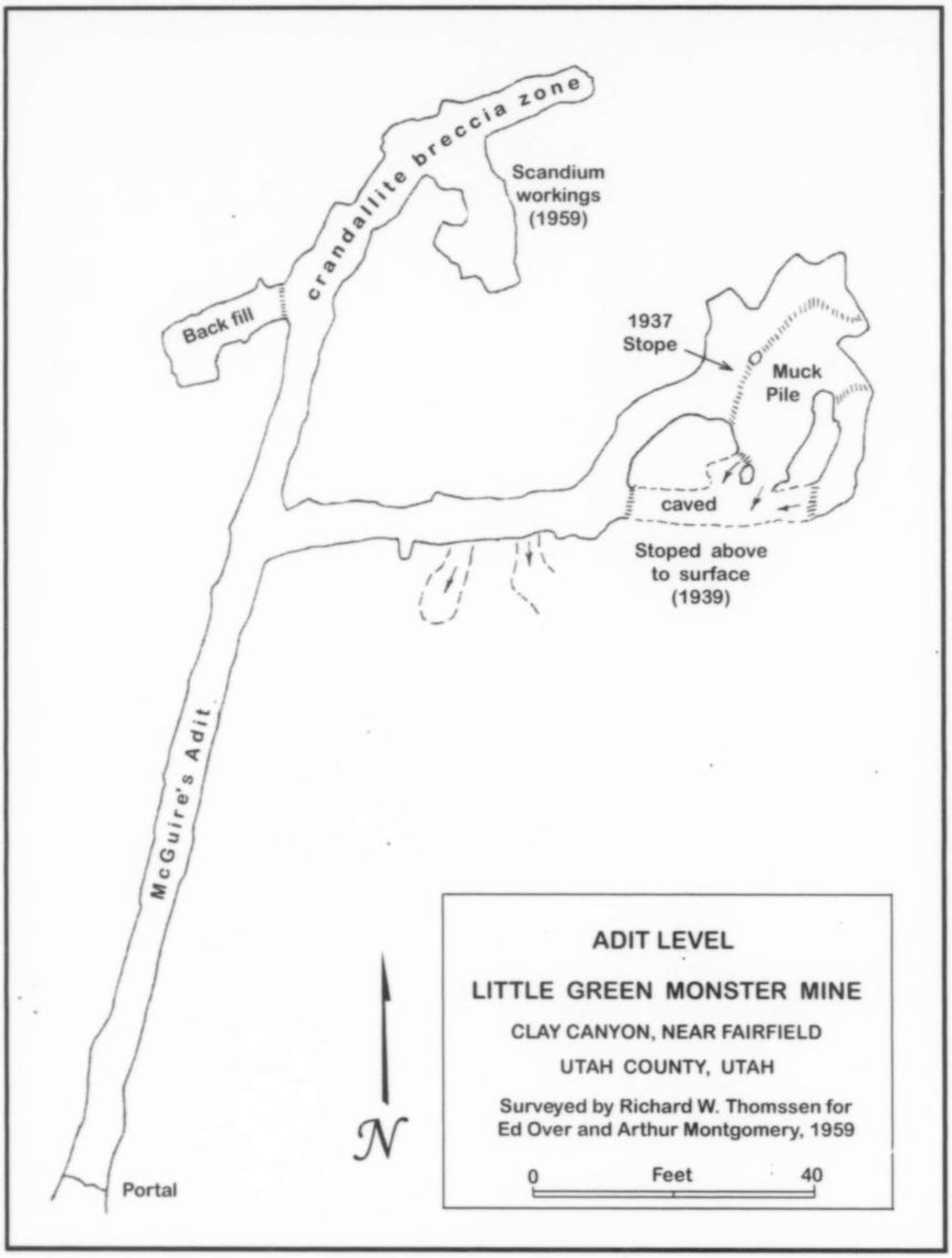


Figure 28. **Underground mine plan based primarily on the 1959 map drawn for Montgomery and Over by Dick Thomssen (Montgomery, 1997), and information contained in an unpublished map drawn by Arthur Montgomery, and on his written descriptions (Montgomery, 1970a, 1970b, 1971a, 1971b).**

Figure 29. **Warner & Grieger ad in the March 1945 issue of *Rocks & Minerals* offering variscite slabs with "pseudowavellite" (crandallite) and wardite. The statement that "the mine has been worked out completely" was not entirely accurate. Who their source was, "the last operators," is uncertain.**

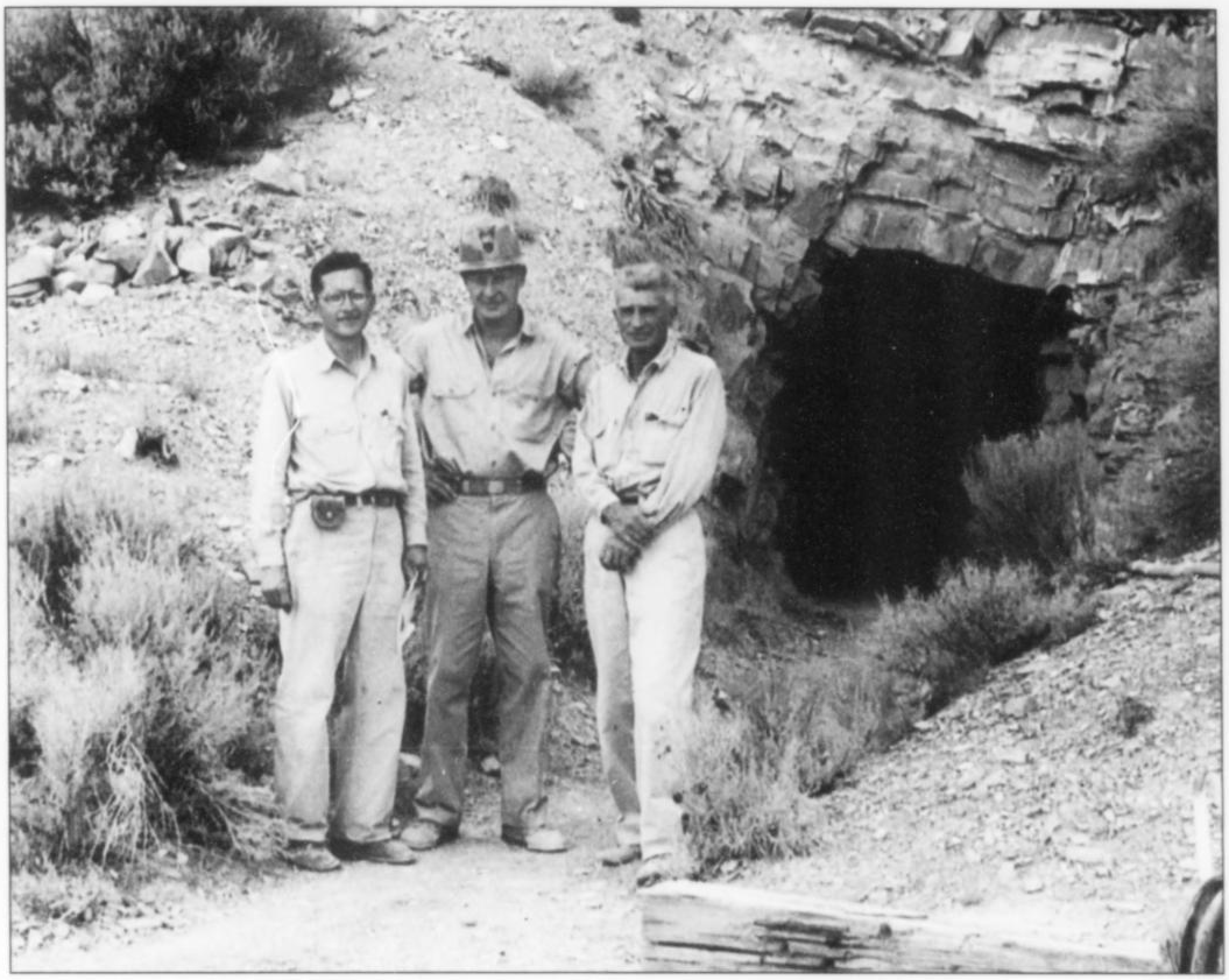


Figure 30. **Arthur Montgomery (*left*), Louis Schoenberger and Ed Over (*right*) at the Little Green Monster mine in 1959, during the brief attempt to mine the deposit for scandium. (Over died four years later.) Photo courtesy of Terry Szenics.**

son, personal communication). Robbe paid miners to mine variscite for him at Clay Canyon in the 1940s, probably under a lease from Montgomery and Over.

Through much of the 1940s the claim was plagued by claim jumpers and unauthorized collectors, including the Chamberlains who continued their efforts to gain control of the property by accusing Gough of not having done the proper assessment work. In 1941 James Chamberlain staked his own claim, calling it the "Green Gem" claim, over Montgomery's claim. Finally, in 1948, Montgomery, Over and Gough applied for a patent on the claim in order to settle the issue once and for all. The Chamberlains were unable to support their case, and the judge granted the patent request in 1952 (patent #1144484, survey 7207). Nevertheless, trespassing and unauthorized collecting continued, as is liable to happen when a famous property is left unguarded for years.

Commercial interest in the property was renewed when Mrose and Wappner (1959) discovered that sterrettite (kolbeckite) found there was actually a phosphate of the strategically important element scandium. Kawecki Chemical Company of Boyertown, Pennsylvania backed new exploration, which was carried out by Ed Over and Louis Schoenberger. A shipment of 330 pounds of crandallite nodules averaging 0.14 weight % Sc_2O_3 was shipped to Boyertown in 1959 so that a refining technique could be developed. A second shipment followed, consisting of 4,000 pounds of crandallite, variscite, chert and limonitic clay averaging 0.1 weight % Sc_2O_3. This ore was all mined from the crandallite breccia zone at the end of the main adit (Montgomery, 1997). The results were disappointing, however, and efforts ceased when major scandium deposits were discovered in Australia (Frondel *et al.*, 1968).

By the mid-1970s (Modreski, 1976) the underground workings had deteriorated and the adits had partially caved and become filled with rubble. Clifford Frondel (who took Over's part of the ownership during the brief scandium investigations) and Arthur Montgomery sold the patented claim to Archie Rae McFarland (1913–1980) of Beehive Machinery, Inc. in Sandy, Utah. Under the terms of the transfer, McFarland agreed to clean out the mine and improve accessibility for the benefit of collectors and students, and he was allowed to carry out small-scale mining. That doesn't seem to have happened, though, and the mine sat idle until it was eventually bulldozed shut as part of a reclamation effort. McFarland passed away, and the ownership of the patented claim was still held by Beehive Machinery, Inc. when that company was acquired by Katy Industries many years later. Having no interest in small-scale mining, Katy Industries sold the claim in 2001 to Reno, Nevada mineral dealer Alan Day of Mineral Exploration Services (formerly a partner with Scott Werschky in the *Miner's Lunchbox* dealership). Alan is confident that variscite can still be found there, and plans to reopen the mine.

GEOLOGY

The country rock exposed in the workings is a shattered and altered black limestone (the "Great Blue" limestone of Upper Mississippian age), the bedding of which strikes N50°W and dips 22°N. The variscite deposit is in a highly altered limonitic breccia zone along a fault dipping roughly 45°N. Sterrett (1908) described the deposit thus:

> Practically everything in this zone has a nodular shape, including the blocks of limestone breccia, etc. Chert forms a prominent part of the filling of the mineralized zone, and has been fractured and cemented by calcite seams and limonite. The nodules of variscite range from one-fourth of an inch to over four inches [actually over 24 inches] in thickness. The nodules have been more or less fractured, and the cracks have been filled in with yellow and white phosphate minerals. Some of the larger nodules contain two or more of the smaller nodules, or irregular masses of variscite, enclosed in yellow or white matrix or shells. Most of the nodules are surrounded by banded layers of the yellow phosphate and some have white coatings as well. The color of the variscite ranges from deep grass-green or emerald-green to paler shades and nearly white.

Larsen (1942c) proposed that the variscite originally formed by the action of descending phosphatic groundwaters produced by surface weathering of phosphorite beds in the overlying Phosphoria Formation, acting on aluminous material. Thomssen (1991) suggested instead that the phosphate was more likely derived from the nearby shale beds in the Great Blue limestone, a much closer source. Groundwater heated by a nearby rhyolite intrusion may have leached phosphate from the shales and circulated it through the breccia zone of the Clay Canyon deposit. After the rhyolite had cooled, the groundwaters were no longer being enriched in phosphates, and the change in chemistry caused alteration of the variscite into other phosphates with relict nodules of variscite remaining. The original vein, consisting almost entirely of pure green variscite, must have been quite spectacular before it was altered.

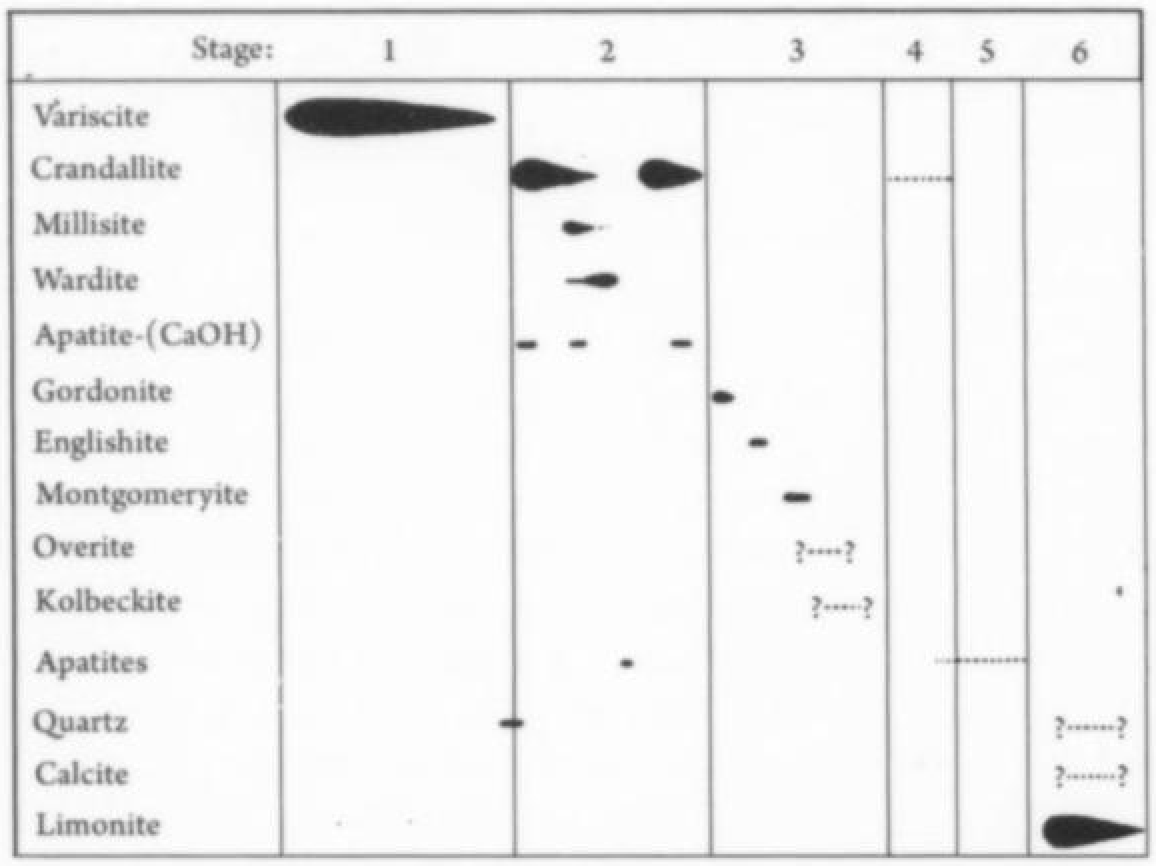


***Figure 31.* Paragenetic relationship between the minerals in the variscite nodules from the Clay Canyon mine. Showing the six stages of mineralization (Larsen, 1942b).**

PARAGENESIS

Larsen (1942b) made a detailed study of the paragenetic relationships in the evolution of variscite nodules in the Clay Canyon deposit, identifying six stages: (1) variscite formation, followed by fracturing and the introduction of thin black quartz veinlets; (2) banded minerals, primarily crandallite, millisite and wardite, replacing and enclosing variscite while opening up cavities through shrinkage (some variscite nodules were entirely replaced by crandallite); (3) formation of free-growing crystals of gordonite, englishite, montgomeryite and probably overite and kolbeckite in cavities; (4) a minor reversion to crandallite formation from solution as isolated oölites; (5) apatite-group minerals; and finally (6) the limonitic phase (limonite is not present inside any of the nodules). Alunite probably preceded variscite formation. There must have been a time interval at the end of stage 1 during which the variscite was fractured and brecciated by tectonic movements. These movements must have continued periodically during stage 2, as shown by spherules and bands which are cut by fractures and offset, although paradoxically the crandallite shells around the variscite nodules are unbroken by these fractures.

MINERALS

Alunite $KAl_3(SO_4)_2(OH)_6$

Larsen (1942a) reported the presence of alunite in the Clay Canyon deposit, as rounded, creamy white to dark gray nodules up to 20 cm in diameter, incorporating about one third of their weight in quartz. The alunite nodules were originally thought to be chert until they were tested.

Calcite $CaCO_3$

Calcite occurs as aggregates of coarse, corroded crystals on the surface of some variscite nodules. Many crystals are darkened by inclusions of limonite. One specimen (john C. Ebner collection) shows a brilliantly lustrous druse of calcite crystals coating limonite in a void inside a variscite nodule.

Carbonate-fluorapatite (see Fluorapatite)

Crandallite $CaAl_3(PO_4)_2(OH,H_2O)_6$

Crandallite was originally described from Germany by Loughlin and Schaller (1917). Larsen and Shannon (1930) described two minerals from the Clay Canyon variscite nodules which they described as pseudowavellite and the new species "lehiite" (they named the latter after the nearby town of Lehi), but both were later discredited as crandallite (Palache *et al.,* 1951; Dunn and Francis, 1986).

Crandallite is prominent in most nodules as dense, yellow to yellow-green crusts forming successive concentric layers of varying shades and textures. Pinkish spherulitic growths and white powdery crusts are also present. In fact, crandallite is the most abundant phosphate at the site, and most nodules found in the Clay Canyon deposit were composed entirely of crandallite (Larsen, 1942b). No distinct crystalline texture is visible in hand specimen, but under magnification the crandallite layers are seen to consist of felted masses of subparallel acicular crystals which appear coarser in some layers and very fine in others. Frondel *et al.* (1968) found that Clay Canyon crandallite contains up to 0.8 weight % scandium oxide; trace amounts of vanadium and chromium probably account for the color.

Davisonite (see Fluorapatite)

Dehrnite (see Fluorapatite)

Dennisonite (see Fluorapatite)

Deltaite (see Hydroxylapatite)

Englishite $K_3Na_2Ca_{10}Al_{15}(PO_4)_{21}(OH)_7 \cdot 26H_2O$

Englishite was described as a new species in the variscite nodules from the Clay Canyon deposit by Larsen and Shannon (1930), who named it after the prominent American mineral dealer George L. English. It occurs in 1-mm layers of transparent, colorless, glassy material in contact (or nearly so) with the variscite cores.

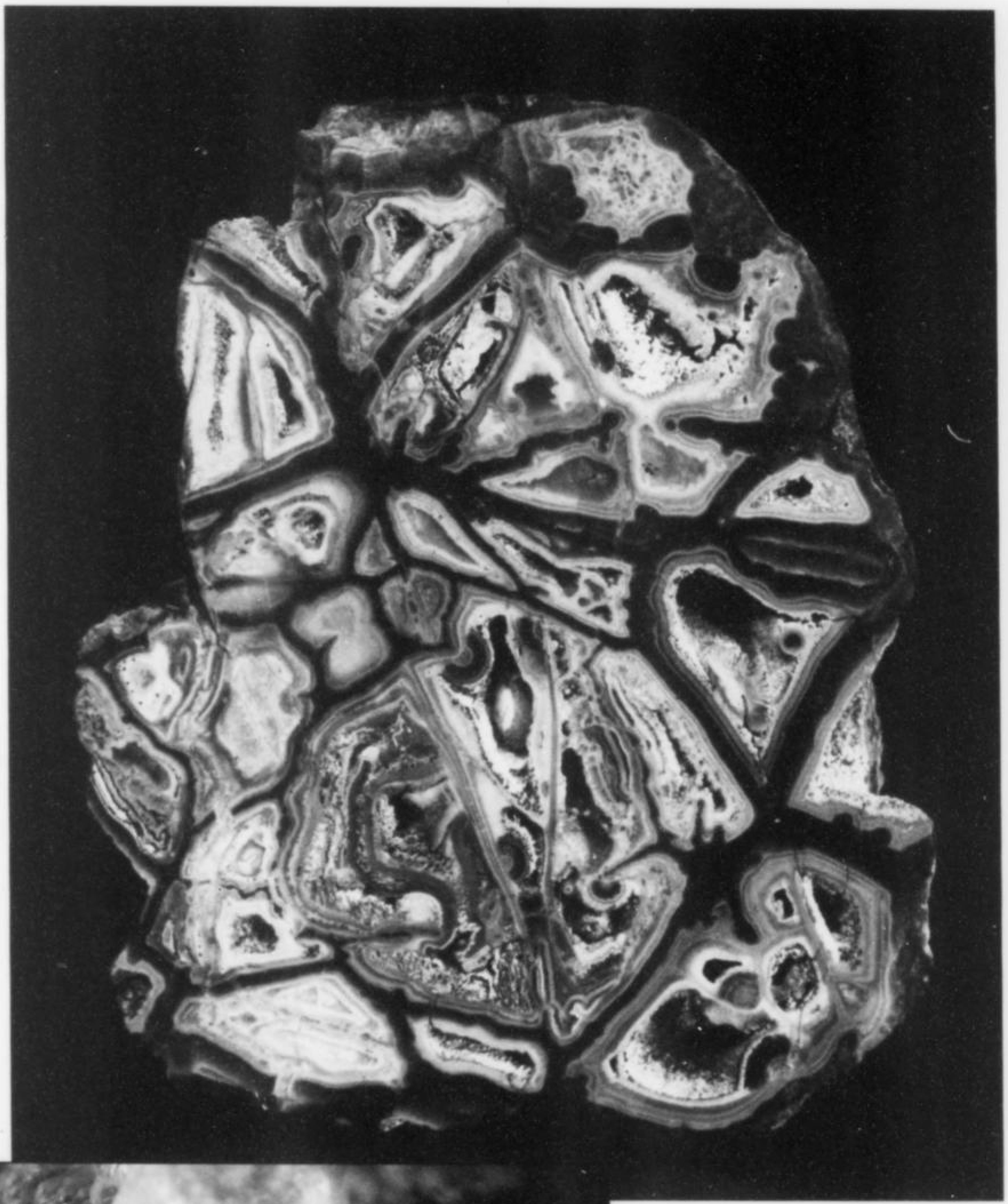


Figure 32. **A variscite nodule that has been completely altered to yellow crandallite and white phosphates, 7.3 cm, from the Clay Canyon mine. Seaman Mineral Museum collection; Jeff Scovil photo.**

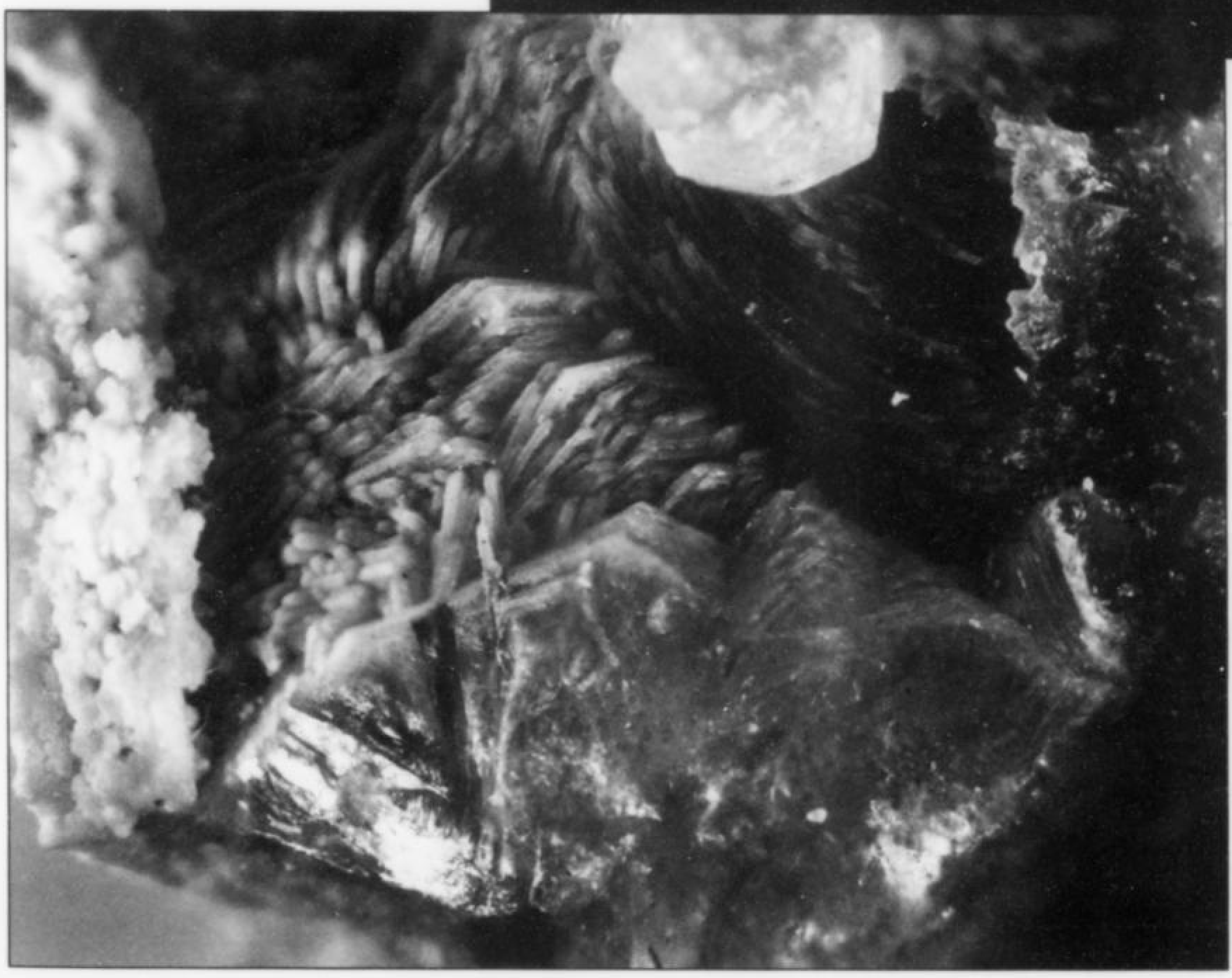


Figure 33. **Englishite in a tightly packed crystal group, 3 mm across, on variscite from the Clay Canyon mine. Note the micaceous luster on the cleavage face, which is diagnostic for the species. Terry Szenics collection; multifocus photo by Alex Halpern.**

Figure 34. **Englishite crystals to 1 mm from the Clay Canyon mine. Terry Szenics collection; multifocus photo by Alex Halpern.**

Figure 35. Fluorapatite ("lehiite") in a spray of acicular crystals less than 1 mm across. Natural History Museum of Los Angeles County collection; multifocus photo by Paul Adams.

Figure 36. **Gordonite crystal (partially replaced by yellow crandallite), less than 1 mm, with fluorapatite ("lewistonite") from the Clay Canyon mine. Natural History Museum of Los Angeles County collection; multifocus photo by Paul Adams.**

Englishite shows a perfect micaceous cleavage with a pearly luster on the cleavage face. It occurs in cavities with wardite, replacing both wardite and variscite, and resembles gordonite, but is more platy, and the cleavage surfaces tend to be larger and curved. Englishite generally occurs in association with montgomeryite and is the earlier-formed of the two.

Fluorapatite[2] $Ca_5(PO_4)_3(F,CO_3)$

Larsen and Shannon (1930) described the two new species "dehrnite" and "lewistonite" (after the town of Lewiston, later known as Camp Floyd and Mercur), as colorless, transparent microcrystals of stout hexagonal prismatic to acicular habit in cavities in variscite nodules. Botryoidal crusts about 1 mm thick line cavities in the nodules and cement fragments of crandallite in some specimens; some cavities are entirely filled, like amygdules. Dehrnite and lewistonite, however, were later discredited as being identical to

[2]Fluorapatite was renamed apatite-(CaF) by Burke (2008), but this change was rescinded, with IMA approval, by Pasero *et al.* (2010).

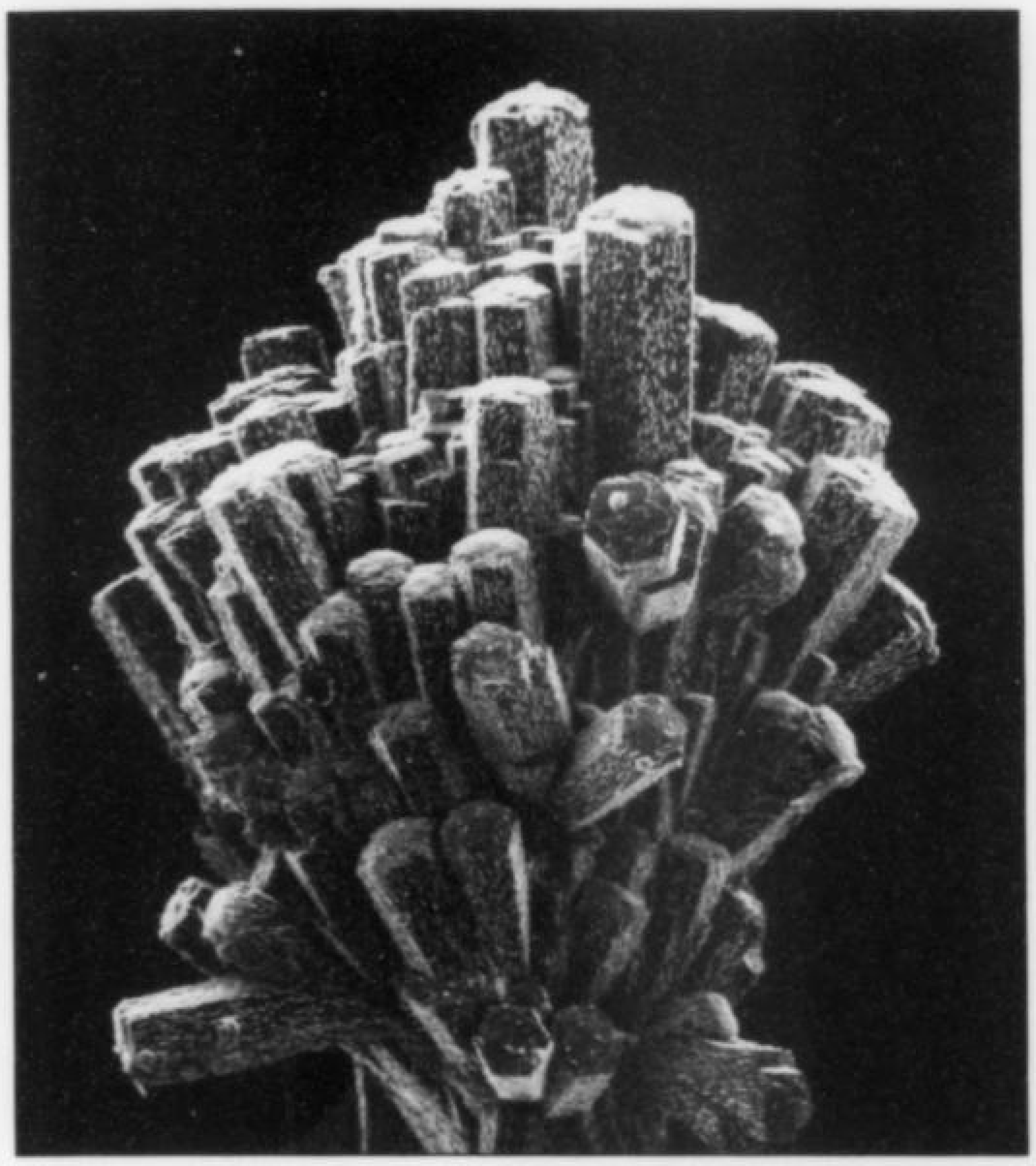


Figure 37. **Fluorapatite crystal cluster, about 2 mm, from the Clay Canyon deposit. Smithsonian Institution collection; SEM by Pete J. Dunn.**

carbonate-fluorapatite (Dunn, 1978). Thirty years later, carbonate-fluorapatite was deemed not to be known in nature with sufficient carbonate to qualify as a distinct species (Burke, 2008), and thus species status was rescinded in favor of fluorapatite until such time as natural specimens are discovered.

Davisonite was also described as a new species from Clay Canyon by Larsen and Shannon (1930), who at first named it "dennisonite," with the intention of honoring the author of the 1896 wardite description. Embarrassingly, this was in error, as the author's name was actually John M. Davison; the error was eventually corrected (more than ten years later!) and davisonite became the mineral name (Palache *et al.*, 1951). However, davisonite was ultimately discredited as a mixture of fluorapatite and crandallite by Dunn and Francis (1986). Thus poor Davison lost out twice in having the mineral named after him.

Dunn (1980) illustrated a number of excellent microcrystals via scanning electron micrography; they vary in habit from hexagonal prismatic to hexagonal tabular.

Gordonite $MgAl_2(PO_4)_2(OH)_2 \cdot 8H_2O$

Gordonite, a triclinic mineral related to paravauxite, was described as a new species from the Clay Canyon variscite deposit by Larsen and Shannon (1930). They named it in honor of Philadelphia mineralogist Samuel G. Gordon (1897–1952), who first described paravauxite. Gordonite occurs there as layers less than 1 mm thick of clear, glassy, cleavable crystals encrusting variscite or very near to it.

Figure 38. **Gordonite crystals to 1 mm from the Clay Canyon mine. Natural History Museum of Los Angeles County collection; multifocus photo by Paul Adams.**

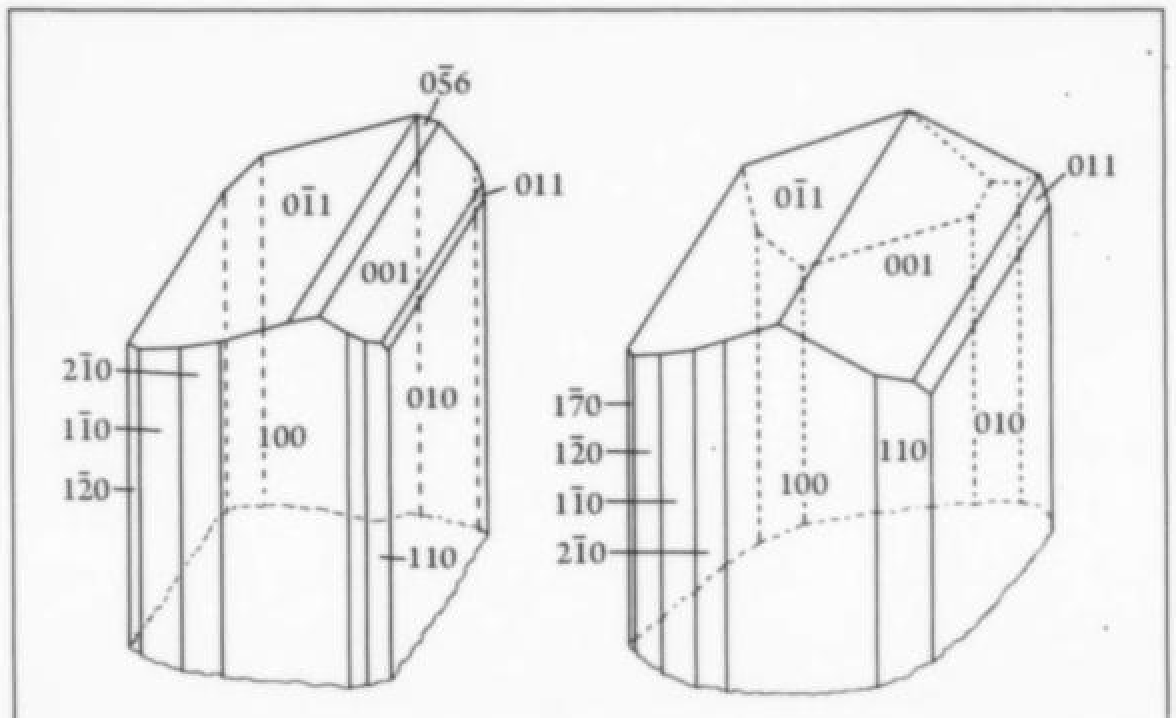


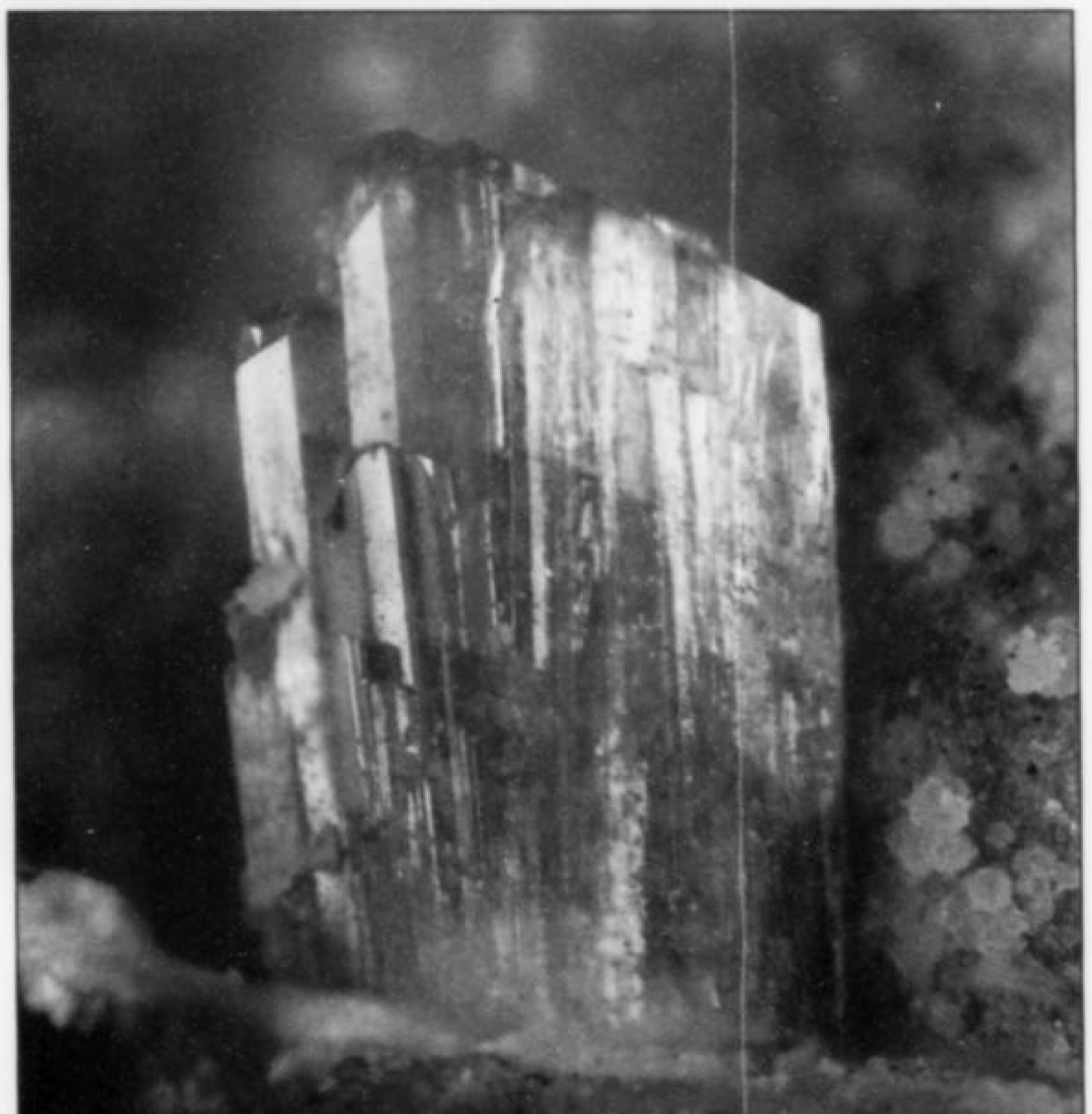
Figure 39. **Gordonite crystal drawings, Clay Canyon mine (after Pough, 1937b).**

Gordonite is among the rarer but better crystallized phosphates in the variscite nodules. The best crystals are lath-shaped, with a perfect cleavage parallel to the axis of elongation, on (100). Forms recognized include {001}, {010}, {100}, {110}, {490} and {211}. Pough (1937b), having obtained better crystallized specimens of gordonite from material collected by Montgomery and Over in late 1936, was able to provide a better description of the crystal morphology.

Like the other phosphates, gordonite formed by alteration of the original variscite. Cavities which opened up between the variscite

Figure 40. **Gordonite crystals to 4 mm on variscite from the Clay Canyon mine. Terry Szenics collection; multifocus photo by Alex Halpern.**

Figure 41. **Gordonite crystal, 1 mm wide, on variscite from the Clay Canyon mine. Terry Szenics collection; multifocus photo by Alex Halpern.**



core and layers of crandallite were sometimes found to contain gordonite crystals growing on both surfaces (the crandallite and the variscite). Gordonite has only been found in nodules that still contain some variscite, and it crystallizes on or near the variscite. Yellow crandallite pseudomorphs after gordonite are known (Larsen, 1942b).

In its purest form gordonite is gemmy and colorless, but it can appear gray when attached to crandallite or variscite; terminations of the gray crystals are in some cases pale pink or lavender. Most crystals occur in bundles or radiating sheaf-like aggregates. A few individual crystals perched on other crystals are doubly terminated. Crystals vary in size from 0.5 to 6 mm, and clusters can reach 5 mm or more. Nineteen crystal forms were identified by Pough (1937b), dominated by {010} (showing a pearly luster as in paravauxite) and lesser striated {100} and $\{1\bar{1}0\}$. Many crystals are terminated solely by $\{0\bar{1}1\}$. Pough recognized the isostructural relationship between gordonite and paravauxite. The crystals are all heavily striated and show a prominent cleavage on {010}, a fair cleavage on {100}, and a poor but distinct cleavage on {001}.

Goyazite $SrAl_3(PO_4)_2(OH,H_2O)_6$

Goyazite was reported from the Clay Canyon variscite locality by Frondel *et al.* (1968) as part of their investigation of the scandium content of the phosphates. The physical properties were not described, other than to say that a "bulk sample of crystallized goyazite" proved to contain 0.3 weight % Sc_2O_3. Microcrystals may exist but they are impossible to distinguish from crandallite without optical or chemical tests.

Hydroxylapatite[3] $Ca_5(PO4)_3(OH)$

Hydroxylapatite crystals in crandallite were described (as a new species, "deltaite") from the Clay Canyon variscite nodules by Larsen and Shannon (1930). The name was in allusion to the triangular (Δ *delta*-shaped) habit of the crystals. Deltaite was discredited as a mixture of hydroxylapatite and varying amounts of crandallite and by Elberty and Greenberg (1960).

[3]Hydroxylapatite was renamed apatite-(CaOH) by Burke (2008), but this change was rescinded, with IMA approval, by Pasero *et al.* (2010).

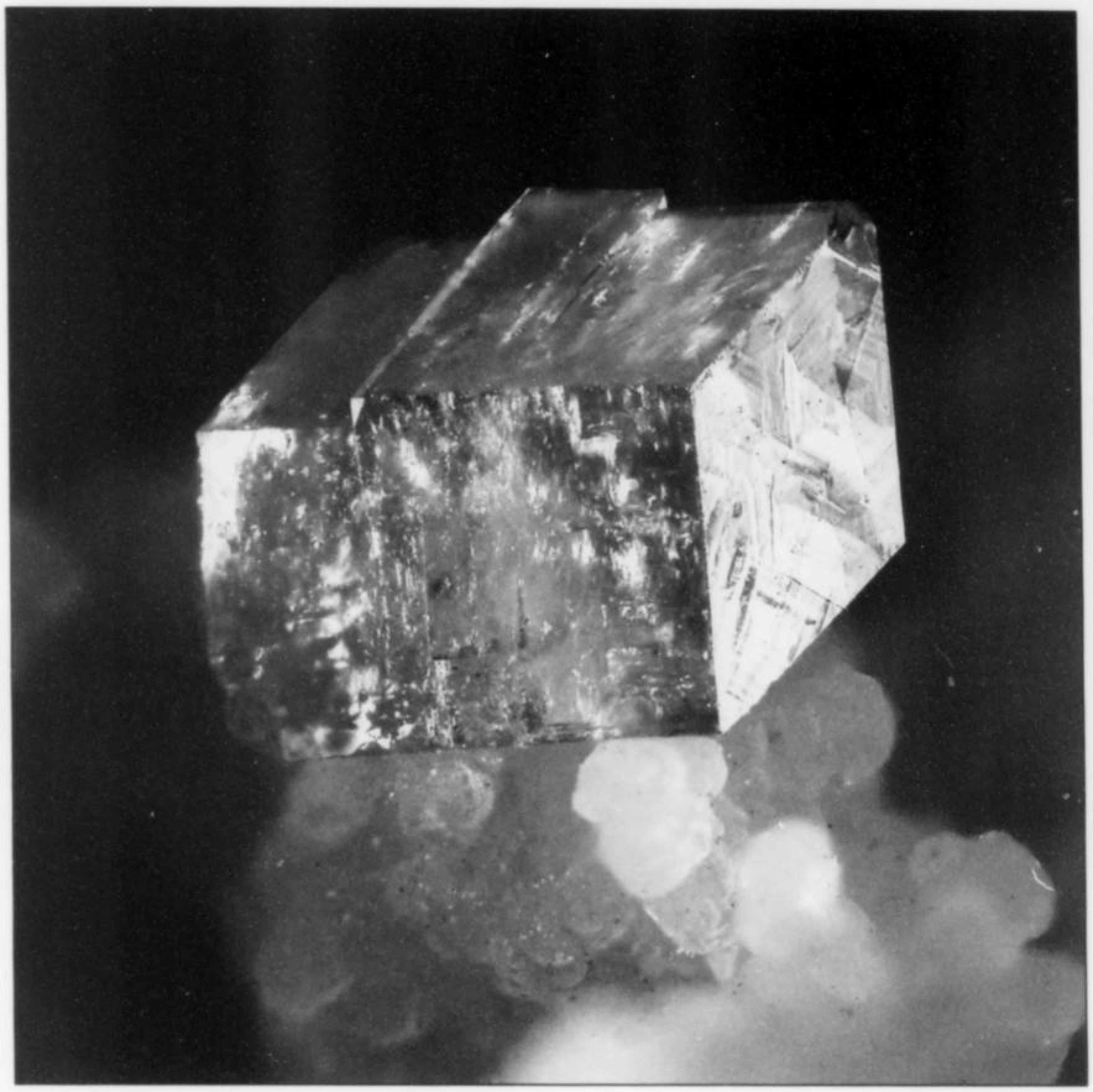


Figure 42. **Kolbeckite ("sterrettite") crystal, 1 mm, from the Clay Canyon mine. Denver Museum of Nature and Science collection; multifocus photo by Alex Halpern.**

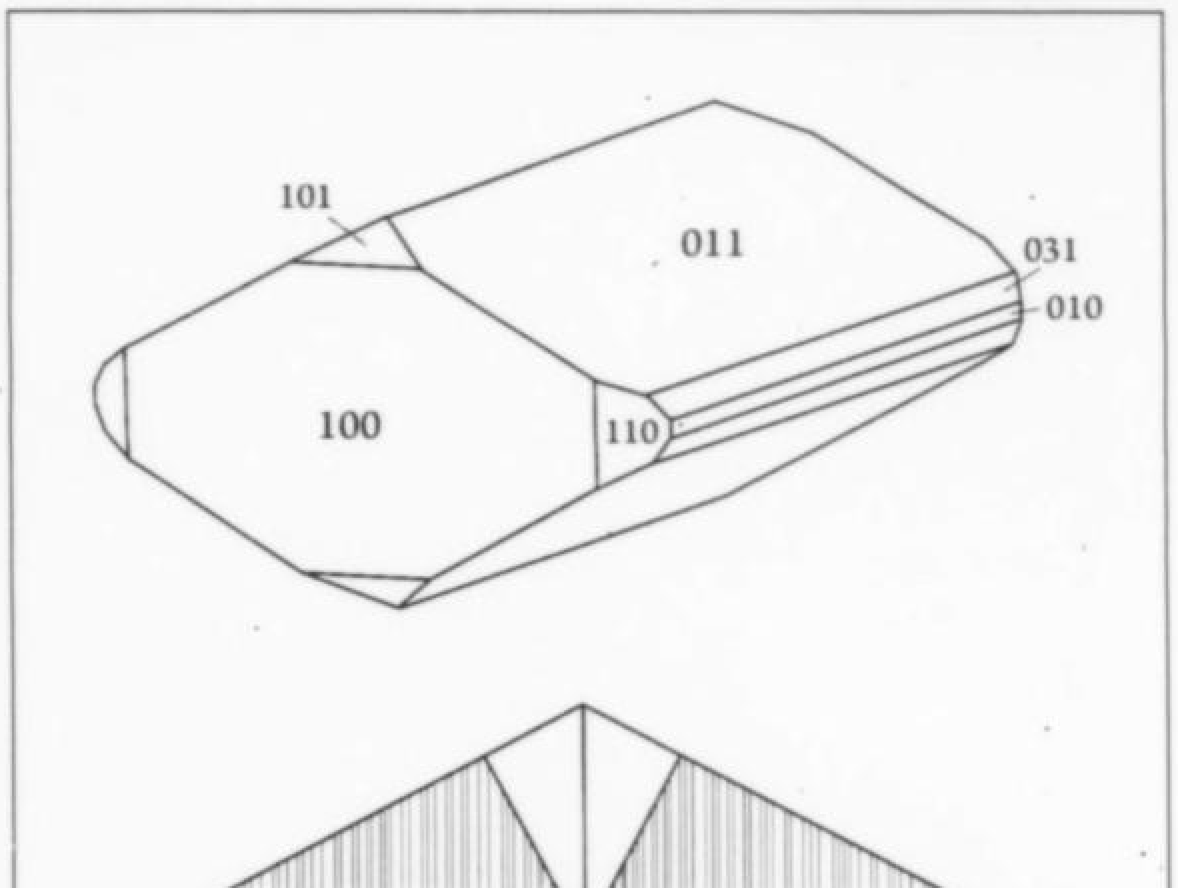


Figure 43. **Kolbeckite crystal drawings, Clay Canyon mine (after Larsen and Montgomery, 1940).**

Individual crystals are very small, generally no larger than 0.05 mm, as fibers and stout prisms with a triangular cross-section. Some crystals taper at one end and are terminated by steep rhombohedron faces on the other. Crystals were observed in parallel growth with their prism edges touching to form an hour-glass cross-section; in others four prisms are arranged with their c-axes parallel and prism edges meeting at one point, with a thin layer of crandallite between them.

Hydroxylapatite in matted fibers constitutes the principal component of dirty gray, dense, cherty looking crusts up to 1 cm thick separating yellow crandallite layers from the variscite cores. Larsen (1942a) described sugary aggregates of canary-yellow microcrystals to 0.02 mm lining the surfaces of lenticular openings between crandallite shells. And lavender-colored trigonal prisms to 0.2 mm and massive lavender to pale blue bands occur in some nodules. The lavender crystals are simple, elongated trigonal prisms $\{10\bar{1}0\}$ capped by $\{0001\}$.

Kolbeckite $ScPO_4 \cdot 2H_2O$

Larsen and Montgomery (1940) described what they thought to be a new species from the Clay Canyon variscite nodules, naming it "sterrettite" in honor of geologist Douglas B. Sterrett. Based on chemical analyses, Larsen and Montgomery (1940) derived the formula for sterrettite from Clay Canyon as $Al_6(PO_4)_4(OH)_6 \cdot 5H_2O$. Unfortunately their analyst, Forest A. Gonyer, misidentified an element, mistaking scandium for aluminum, hence the discreditation of the name sterrettite in favor of kolbeckite (Mrose and Wappner, 1969).

Kolbeckite occurs rarely in cavities in tan-colored crandallite from only one small area of the deposit, separated horizontally from the main zone of mineralization. The colorless, orthorhombic, simple prismatic crystals are slightly elongated along [100] and normally reach no more than 1 mm in size, though a few larger crystals up to 8 mm have been reported (Thomssen, 1991). The kolbeckite crystals are beautifully formed, and are the only species at Clay Canyon occurring in crystals that are free of subparallel growths

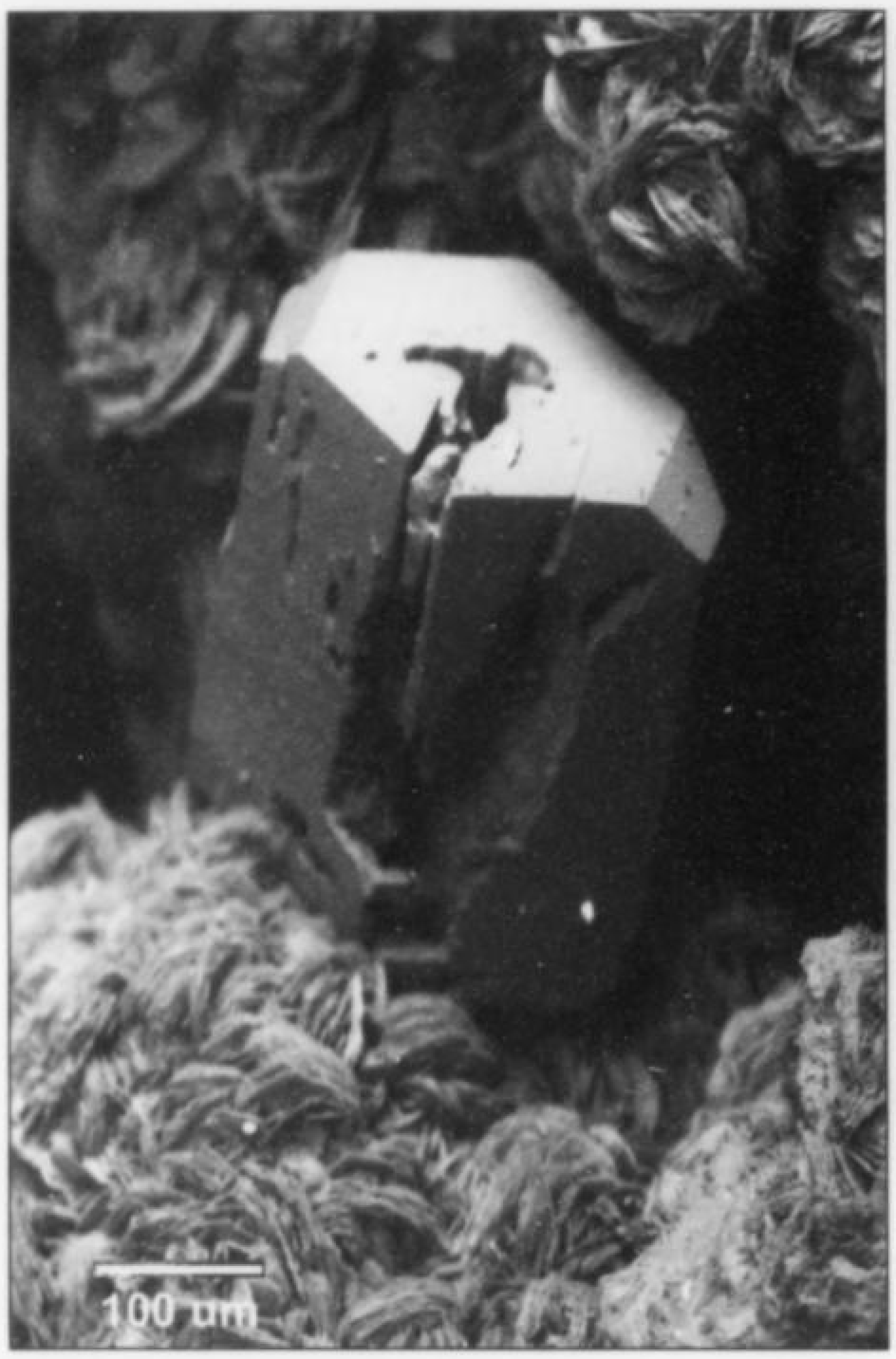


Figure 44. **Kolbeckite crystal on crandallite from the Clay Canyon mine. Natural History Museum of Los Angeles County collection; SEM by Paul Adams.**

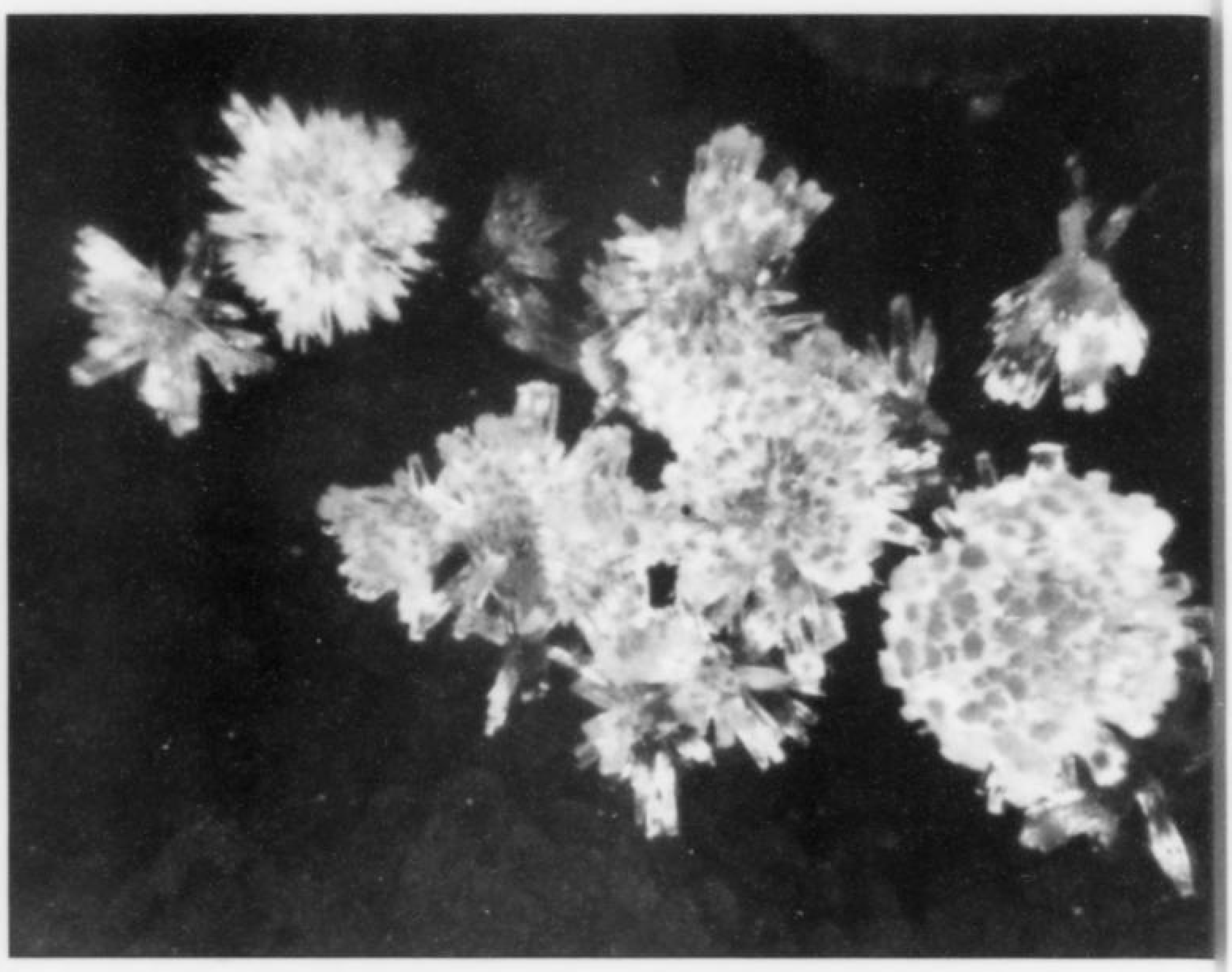


Figure 45. **Millisite crystals, field of view less than 1 mm, from the Clay Canyon mine. Natural History Museum of Los Angeles County collection; multifocus photo by Paul Adams.**

and vicinal faces. The {011} prism and the {100} pinacoid are the only important forms, but {110}, {010}, {031} and {101} are also present. All crystals are twinned, as evidenced by clear sutures across the terminations. There is a fair cleavage on {110}.

Lehiite (see Crandallite)

Lewistonite (see Fluorapatite)

Millisite $(NaK)CaAl_6(PO_4)_4(OH)_9 \cdot 3H_2O$

Millisite was described as a new species from Clay Canyon by Larsen and Shannon (1930); they named it after F. T. Millis, the apparent discoverer of the locality, who first supplied specimens for analysis. Millisite forms white felted layers and irregular crusts resembling chalcedony, interlayered with green wardite. Spherules in the variscite nodules often show a white core of millisite surrounded by layers of green, granular wardite.

Montgomeryite $Ca_4MgAl_4(PO_4)_6(OH)_4 \cdot H_2O$

Montgomeryite was named after Arthur Montgomery by Larsen (1940) based on crystals from variscite nodules collected by Montgomery and Over at Clay Canyon in 1936 and 1937. The formula was originally determined to be $Ca_4Al_5(PO_4)_6(OH)_5 \cdot 11H_2O$ but has since been refined to that shown above.

The monoclinic, lath-shaped crystals up to several millimeters long are found in cavities in variscite nodules. They are usually bright green to blue-green (rarely pale green to colorless) and, like overite, are flattened on {010} with perfect cleavage on {010}, elongation parallel to [001], and a tendency toward parallel growth. Massive green montgomeryite also occurs in layers surrounding and replacing green variscite cores. Englishite is a common association. Crystals commonly have {$\bar{1}$11} pyramidal terminations and dominant {010} faces with striations parallel to [001]. Minor forms include {100}, {170}, {150}, {290}, {140}, {270}, {130}, {120}, {110}, {$\bar{1}$31}, {021} and {041}.

Figure 46. **Millisite spherule on crandallite, about 2 mm, from the Clay Canyon mine. Natural History Museum of Los Angeles County collection; multifocus photo by Paul Adams.**

Overite $CaMgAl(PO_4)_2(OH) \cdot 4H_2O$

Overite is among the rarest of the crystallized minerals in the Clay Canyon variscite nodules, a fact that hindered initial descriptions. Larsen and Shannon (1930) made a preliminary description of the physical and optical properties of a new species from the nodules but

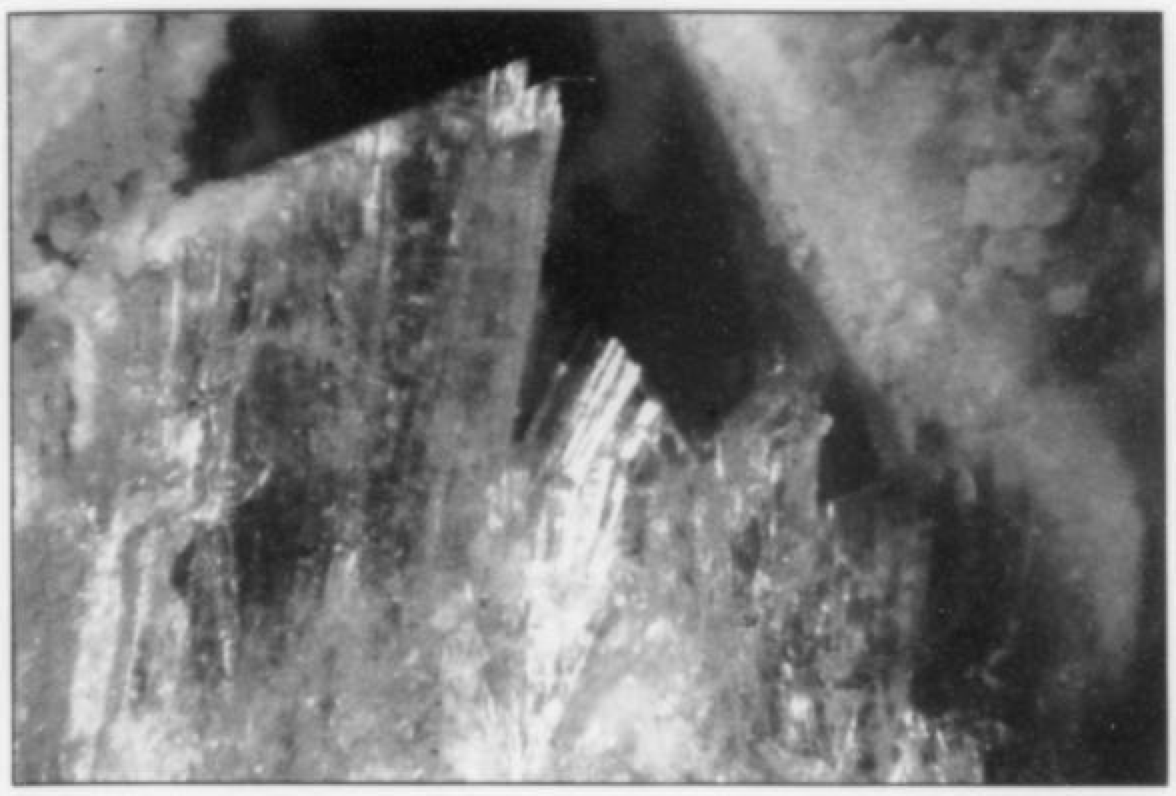


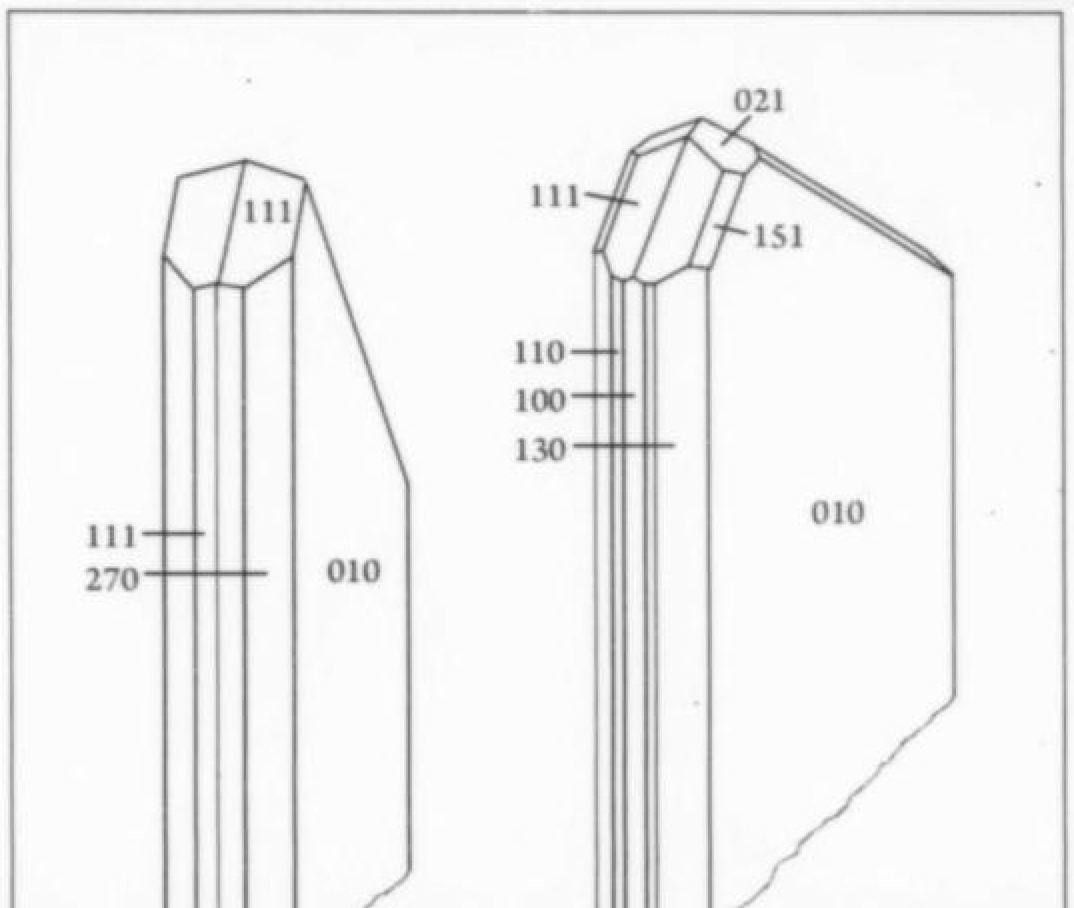
Figure 47. **Montgomeryite crystals to about 2 mm from the Clay Canyon mine. Lou Perloff collection and photo.**

did not have enough material for a full characterization; they called it "unknown no. 8." The mineral was finally described and named after Ed Over by Larsen (1940) on the basis of new specimens collected by Over and Montgomery at Clay Canyon in 1936 and 1937. The formula was originally determined to be $Ca_3Al_8(PO_4)_8(OH)_6 \cdot 15H_2O$ but has since been refined to that shown above.

The orthorhombic prismatic crystals, up to 4 mm in size, are pale apple-green to colorless and somewhat flattened on {010} and elongated parallel to [001], with a perfect cleavage on {010}. They occur in the cavities in the margin surrounding relict lumps of variscite. The crystals are generally well-formed and there is a marked tendency toward parallel growth. Dominant forms are {010}, {121} and {110}; minor forms include {100}, {150}, {130}, {250}, {120}, {350}, {430}, {320}, {310}, {410} and {021}.

Figure 48. **Montgomeryite crystals to about 3 mm from the Clay Canyon mine. Natural History Museum of Los Angeles County collection; multifocus photo by Paul Adams.**

Figure 49. **Montgomeryite crystal drawings, Clay Canyon mine (after Larsen, 1940).**



Pseudowavellite (see Crandallite)

Quartz SiO_2

Thin black quartz veinlets penetrate many of the nodules. Much of the matrix in which the nodules are embedded is brecciated quartz or chert, along with calcite, alunite and limonite.

Sterrettite (see Kolbeckite)

Variscite $AlPO_4 \cdot 2H_2O$

Variscite occurs primarily as microcrystalline masses forming the relict cores of the nodules, and it is obviously the original mineral from which the other phosphates developed by alteration. The color ranges from deep green to slightly yellowish green, bluish green, pale green and white—the white powdery crystals having recrystallized in bands around the margins of the green cores, alone or in a mixture with crandallite (Larsen and Shannon, 1930).

Many nodules show the palest color near the fractures where alteration has been taking place, and the darkest color in the unfrac-

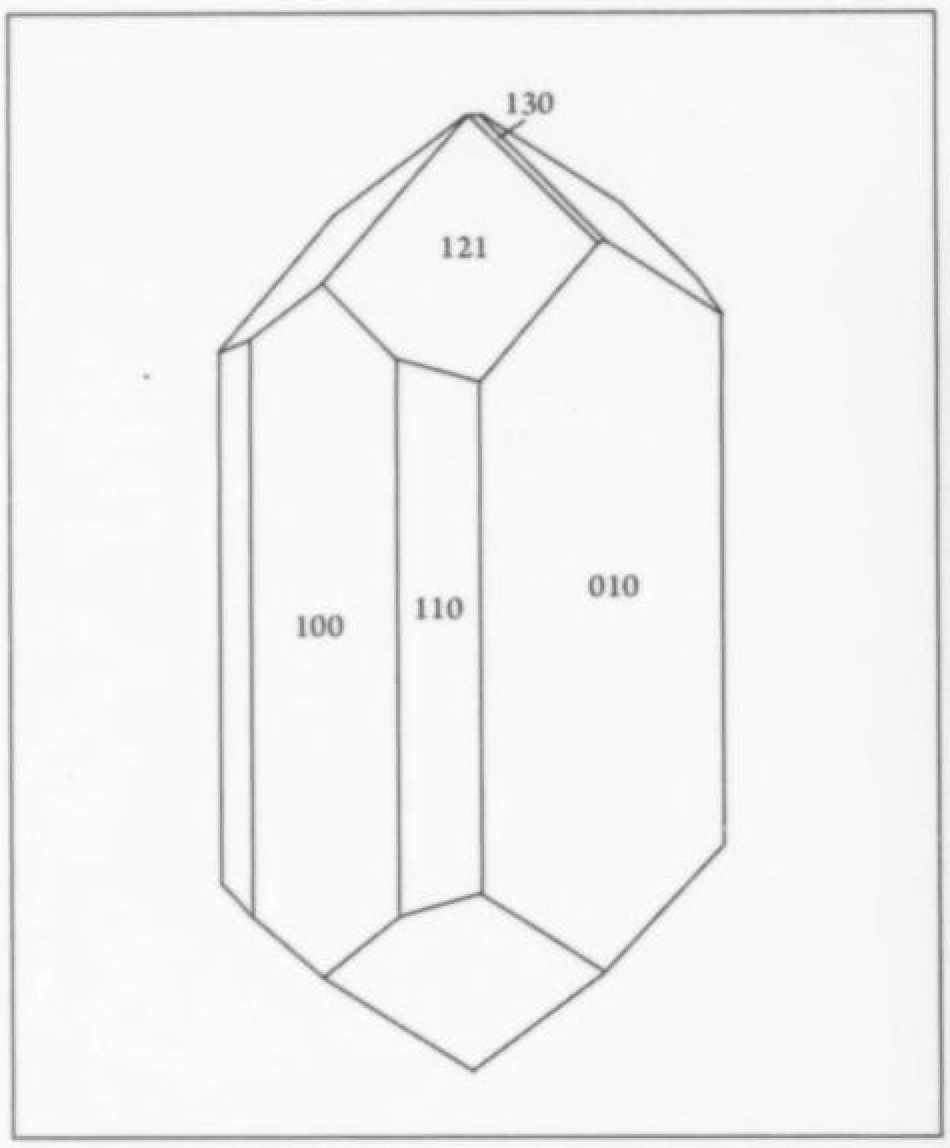


Figure 50. **Overite crystal drawing, Clay Canyon mine (adapted from Larsen, 1940).**

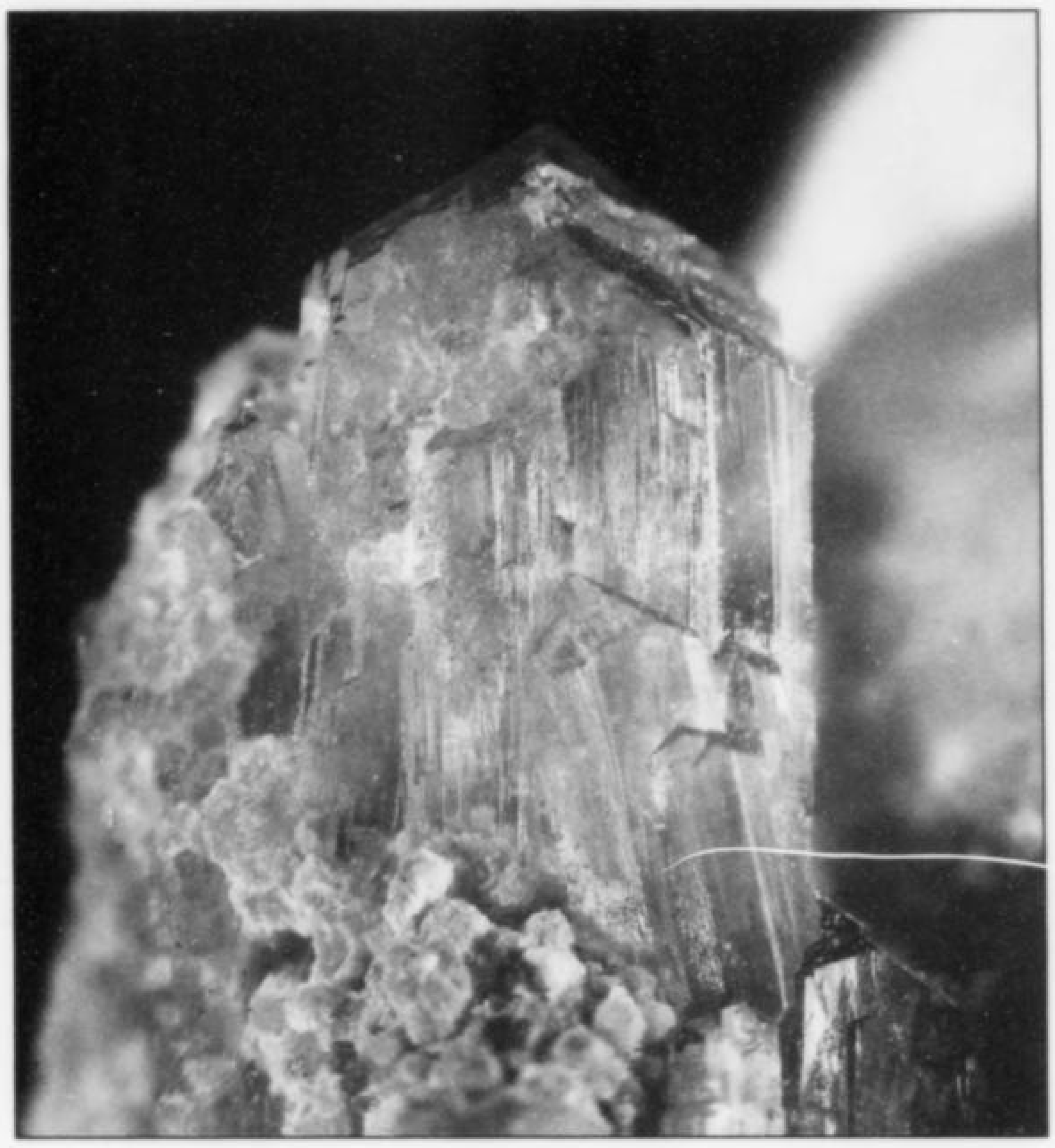


Figure 51. **Overite crystal, 2 mm wide, from the Clay Canyon mine. John C. Ebner collection; multifocus photo by Alex Halpern.**

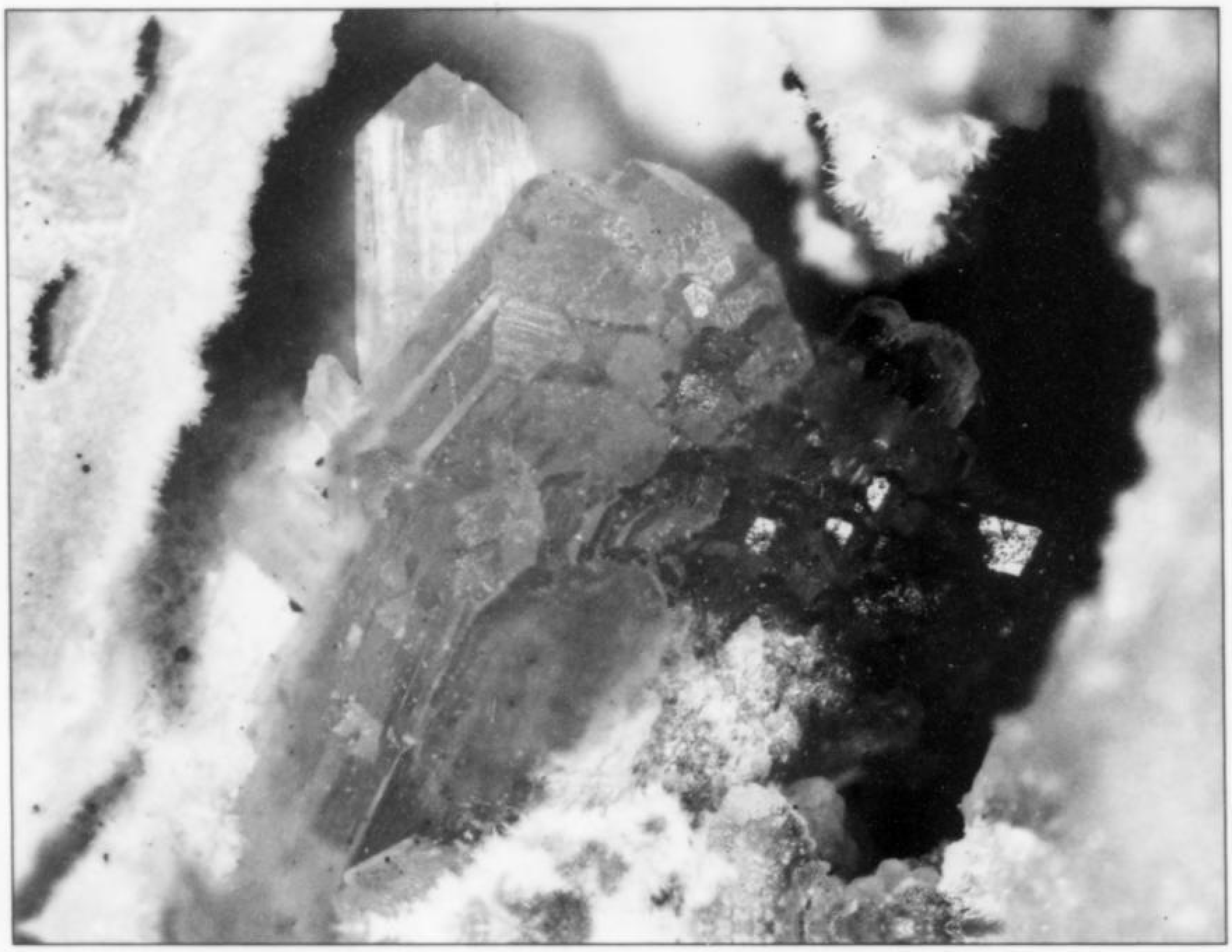


Figure 52. **Overite crystal cluster, 3.5 mm wide, from the Clay Canyon mine. Terry Szenics collection; multifocus photo by Alex Halpern.**

tured interior portions, suggesting that the darkest color represents the original unaltered appearance. However, some (comparatively very rare) nodules show the reverse pattern, being darkest near the fractures. Some nodules are pale green throughout, whereas others are almost entirely dark green.

Calas *et al.* (2005) have concluded that the green color of Utah variscite is due solely to trace amounts of chromium. As yet no one has conducted any analyses to determine the nature of the change that takes place when dark green variscite alters to pale green variscite. But it is possible that chromium is leached away during alteration, resulting in paler shades of green.

The end product of the alteration process appears to be a complete conversion to yellow crandallite and other phosphates. In some, but not all, cases this alteration is accompanied by a volume reduction, leaving open voids in the nodules.

Wardite $NaAl_3(PO_4)_2(OH)_4{\cdot}2H_2O$

Wardite was described as a new mineral species from the Clay Canyon variscite nodules by Davison (1896), based on material

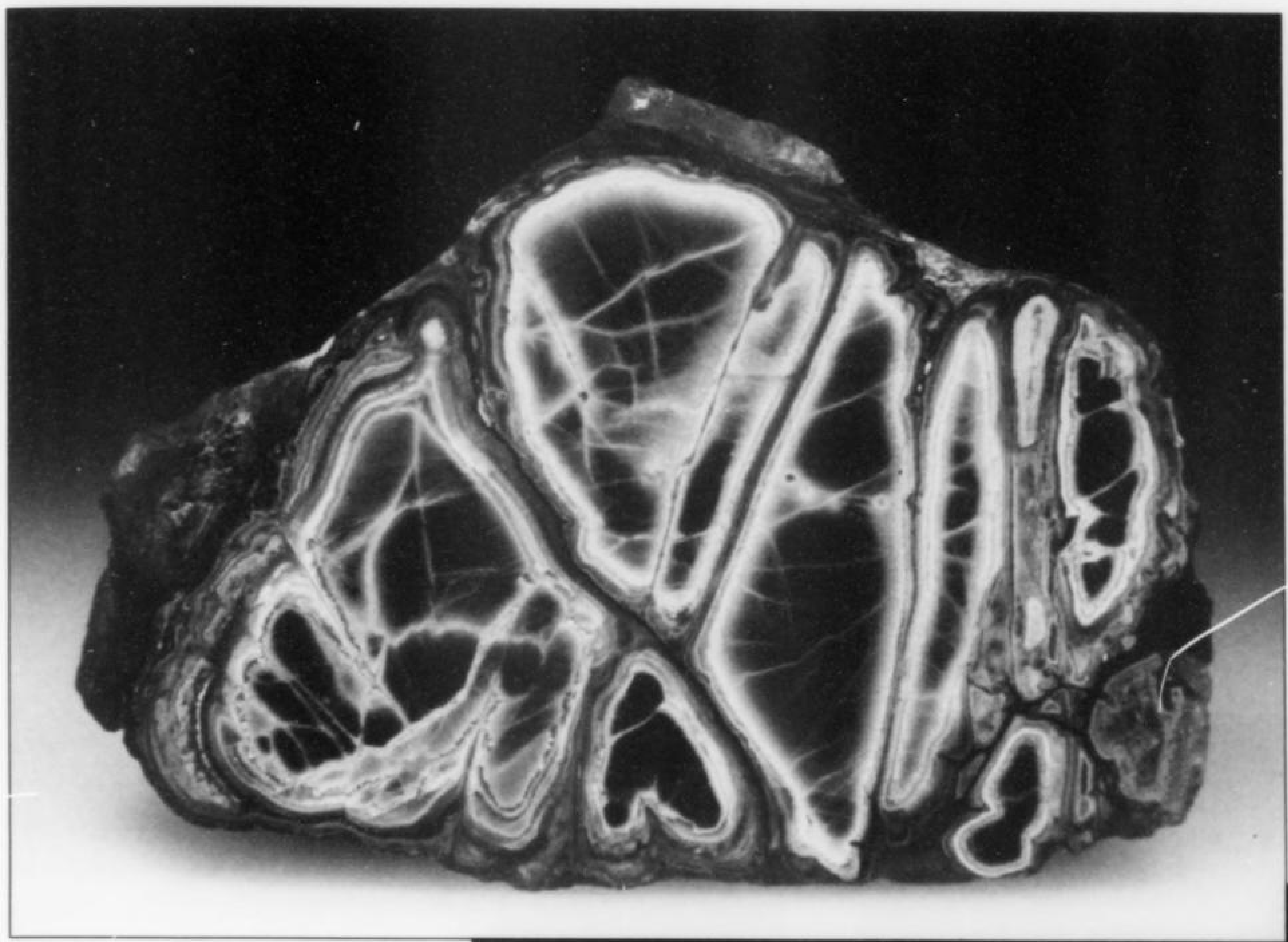


Figure 53. **Variscite nodule, 9.2 cm, from the Clay Canyon mine. Martin Zinn collection; Jeff Scovil photo.**

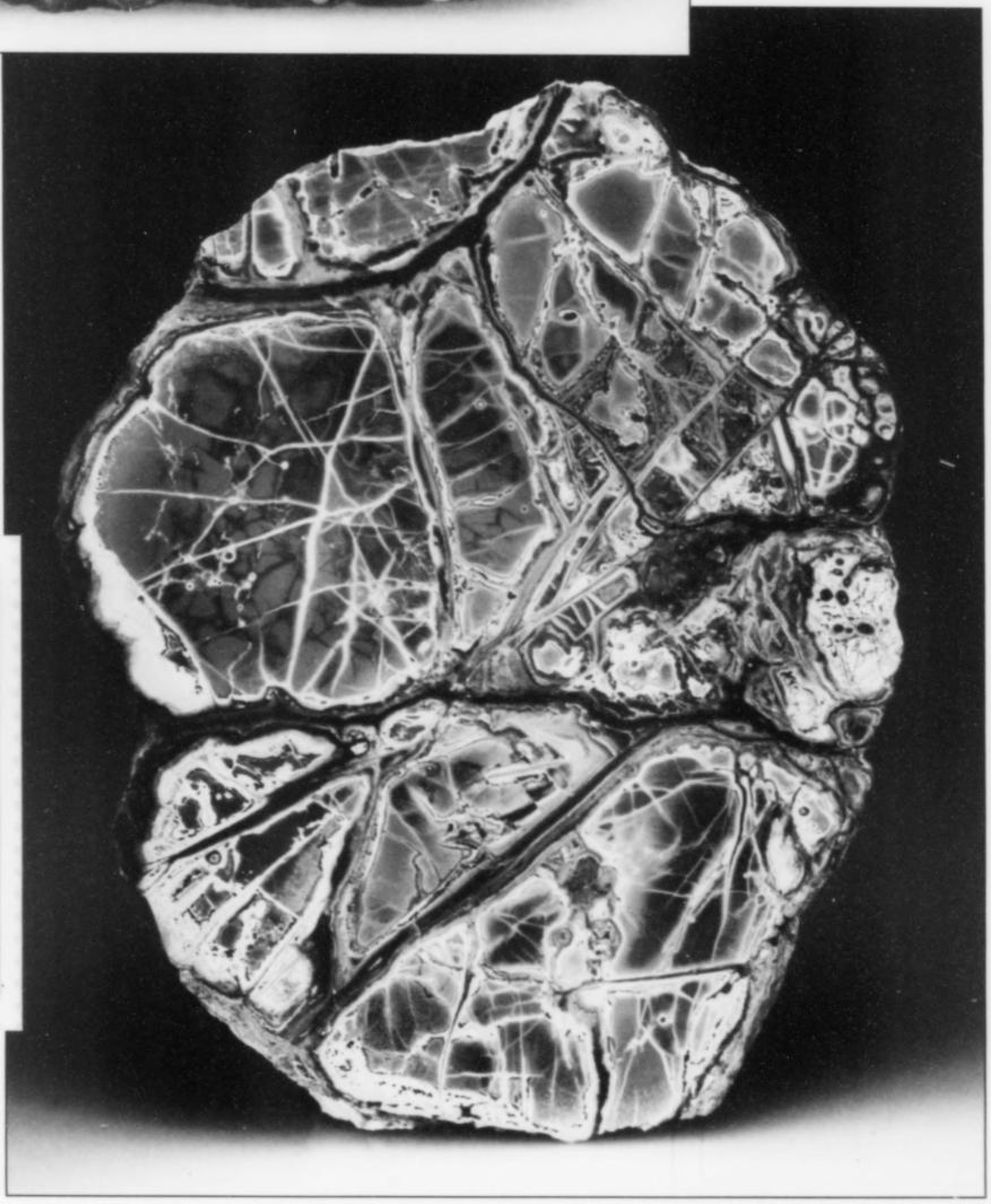


Figure 54. **Large variscite nodule, 28.6 cm, from the Clay Canyon mine. Seaman Mineral Mueum collection; Jeff Scovil photo.**

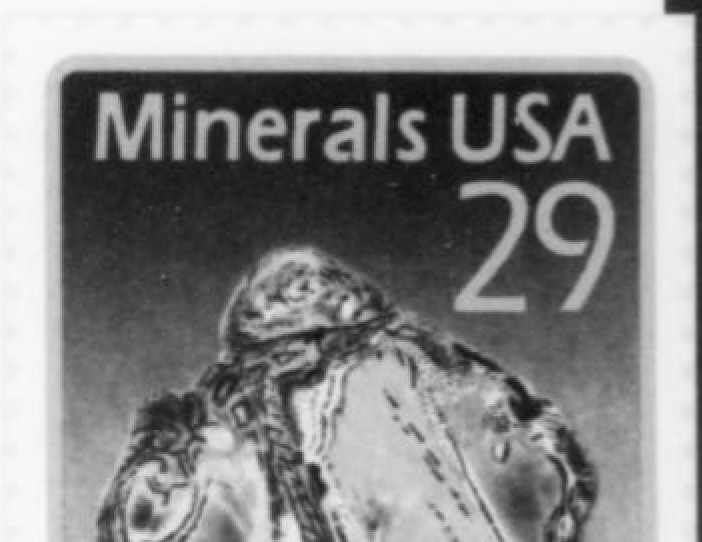


Figure 55. **U.S. postage stamp issued in 1992, depicting a Clay Canyon variscite nodule in the collection of the Smithsonian Institution.**

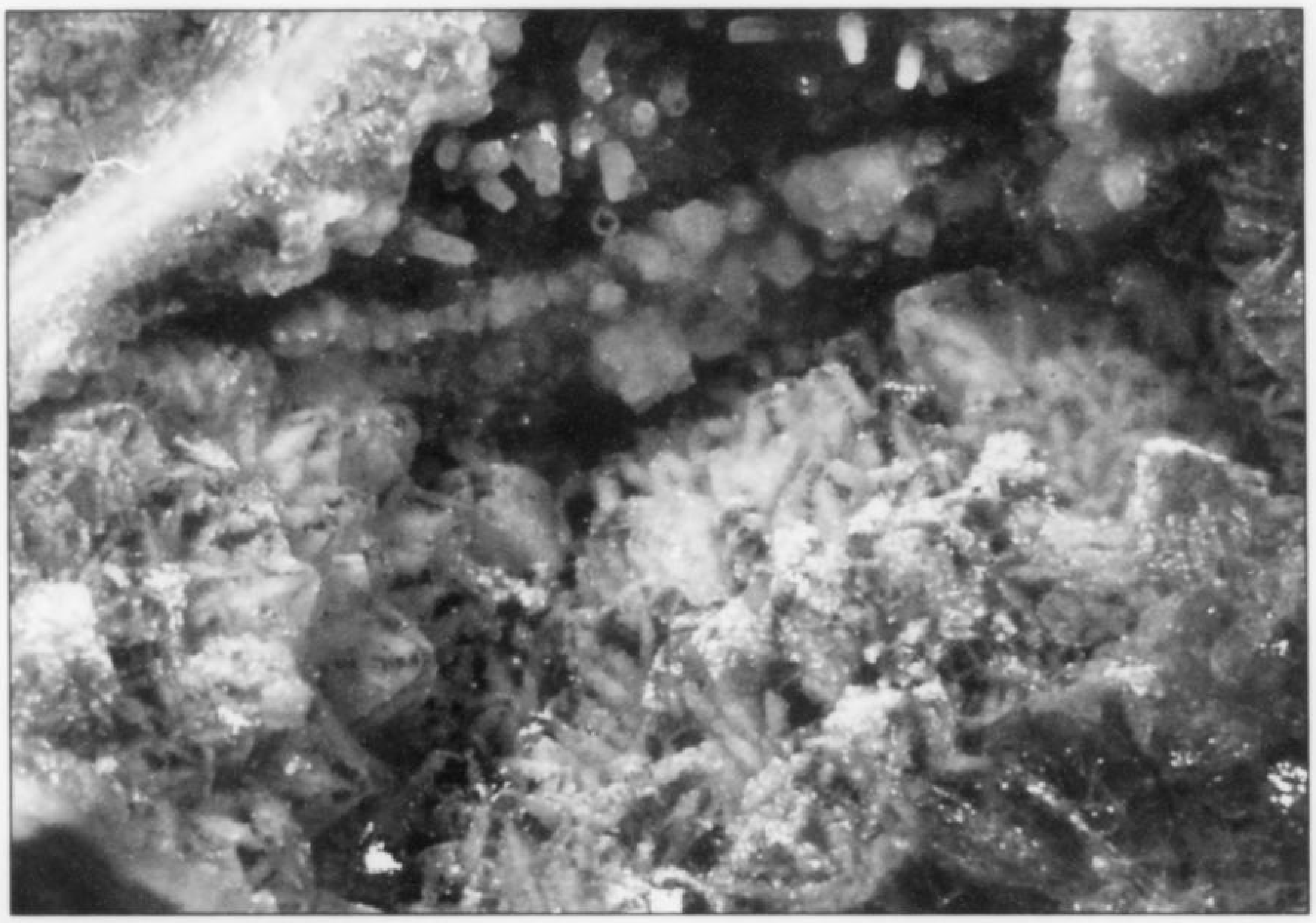


Figure 56. **Wardite crystals (blue) with minor crandallite (yellow), from the Clay Canyon mine; the view is about 3 mm across. Natural History Museum of Los Angeles County collection; multifocus photo by Paul Adams.**

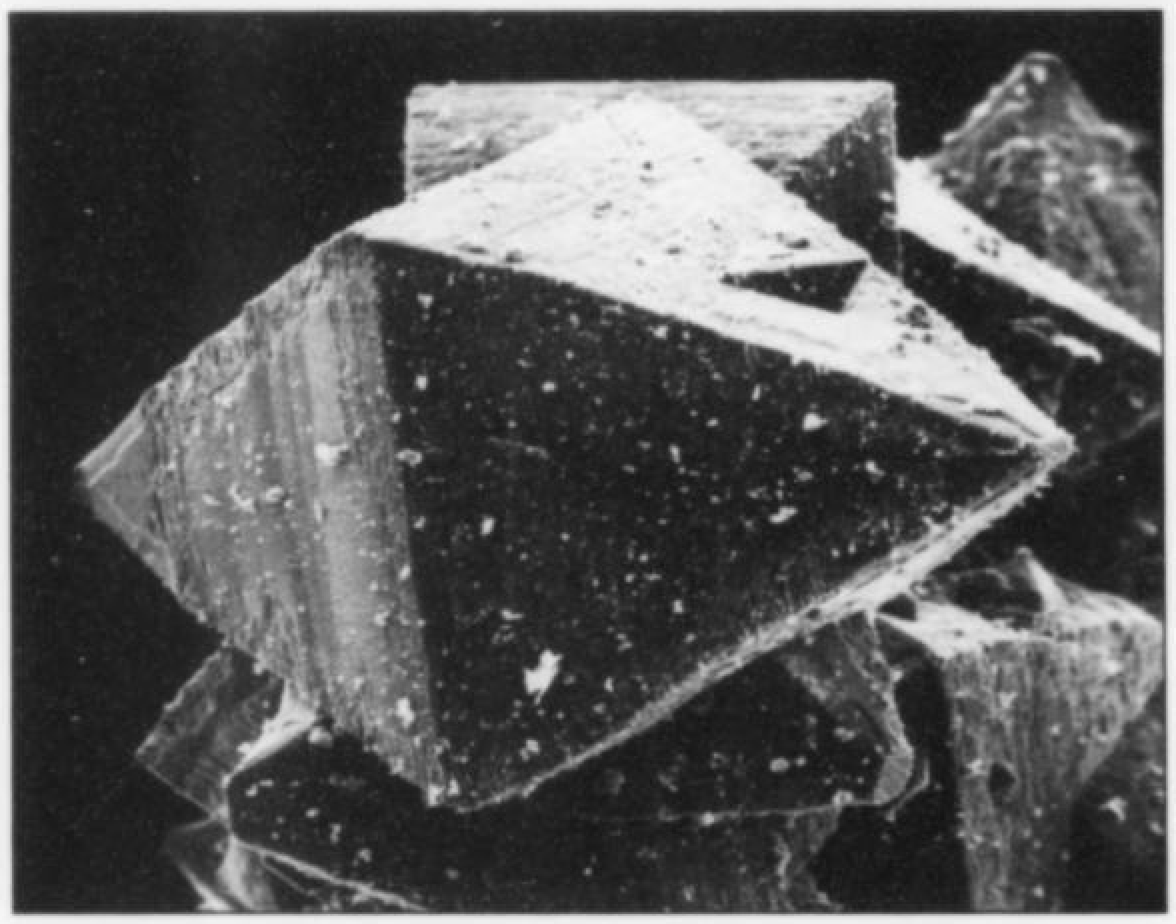


Figure 57. **Wardite crystals about 0.5 mm, from the Clay Canyon mine. Smithsonian Institution collection; SEM by Pete J. Dunn.**

purchased by Ward's Natural Science Establishment in Rochester, New York. Davison, a professor at the University of Rochester, named the mineral for Henry A. Ward, the founder of Ward's.

Davison observed that in the variscite nodules wardite forms cavity linings of a pale green to bluish green color and a vitreous luster. Its concentric habit also manifests itself as oölitic structure, that is, small spherules "resembling clusters of fine shot with rough surfaces." Larsen and Shannon (1930) expanded the description, noting that wardite also forms nearly colorless thin layers within and on the surface of dirty gray, chalcedonic nodules of millisite and also forms as scattered crystals and thin crusts within the yellow crandallite. The wardite is nearly always distinctly crystalline and granular, in individual grains up to 1 mm across. In a few of the specimens studied by Larsen and Shannon it occurs as poorly developed, drusy crystal aggregates. Some fairly well-formed crystals that were found embedded in the crandallite and millisite appear to show a roughly octahedral habit.

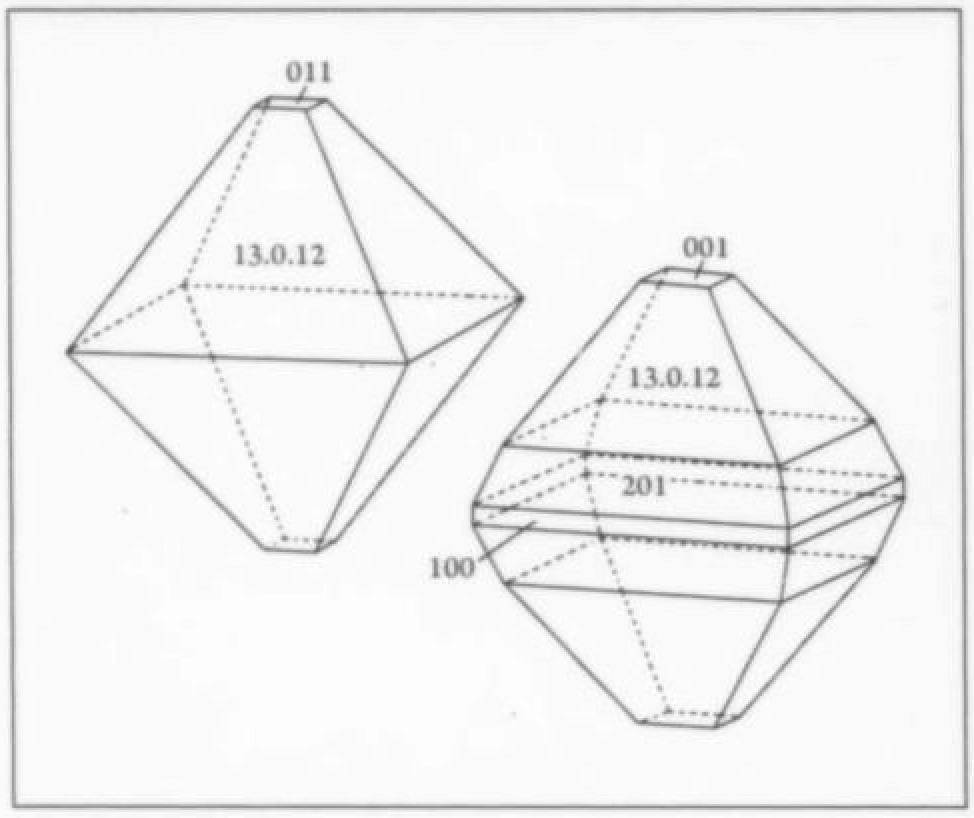


Figure 58. **Wardite crystal drawings, Clay Canyon mine (after Pough, 1937a).**

Figure 59. **Wardite crystals, less than 1 mm, from the Clay Canyon mine. Natural History Museum of Los Angeles County collection; multifocus photo by Paul Adams.**

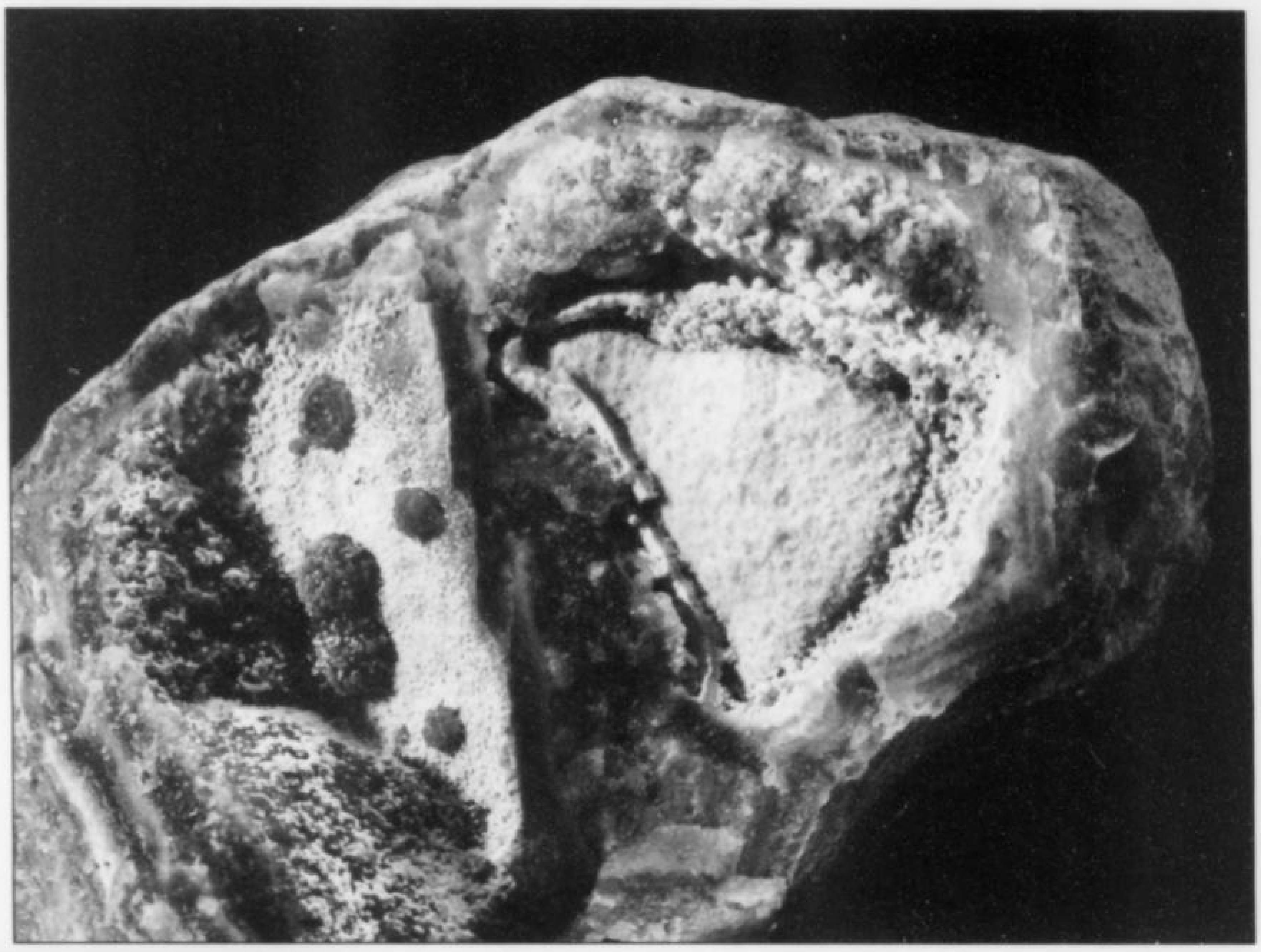


Figure 60. **Blue wardite on crandallite in a broken nodule, 5.8 cm, from the Clay Canyon mine. Kevin Downey (*Well Arranged Molecules*) specimen and photo.**

Figure 61. **Unknown, dark red species on fluorapatite. John C. Ebner collection; multifocus photo by Alex Halpern.**

Pough (1937a), having obtained better crystallized specimens of wardite from material collected by Montgomery and Over in late 1936, was able to describe the crystal morphology. Wardite, like the other phosphates, formed by alteration of the original variscite. Wardite appears to be one of the later-formed minerals and is relatively common, especially in comparison to the much rarer gordonite. It forms crusts of varying thickness, with well-developed pale blue to blue-green crystals to 1 mm visible in open vugs. The crystals are tetragonal bipyramids and are, perhaps, the most easily recognized of the various crystallized species in the nodules. Crystal forms noted include {001}, {100}, {112}, {13.0.12} and {201}. (See also Larsen, 1940a.)

SPECIMEN PREPARATION

Variscite nodules are normally sawn in half or slabbed and polished for display; very rarely are they shown as broken nodules, except occasionally where prominent, open crystal-lined cavities are present. Dietrich (2007) provides three observations regarding specimen preparation: (1) Sawing should never be done using oil as a blade lubricant or coolant because variscite and some of the other minerals in the nodules may absorb oil and become discolored. (2) When polishing nodules, a perfectly flat surface may be difficult to obtain because the various constituent minerals vary in hardness and friability. (3) Cleaning any variscite that has not first been treated with a stabilizing agent should be done with caution. Ultrasonic cleaning may cause crumbling of softer layers. Common cleaning agents and other chemicals such as alcohol, acetone, steam, or even hot water should be avoided. Use only a clean, soft, absorbent, lightly moistened cloth, and leave the specimen to dry on an absorbent cloth; never let it soak in water.

CONCLUSIONS

The Clay Canyon deposit has yielded thousands of pounds of the world's finest variscite specimens, though by now many of them have been chopped up and converted into jewelry items. The remaining specimen material is highly coveted by mineral collectors, and examples still appear on the mineral market from time to time. It remains possible that more variscite will be recovered from the Clay Canyon mine in the future, as exploration continues.

ACKNOWLEDGMENTS

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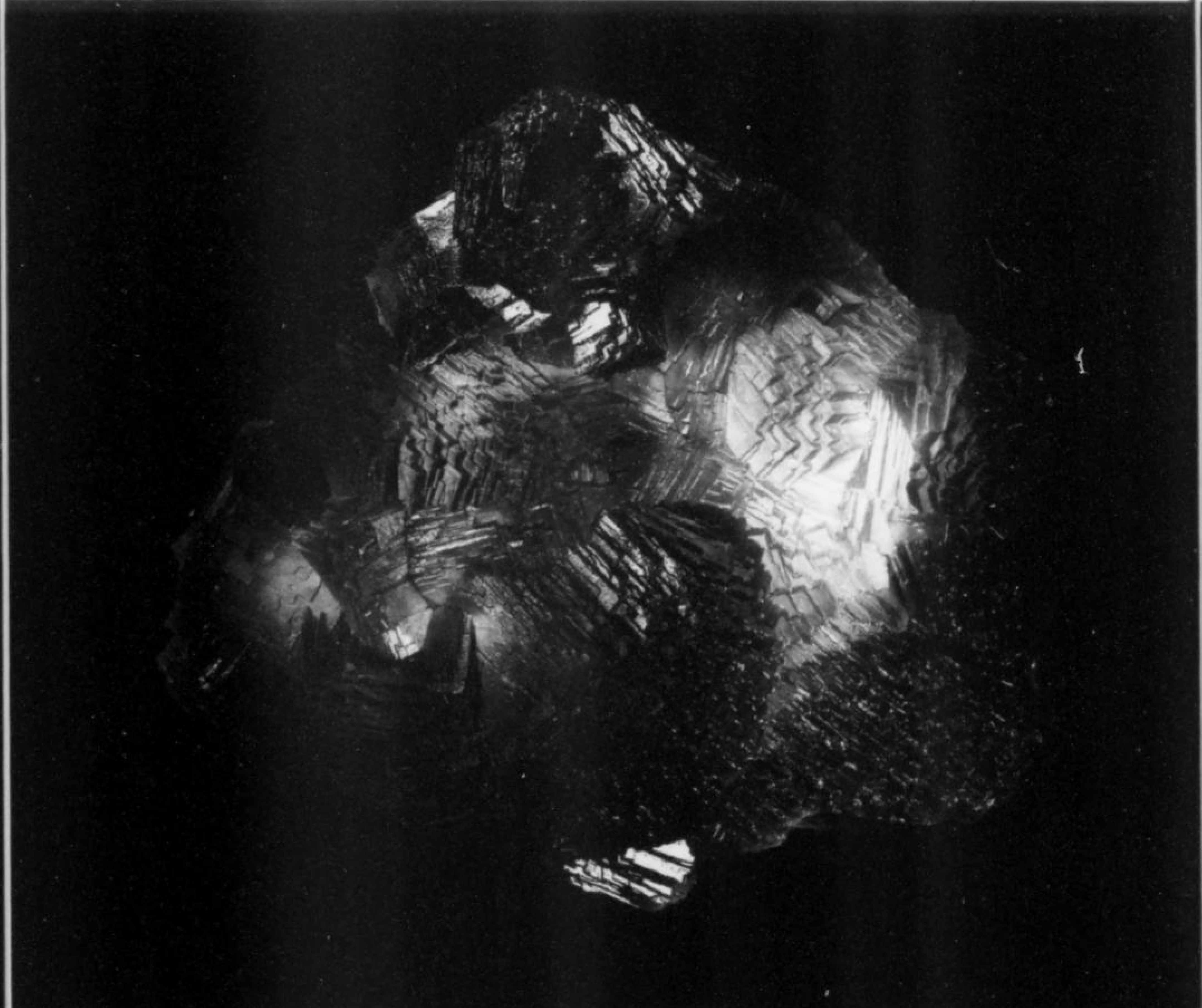

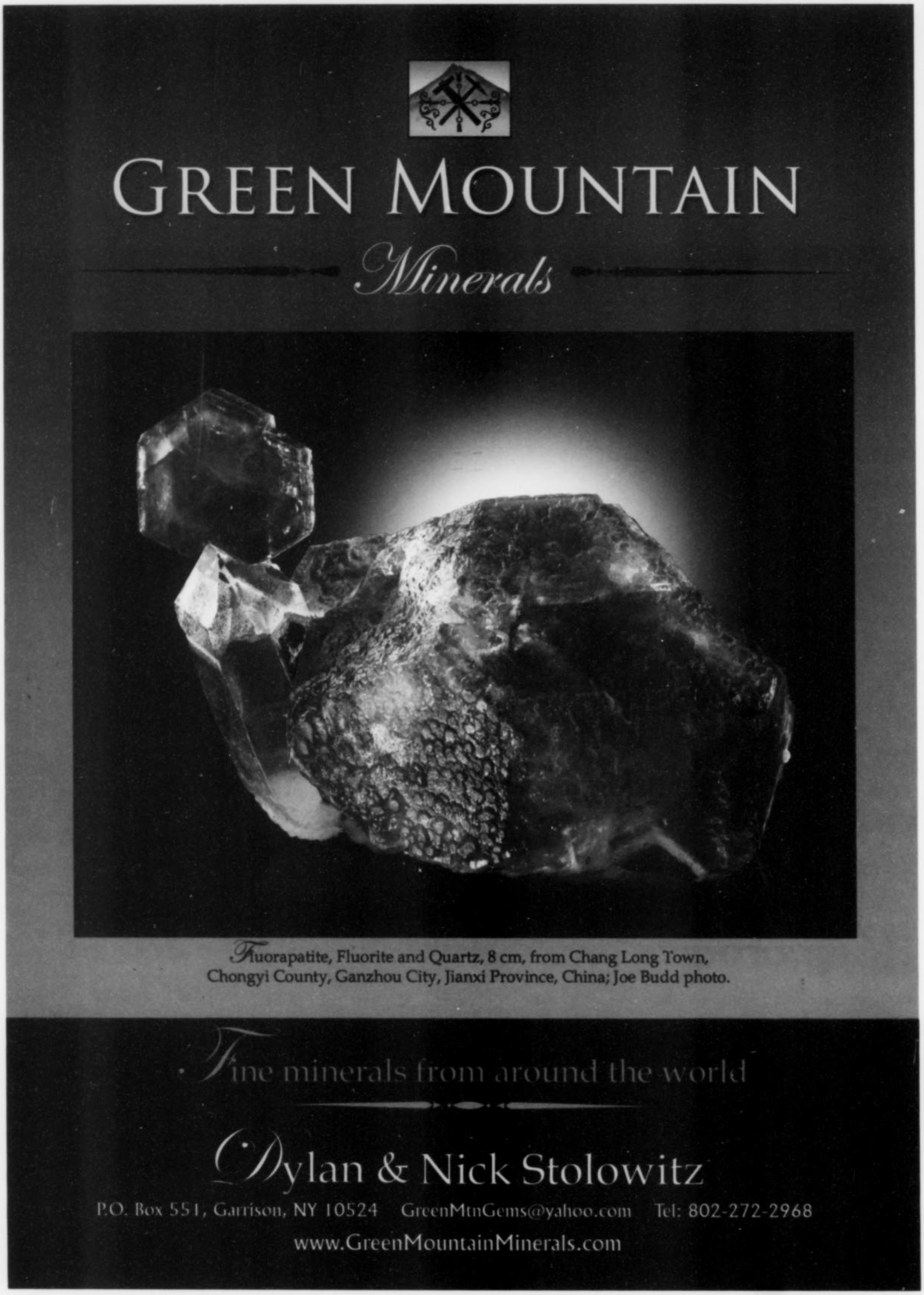
GREEN MOUNTAIN
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THE BLACKBIRD MINE

Lemhi County, Idaho

Allan Young
315 East Carter Street
Boise, Idaho 83706

The Blackbird mine, located in east-central Idaho, has the dual distinction of being the only primary producer of cobalt in the United States, and also the source of some of the world's finest crystals of ludlamite and vivianite. The mine closed in 1982 and is currently undergoing environmental remediation, so it is unlikely that any additional specimens will ever be collected there.

INTRODUCTION

The Blackbird mine is situated in the Salmon River Mountains of Lemhi County, Idaho, about 25 air miles west of the town of Salmon. The mine area is characterized by steep-walled canyons and heavy conifer forest, with elevations ranging from 7,000 to over 8,000 feet. This is a relatively remote region of east-central Idaho, with the shortest access route via 45 miles of mostly unpaved Forest Service roads from Salmon. The boundary of the Frank Church River of No Return Wilderness is about five miles to the west. At over two million acres, it is the largest contiguous wilderness area in the lower 48 states. The Blackbird mine site covers about 830 acres of private patented mining claims surrounded by the Salmon-Challis National Forest. All mining activities ceased there in 1982 and environmental impacts from historic mining operations are currently being remediated under Superfund authority.

The Blackbird mine has the distinction of having been the only "primary" producer of cobalt (i.e. as a main product rather than as a byproduct of mining other elements) in the United States. Cobalt is a strategic metal used in industrial, high-tech, medical, environmental and military applications, and is essential in the manufacture of jet engines. The mine has also distinguished itself as a mineral specimen producer, but not of cobalt-bearing species. During operations in the 1950s, the mine produced exceptional specimens of the phosphates ludlamite and vivianite, which currently grace many public and private collections worldwide.

HISTORY

The Blackbird mine is the principal mine in the Blackbird mining district, which covers about 72 square miles and includes a number of smaller mines and prospects generally oriented along a northwest-southeast trend (Anderson, 1943). Blackbird Creek bisects the district and was named for the bird species by Samuel James while prospecting for gold along its banks in 1890 (Steele, 2009). The first discovery of copper-gold mineralization in the district was made in 1892 by a local Indian prospector who showed the rich float copper samples from his find to Robert Bell in Salmon. Bell, who was later to become Idaho State Mine Inspector, located the district's first mining claim the following year (Bell, 1919). By 1894, prospectors from the Leesburg gold district, 14 miles to the northeast, had arrived and made locations on the most promising showings. These claims included the Uncle Sam, St. Joe, Chicago

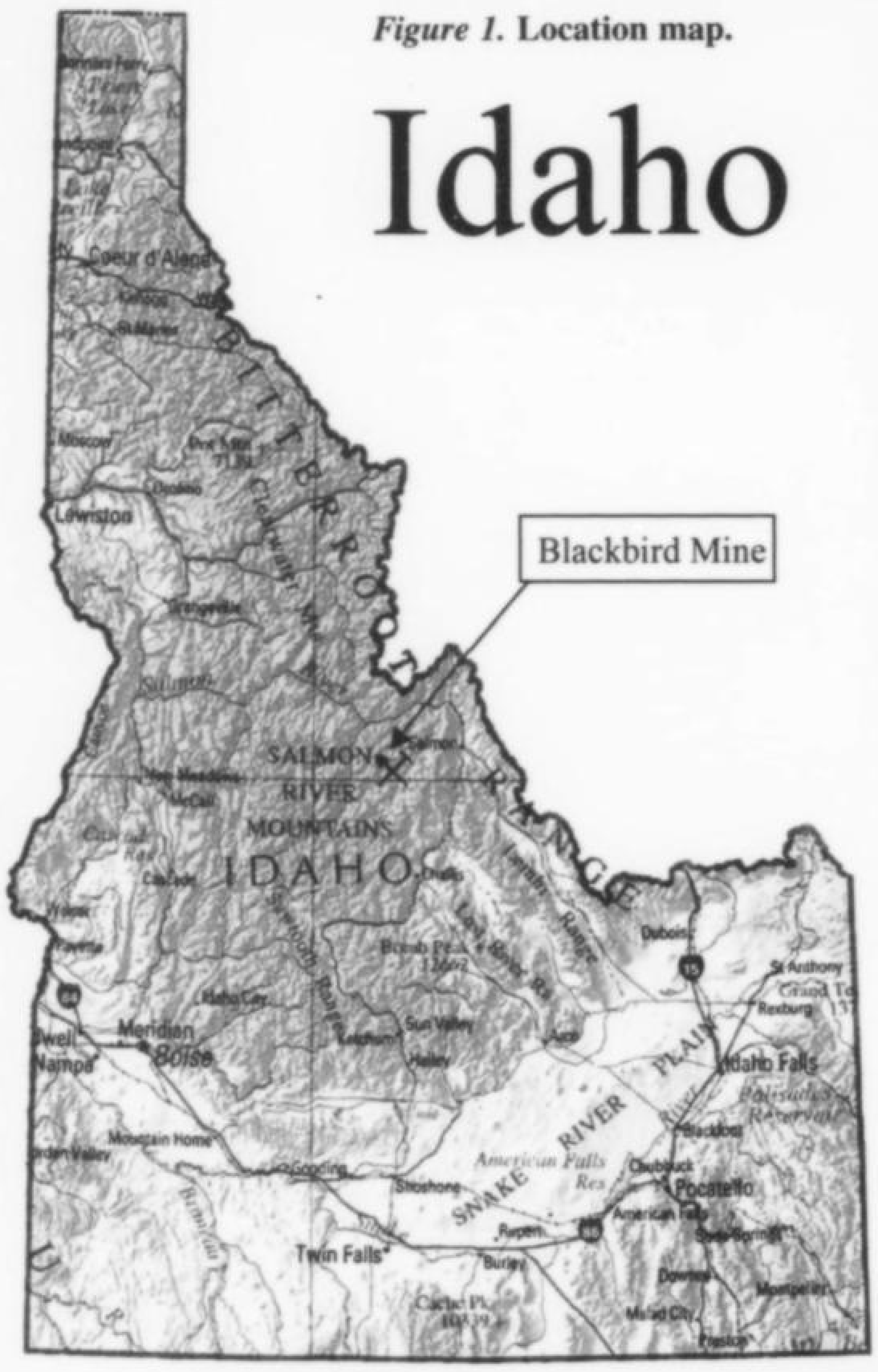
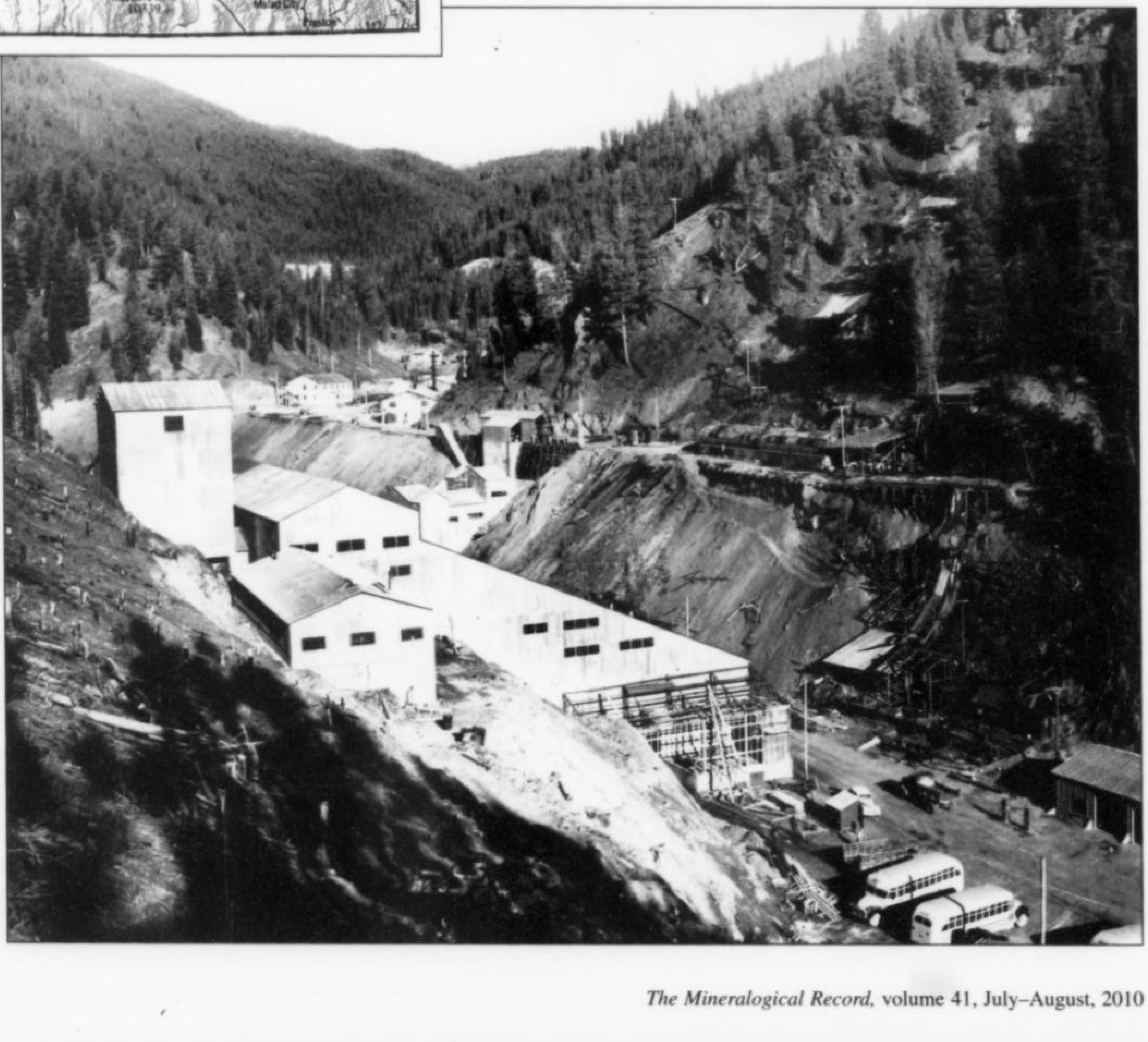


Figure 1. **Location map.**

and Brown Bear, which formed the core of what was to become the present Blackbird mine. In 1899, these and other claims were consolidated under the newly formed Blackbird Copper-Gold Mining Company, Limited. During the next two years, about 1,400 feet of development work were completed on these claims, and some enriched copper-gold ore was found. Plans were made to construct a small copper smelter on site, but this idea was later abandoned because of high transportation costs (Anderson, 1943). It was during this period that the presence of cobalt was first detected. Development work at the Blackbird mine was suspended in 1901.

The first cobalt claims in the district were located in 1901 by John Belliel, probably on outcrops of erythrite or "cobalt bloom" along the West Fork of Blackbird Creek. A second group of claims, known as the Mona group, was later added, extending Belliel's holdings northward across the main fork of Blackbird Creek. There was no market for cobalt at the time, and the claims received little attention until 1915, when the property was purchased by the Haynes Stellite Company of Kokomo, Indiana (Anderson, 1943). The founder of the company, Elwood Haynes, was an inventor, automotive pioneer and metallurgist. In 1913, Haynes received a patent on a wear-resistant cobalt-chromium alloy known as *stellite* and this led him to look for a domestic source of cobalt. After purchasing the Mona group property, the Haynes Stellite Company built a camp and began exploration and development work. A 10-stamp mill was later constructed and, with the advent of World War I, the company received large government contracts for the new alloy. In 1918, about 4,000 tons of cobalt ore were processed, yielding 55 tons of concentrates containing about 18% cobalt. These concentrates were shipped to Niagara Falls, New York for reduction. Exploration and development

Figure 2. **Calera mill (ca. 1955). Idaho State Historical Society.**



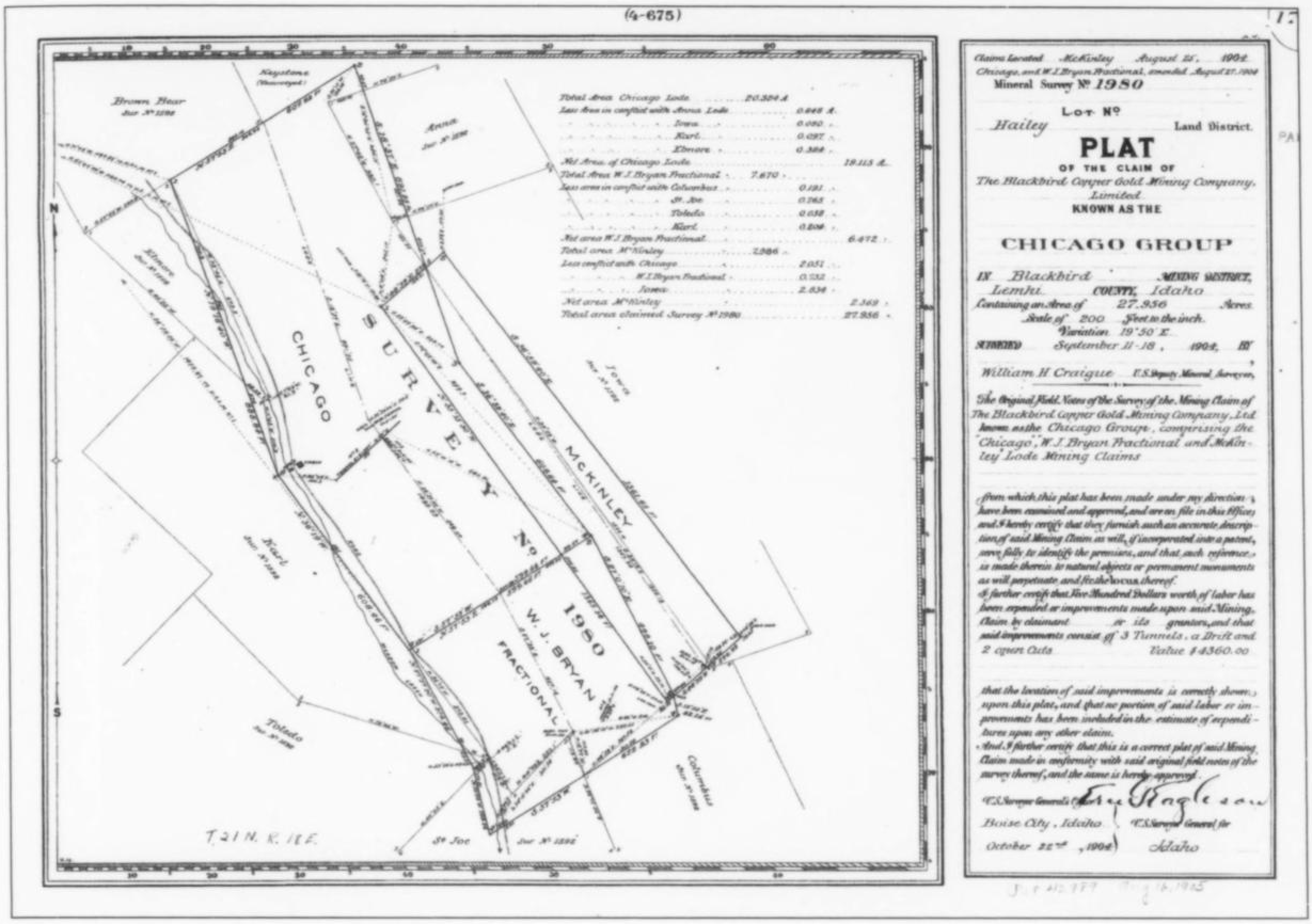


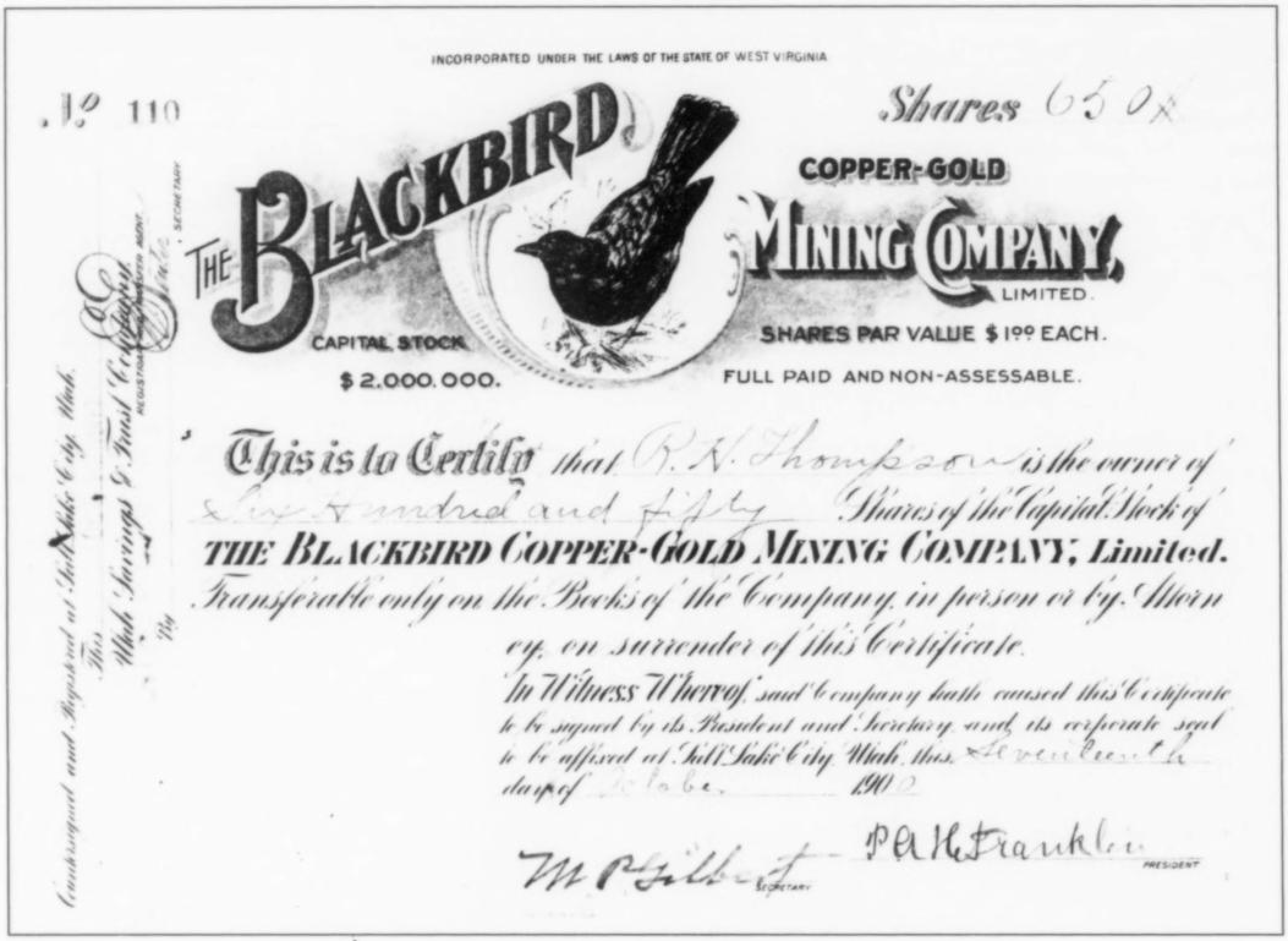
Figure 3. **Mineral survey plat of the Chicago claims group (1904).**

continued through 1919, but in 1920 all operations permanently ceased (Reed and Herdlick, 1947). Ruins from the Haynes Stellite operation can still be seen along the north side of Blackbird Creek, about 1.75 miles east of the Blackbird mine.

The Blackbird district was idle for many years after Haynes Stellite ceased operations. In 1938, the holdings of the Blackbird Copper-Gold Mining Company were acquired at a tax sale by James and Howard Sims of Salmon. Later that year, the Sims leased the property to the Uncle Sam Mining and Milling Company. This company reopened and extended two tunnels on the Uncle Sam claim and partially reopened tunnels on the Chicago and Brown Bear claims. The Uncle Sam portion of the Blackbird mine was made ready for mining and a 75-tons-per-day flotation plant was constructed near the juncture of Blackbird and Meadow Creeks. Records show that about 560 tons of copper-cobalt concentrates were shipped to the smelter at Anaconda, Montana, but no payment was received for the cobalt (Reed and Herdlick, 1947). Like its predecessors, this operation was also unprofitable and it closed in 1941.

Under a wartime program to search for domestic sources of strategic minerals, the U.S. Bureau of Mines conducted preliminary exploration work in the Blackbird district during 1942–43. In 1943, the Howe Sound Company became interested in the district and optioned the Blackbird mine property from Uncle Sam Mining and Milling. Howe Sound continued the exploration program begun by the Government and this effort resulted in the discovery of two large bodies of cobalt-copper ore in the area of the Brown Bear and Chicago claims (Reed and Herdlick, 1947). In 1945, when manpower previously devoted to the war effort became available, the Calera Mining Company, a subsidiary of Howe Sound, began underground exploration and development in the Brown Bear and Chicago ore zones. By 1950, sufficient reserves had been developed to construct a flotation mill. The townsite of Cobalt, located about 6 miles southeast of the mine on Panther Creek, was also established at this time to house the mine and mill workers, which numbered more than 400 during the mine's heyday. The Blackbird mine commenced production in 1951 at a rate of 600 tons per day, later increased to 1,000 tons per day. From the start of production in 1951 until the contract was fulfilled in 1959, Calera enjoyed a premium price paid for its cobalt by the U.S. Government. Further exploration work during the production years resulted in the discovery of additional orebodies. The most important of these, the Blacktail zone, was located to the northwest of the Brown Bear and was mined as a small open pit beginning in 1957. The Government's premium price contract expired in 1959 and all mining at the Blackbird ceased shortly thereafter. Milling operations continued until July 1960, when all stockpiled ore from the Blacktail pit had been exhausted. All Calera Mining Company operations were then terminated, thus ending the most productive period in the mine's history (Kiilsgaard and Bookstrom, 2005).

In 1960, the mine property was leased by Machinery Center, Inc. of Salt Lake City. Mining operations resumed at the Blackbird in 1963, but only copper was recovered and on a smaller scale than before. The underground portion of the mine was leased to Earl Waite and William Barnes, while the Blacktail open pit was operated by Machinery Center (Steele, 2009). Operations continued through 1966, with most of the production coming from the open


INCORPORATED UNDER THE LAWS OF THE STATE OF WEST VIRGINIA

No 110

Shares 650

THE BLACKBIRD COPPER-GOLD MINING COMPANY, LIMITED.

CAPITAL STOCK $2.000.000.

SHARES PAR VALUE $1.00 EACH.

FULL PAID AND NON-ASSESSABLE.

This is to Certify that R. H. Thompson is the owner of Six Hundred and fifty Shares of the Capital Stock of THE BLACKBIRD COPPER-GOLD MINING COMPANY, Limited. Transferable only on the Books of the Company in person or by Attorney on surrender of this Certificate.

In Witness Whereof, said Company hath caused this Certificate to be signed by its President and Secretary and its corporate seal to be affixed at Salt Lake City, Utah, this Seventeenth day of October 1900

M P Gilbert, Secretary — P A H Franklin, President

Countersigned and Registered at Salt Lake City, Utah. This ... Utah Savings & Trust Company ... Registrar ... Secretary

***Figure 4.* Stock certificate for The Blackbird Copper-Gold Mining Company Limited (1900). Allan Young collection.**

pit. In 1967, the property was sold to the Idaho Mining Company, a subsidiary of Hanna Mining Company. Exploration work continued until 1969, at which time the Blackbird was again idled. According to U.S. Bureau of Mines records, production from the Blackbird mine for the period 1939–1968 totaled approximately 13.9 million pounds of cobalt, 53.5 million pounds of copper, 24,100 ounces of gold and 54,000 ounces of silver (Johnson *et al.*, 1998). Total ore mined likely exceeded two million tons (Idaho Geological Survey, 1997). By 1968, the Blackbird mine contained over 81,000 feet of underground workings (Bennett, 1977).

In 1977, Noranda Exploration optioned the property from the Idaho Mining Company and initiated an aggressive program of exploration. In 1979, Noranda Mining, Inc. and Hanna Services Company formed the Blackbird Mining Company, a limited partnership, for the purpose of re-opening the mine. Refurbishment, development and test mining activities followed, but by 1982 the price of cobalt had fallen significantly and plans for resuming production were consequently scrapped (U.S. Department of Agriculture, 2008). There have since been no serious attempts to re-open the Blackbird mine.

During periods of active mining, spills of tailings into Blackbird Creek were known to have occurred. Subsequently, debris flows, erosion and acid rock drainage resulted in the spreading of arsenic, copper and cobalt contamination to downstream locations. In 1995, the group of companies composed of current and former operators or owners of the Blackbird mine settled a lawsuit brought by the United States and the State of Idaho for environmental damages to the Panther Creek drainage. Under a 1995 Consent Decree, the companies agreed to take response actions at the site to clean up the contamination and to implement a natural resources restoration plan (U.S. Department of Agriculture, 2008). This work is presently ongoing and a wastewater treatment plant constructed in 1981 continues to treat drainage from the 6,850-foot level of the mine (levels are numbered according to elevation above sea level). Additionally, a small mining crew is employed on a seasonal basis to maintain the underground workings. Access to the Blackbird mine site is currently prohibited.

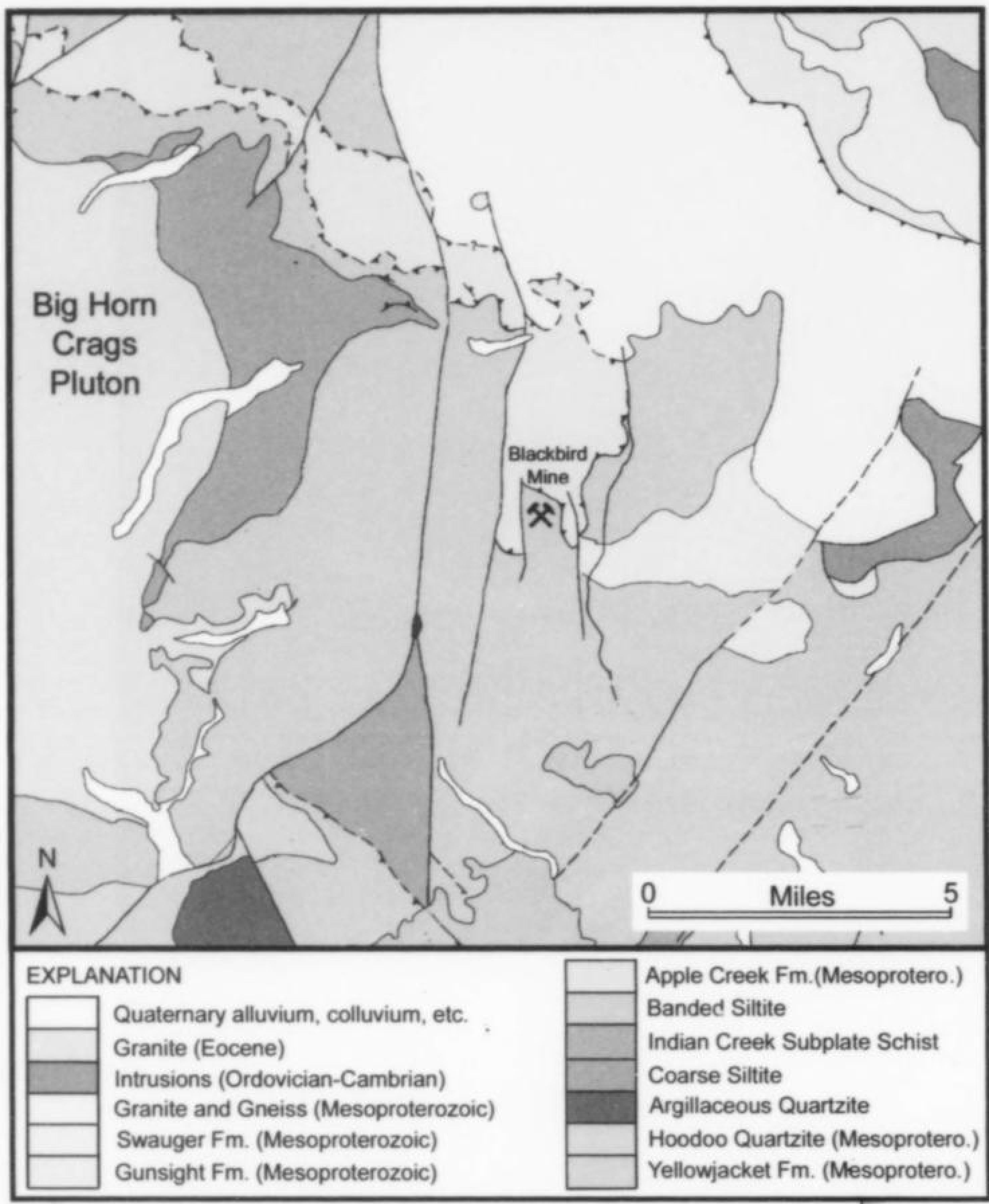
GEOLOGY AND ORE DEPOSITS

The complex geology of the Blackbird mining district has only recently been well understood. For many years, the Blackbird deposits were thought to be hosted in the Middle Proterozoic Yellowjacket Formation and correlated with the lower part of the Belt Supergroup of Montana and northern Idaho. Instead, recent mapping identified the banded siltite unit of the Apple Creek Formation as the dominant stratigraphic unit in the district. Preliminary age-dating studies indicate that much of the stratigraphic succession of east-central Idaho is younger, at less than 1.4 billion years, than the Belt Supergroup (Lund and Tysdal, 2007). While early workers suggested that the Blackbird deposits were epigenetic hydrothermal lodes or hydrothermal replacements along shear zones (Vhay, 1948), they are now believed to have originated as sedimentary exhalative deposits, similar to the Sullivan deposit in British Columbia, in a relatively deep-water, rift-basin environment (Lund and Tysdal, 2007). Mafic igneous rocks were probably the source of the ore metals, with the enrichment of cobalt caused by selective extraction and transport in the submarine geothermal system (Nash and Hahn, 1986). Low-grade regional metamorphism affecting the intact stratigraphic section occurred over most of the region during the Middle Proterozoic. However, Cretaceous metamorphism related to thrust faulting was the dominant event that over-printed earlier sedimentary features and metamorphic fabrics in the region (Lund and Tysdal, 2007).

***Figure 5.* Aerial view of Blackbird mine area, looking southeast from the Blacktail pit (Idaho Department of Environmental Quality, 1993).**

The area of east-central Idaho encompassing the Blackbird mining district is underlain by a series of thrust plates, with the Blackbird mine lying in the upper part of the Poison Creek plate. Here, both hanging-wall and footwall rocks are strongly deformed, resulting in major overturned folds in the hanging wall and imbricate thrust plates in the footwall. The upper imbricate in the Poison Creek plate contains chloritoid-garnet schists, while the intermediate imbricate forms the lower to middle greenschist Blackbird subplate containing the sediment hosted cobalt-copper deposits of the Blackbird mine. The structurally lowest imbricate forms the Haynes Stellite subplate and includes the youngest rocks and mineralized tourmaline breccias. Northwest-striking and north-striking normal faults dismembered the related imbricate thrust faults, resulting in the present juxtaposition of different stratigraphic units, regional metamorphic facies, structural levels and styles of mineralization within the district. In the Blackbird subplate, sulfide minerals were locally remobilized along discrete shear zones and in the axial zones of folds (Lund and Tysdal, 2007).

The primary ore minerals at the Blackbird mine were cobaltite and chalcopyrite. Some arsenopyrite and pyrite were also mined for their cobalt content. Other sulfide minerals found in the mine included pyrrhotite, safflorite and linnaeite. Native gold ("electrum") and silver occurred in very minor amounts. Magnetite, sphalerite, galena and enargite were also reported. Natural outcrops were few but where ore zones did reach the surface, a leached cap was present and extended downward 60 to 100 feet from the surface, roughly paralleling the topography. Minerals occurring in this leached zone included goethite, hematite, jarosite, erythrite, native bismuth, bieberite, heterogenite, nontronite and pitticite. The oxidation of chalcopyrite produced considerable amounts of limonite and malachite together with cuprite, native copper and azurite near the tops of ore zones. Below the leached cap was a zone of mild supergene enrichment, which reached an average depth of about 100 feet before encountering primary sulfides. Chalcocite, covellite, cuprite and native copper were found in the supergene zone. Also occurring within this zone and below were large, well-formed crystals of ludlamite and vivianite (Anderson, 1943; Vhay, 1948; Cole, 1956).



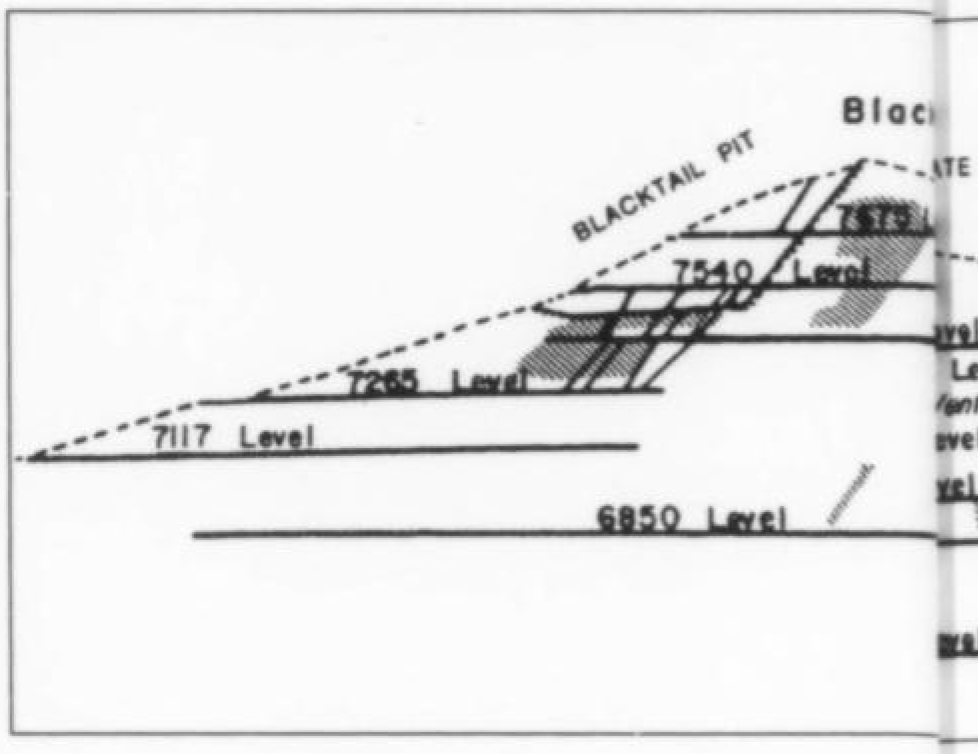
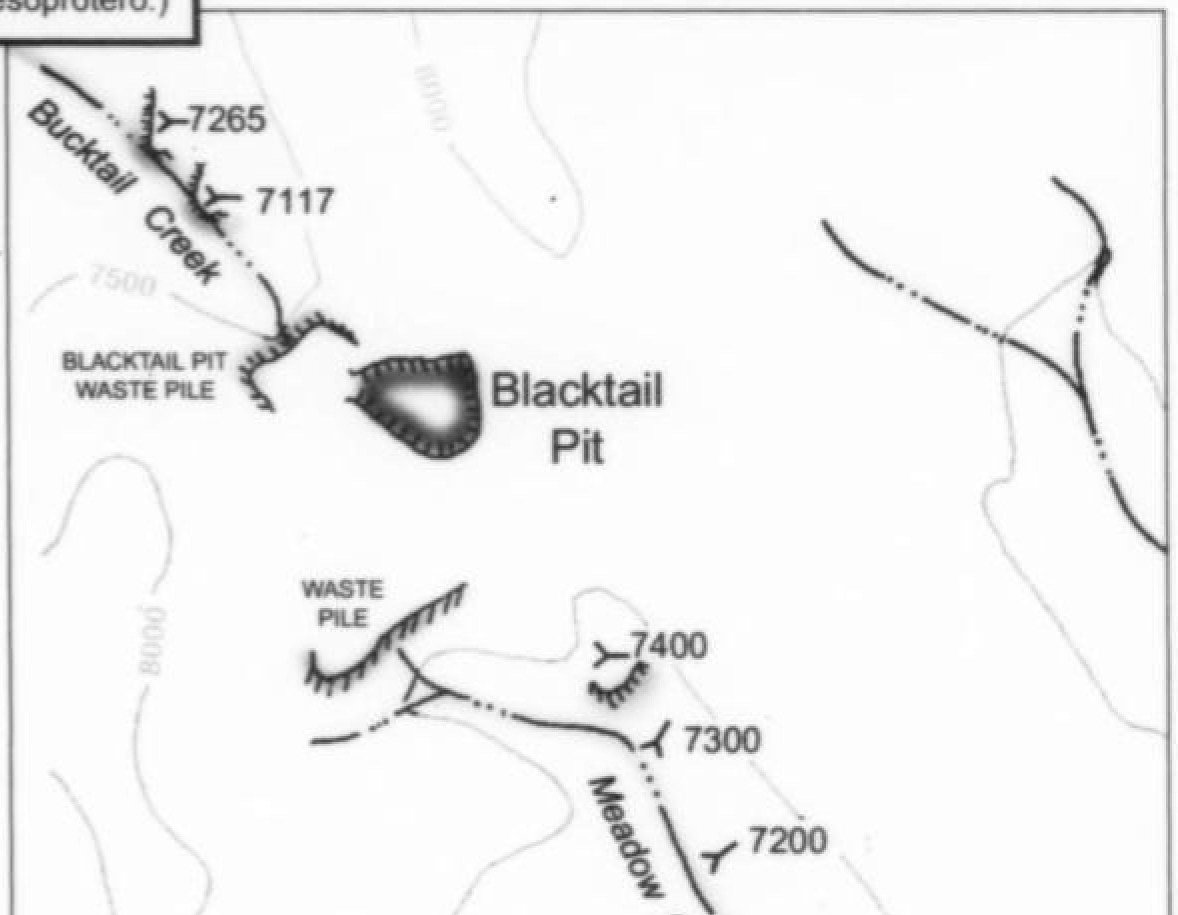


Figure 6. **Geologic map, simplified from Lund *et al.*, 2007.**

Figure 7. **Plan map of Blackbird mine workings (from Baldwin, 1977).**



Quartz and biotite constituted the chief gangue minerals at the Blackbird mine. Quartz occurred as small irregular veinlets in both the mineralized zones and the country rock and as small elongate lenses in the silicified schist. Biotite occurred as disseminated green grains in the ore zones and as dark greenish brown grains in the country rock. Other gangue minerals included hornblende, tourmaline, chlorite, muscovite, ankerite, siderite, calcite and apatite (Cole, 1956).

The principal ore zones of the Blackbird mine were, from southeast to northwest, the Chicago, the Brown Bear and the Blacktail. All trended in a northwesterly direction and dipped steeply to the northeast. Most underground production was from the Chicago and Brown Bear ore zones. Major production was also reported from an open pit in the Blacktail zone (Bennett, 1977).

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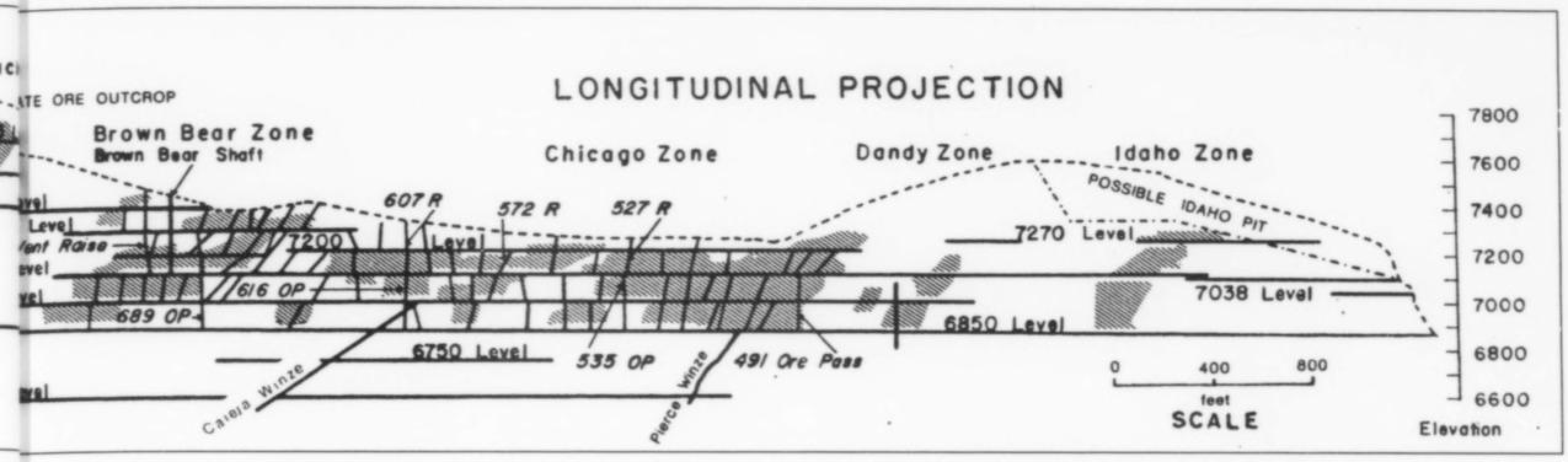

Figure 8. **Longitudinal map of Blackbird mine workings (Idaho Mining Company, ca. 1968).**

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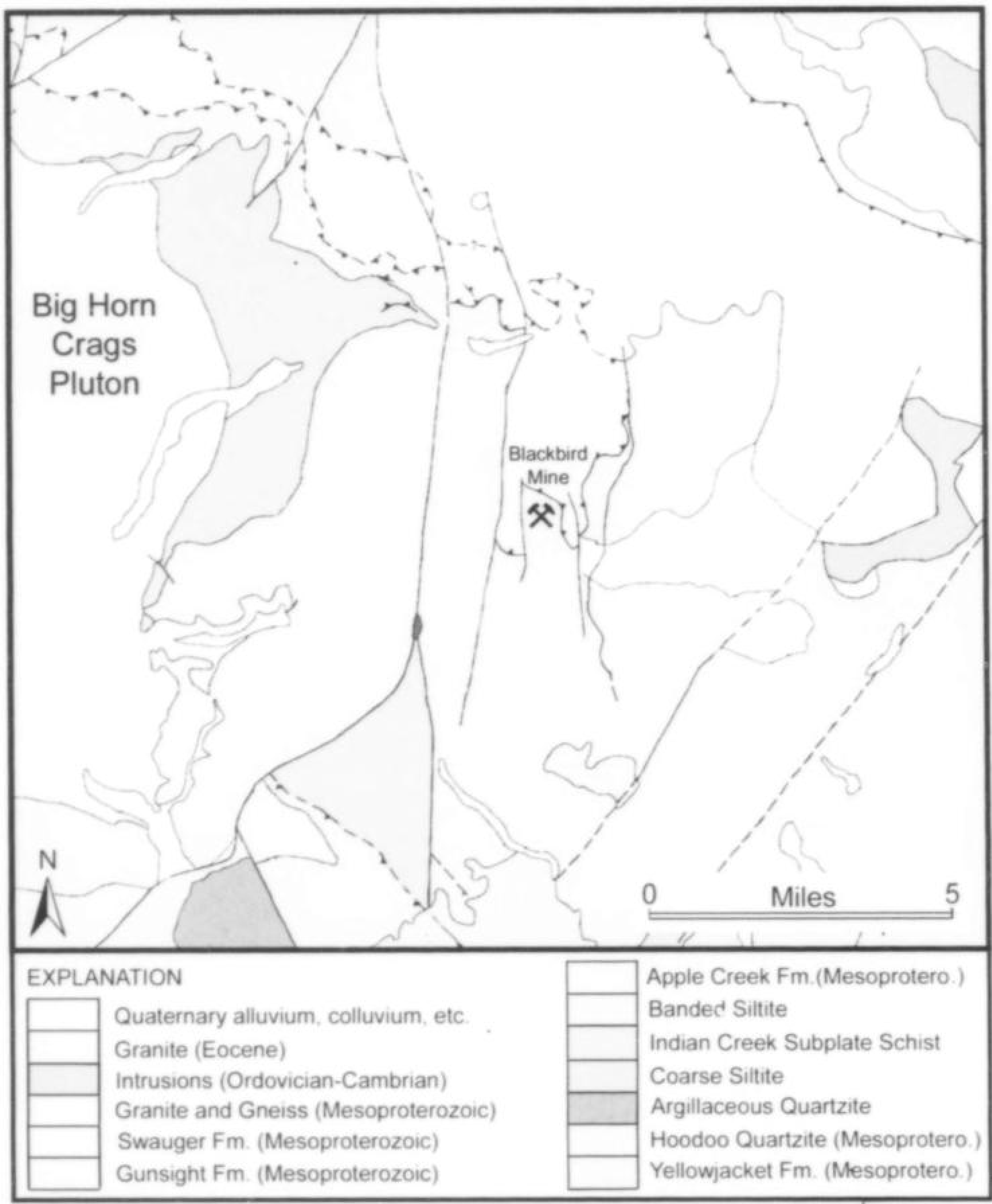


Figure 6. **Geologic map, simplified from Lund *et al.*, 2007.**

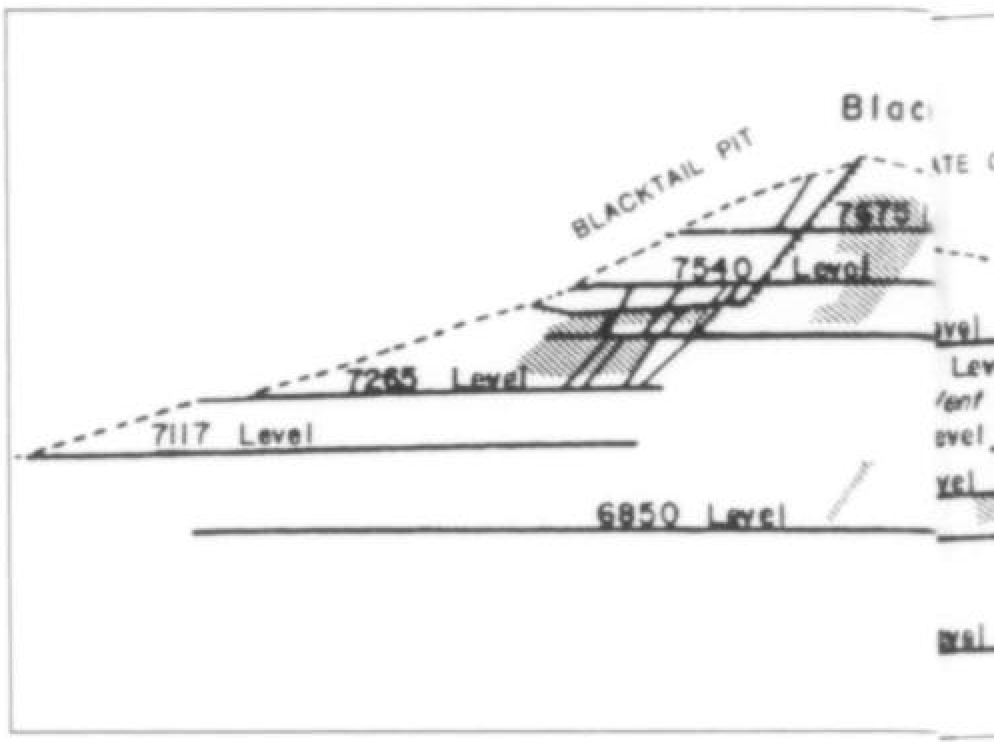
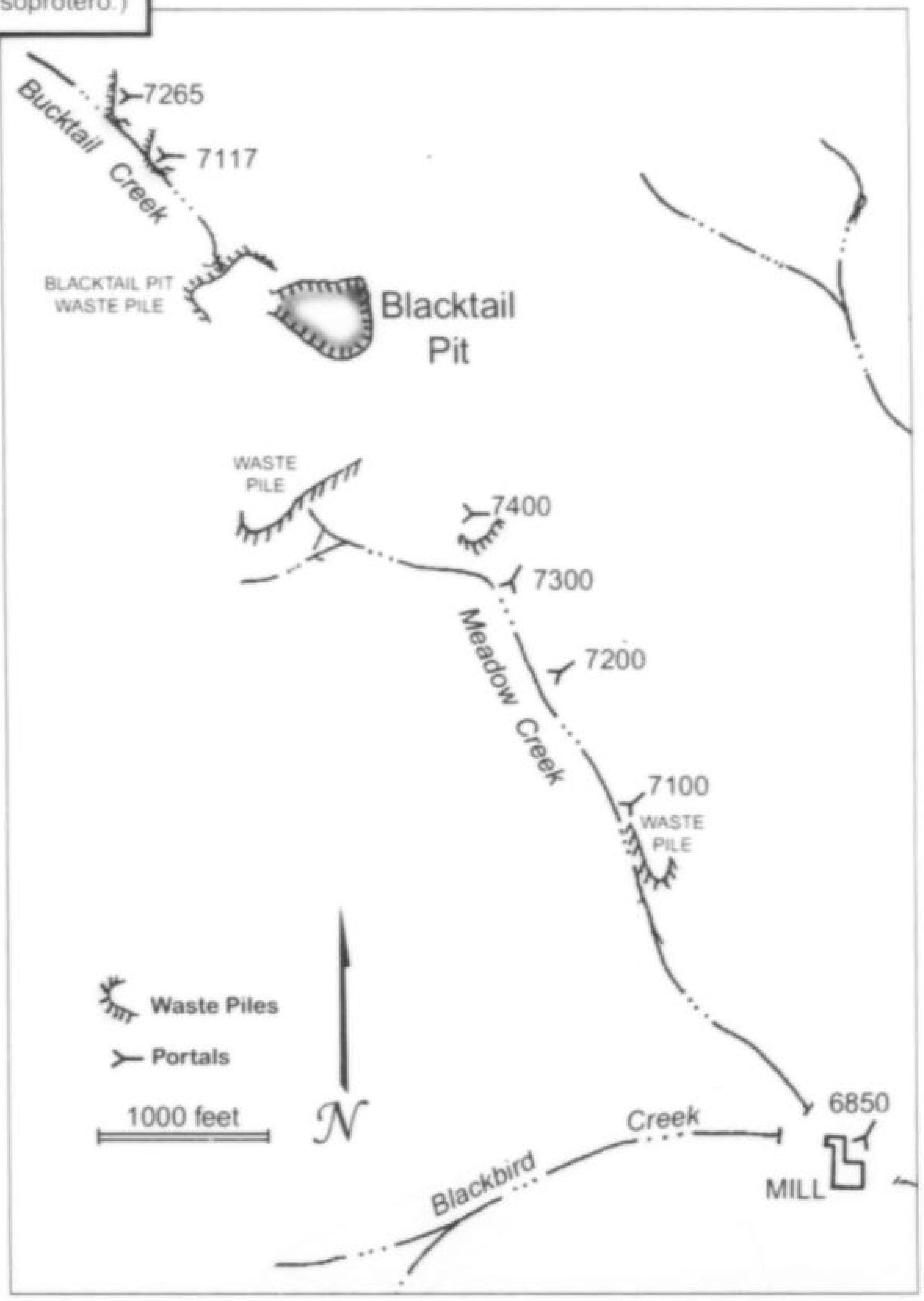


Figure 7. **Plan map of Blackbird mine workings (from Baldwin, 1977).**



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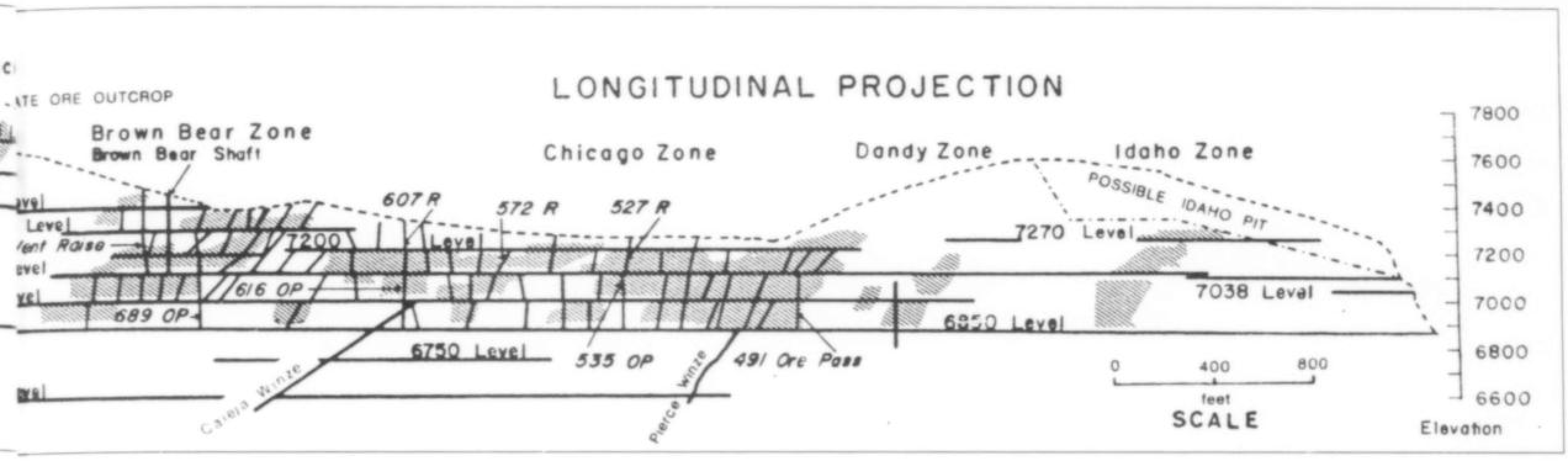

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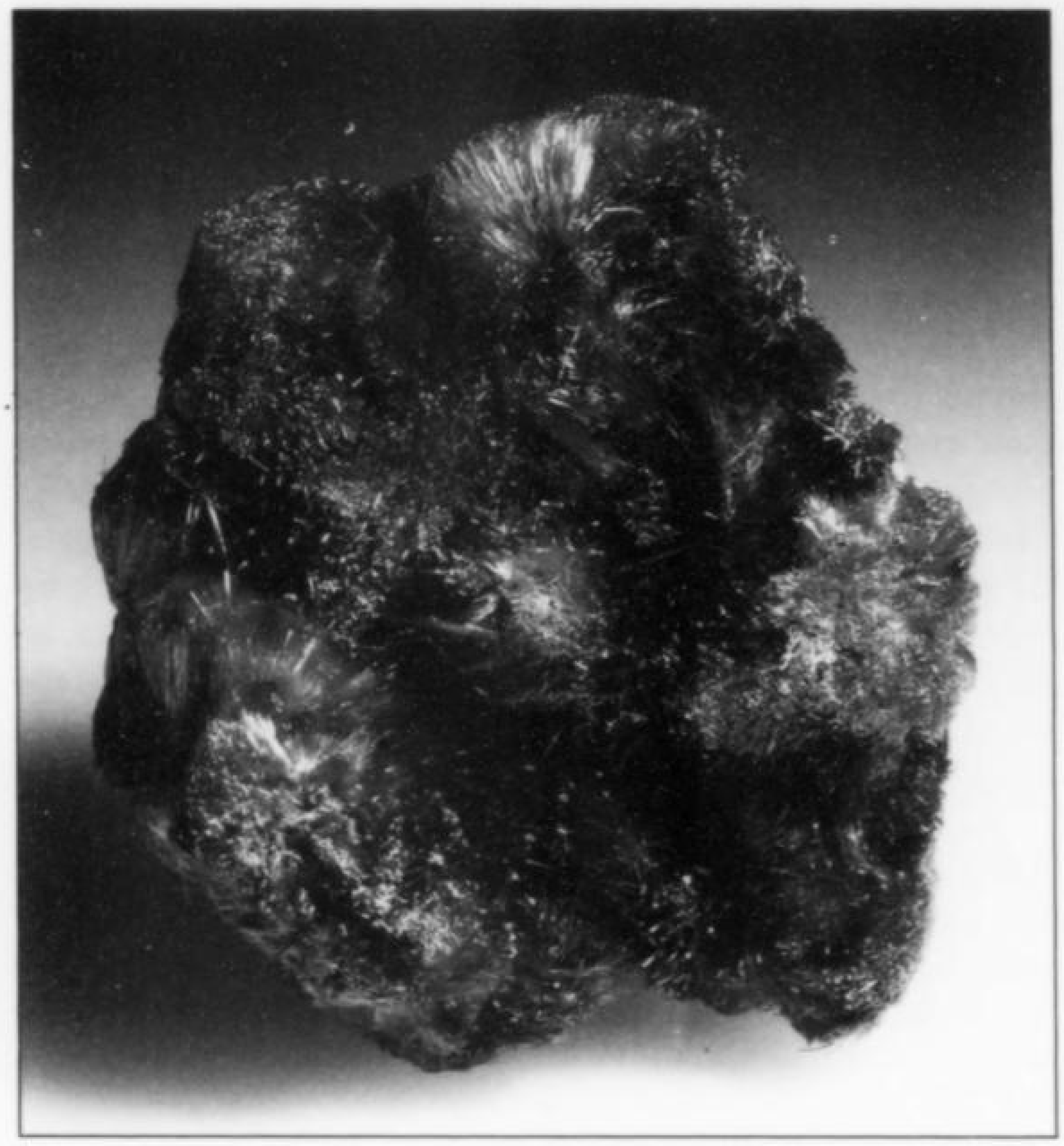
Figure 9. **Copper with cuprite, 2.0 cm, from the Blackbird mine. Allan Young collection and photo.**

Figure 10. **Erythrite, 2.3 cm, from the Blackbird district. Allan Young collection and photo.**



zone in the area bounded by the 491 and 535 ore passes, between the 6850 and the 7100 levels. According to Riggan, the 503, 508 and the 525 stopes were among the best producers of ludlamite and vivianite. It was impossible to predict when a cavity containing crystals would be encountered but, when one was found, specimens were packed out of the mine by the powder box. The unpredictable nature of the cavities also resulted in many specimens being destroyed by blasting. Riggan remembers a mineral dealer from Spokane, Washington as being one of the buyers of specimens during his time at the mine (Jim Riggan, personal communication, 2009). This may have been Carl Fair, who ran a mineral shop in Spokane known as "Ore, Incorporated."

During the mid-1970s, Idaho Mining Company collected a bulk sample for metallurgical testing from the Pierce winze area on the 6850 level. Many crystals of ludlamite and vivianite could be seen in the drums of ore, which had been topped off with water to prevent oxidation of the sulfides (Earl Bennett, personal communication, 2005).

MINERALS

While more than 30 valid mineral species have been reported from the Blackbird mine area, only the few that are of collector interest are described here.

Cobaltite CoAsS

Cobaltite typically occurred in the Blackbird mine as microscopic, reddish gray grains in quartz with tourmaline and cobalt-rich arsenopyrite. Cubic and octahedral crystals of cobaltite to 5 mm were also found disseminated in quartz, associated with biotite, chlorite and apatite (Ream, 2004). Some cobaltite grains as large as 1.2 cm were reported from the Uncle Sam mine. Cobaltite found here is distinctly crystalline and the grains, even in aggregates, show cubic faces. The crystals are nearly as white as those of arsenopyrite and contain some nickel. The cobaltite did not appear to oxidize as readily as the pyrite and chalcopyrite, and in some places the disseminated grains were so closely spaced as to comprise bands of almost massive cobaltite several inches wide (Anderson, 1943). In the Chicago zone, cobaltite was present in both coarse-grained and fine-grained varieties (Cole, 1956).

Copper Cu

Excellent specimens of arborescent copper, as well as thin, hackly sheets, were found in the Blacktail pit (Ream, 2004). On the 7100 level of the Blackbird mine, groups of small copper crystals to 1 mm and coated with cuprite occur in a small quartz vein in the footwall of the Chicago zone (personal observation). Arborescent copper was also found in the Brown Bear zone on the 7400 level of the mine.

Erythrite $Co_3(AsO_4)_2 \cdot 8H_2O$

In the Blackbird mining district, many fracture surfaces and other cavities in the ore deposits have thin coatings of crudely crystalline, drusy crusts of erythrite, but fine specimens showing coarse, euhedral crystals are rare. Some fine-quality, coarse crystals were found in the Blacktail pit. In the Blackbird mine, rose-red fibrous

Figure 11. **Ludlamite crystals on matrix, 6.6 cm, from the Blackbird mine. Martin Zinn collection, ex Arkenstone; Joe Budd photo.**

Figure 12. **Ludlamite crystals to 1.1 cm, from the Blackbird mine. Allan Young collection (ex Jim and Dawn Minette collection); Allan Young photo.**

coatings of erythrite along seams and cracks were found in a black tourmaline-quartz rock (Ream, 2004).

Ludlamite $Fe_3(PO_4)_2 \cdot 4H_2O$

Ludlamite was found mainly in the Chicago zone of the Blackbird mine, within both the supergene and primary sulfide zones. It was likely of secondary origin, probably deposited from circulating groundwater (Bennett, 1977). Vhay (1948), however, suggested that ludlamite may have been a later, primary mineral, since it occurred with quartz and pyrite. Crystals were found in vugs and in veinlets in sulfide ore consisting of pyrrhotite, chalcopyrite, pyrite and cobaltite, along with minor minerals such as safflorite, tourmaline, apatite, micas and carbonates (Glass and Vhay, 1949). They were also found on dark, oxidized wall rock in association with vivianite, and alone (Ream, 2004). Druses of small, lustrous ludlamite crystals were referred to as "frog eggs" by the miners (Bill James, personal communication, 2008).

Ludlamite crystals from the Blackbird mine typically occur as isolated individuals on matrix and as stacked crystal aggregates to several centimeters high. Crystals vary in color from a pale sea-green to dark green. Many are transparent and are remarkably free from inclusions. They form monoclinic basal tablets, with the *c* {001} face dominant. The crystals are typically 8 to 12 mm across, though

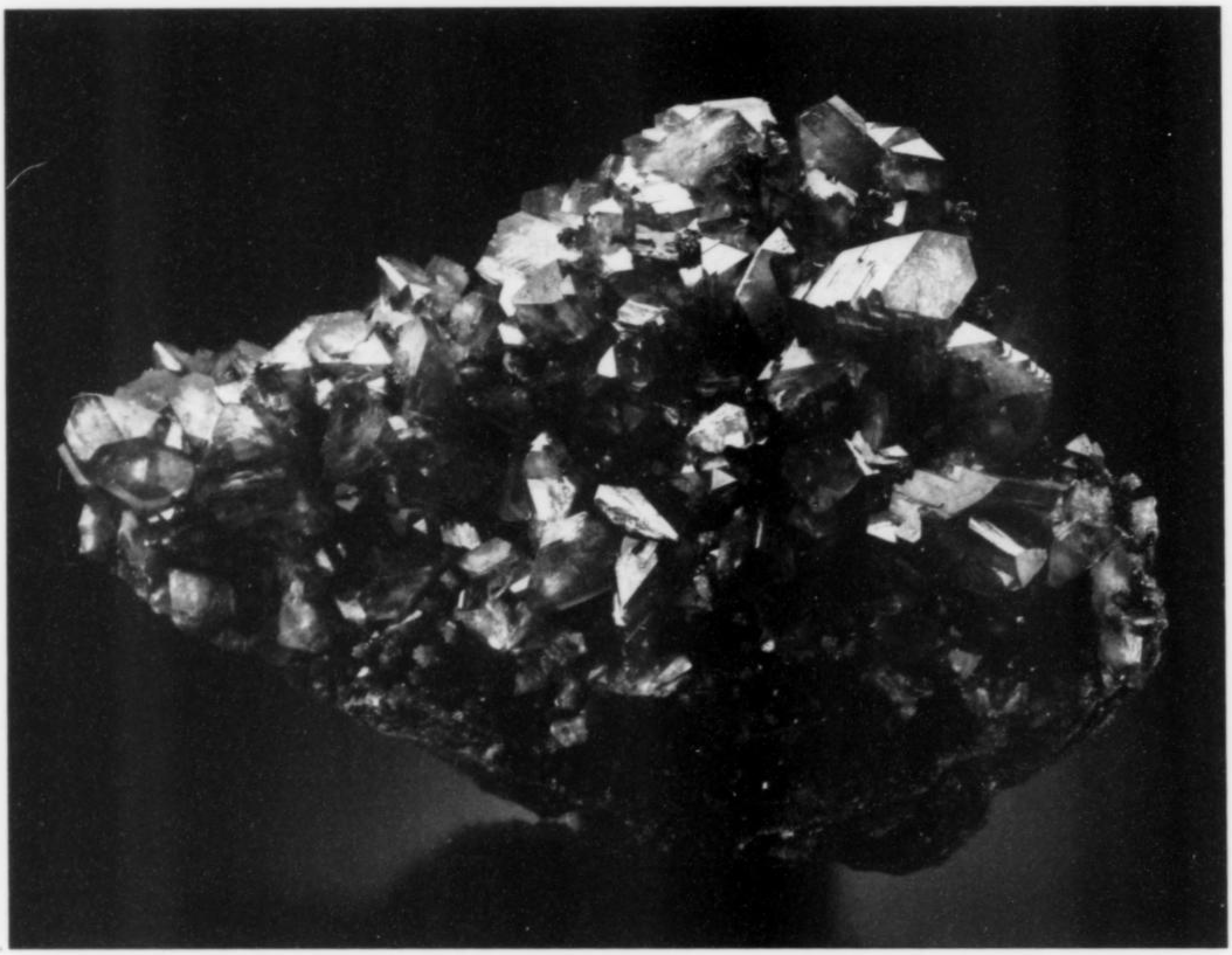
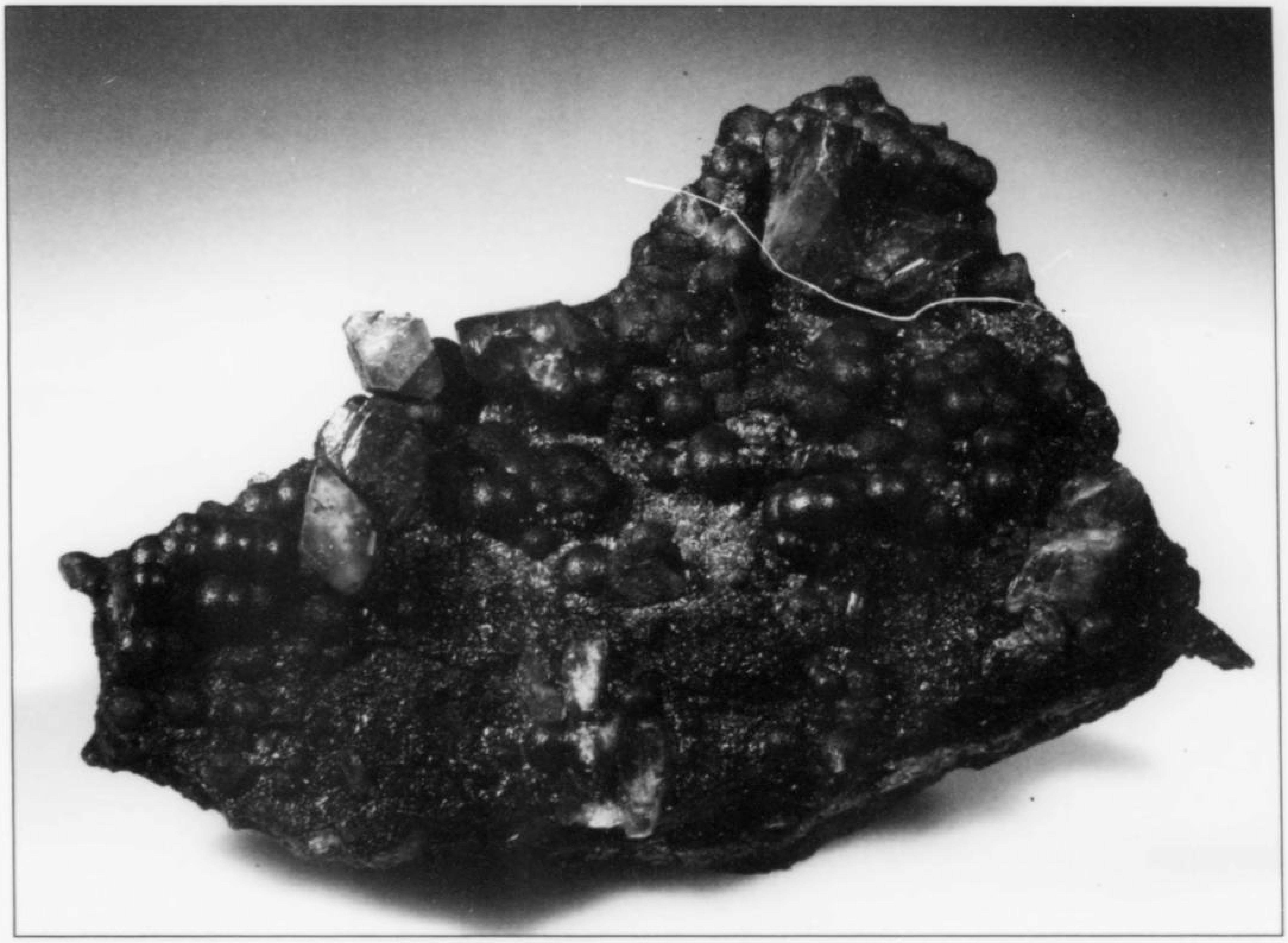


Figure 13. **Ludlamite crystals with siderite on matrix, 8.2 cm, from the Blackbird mine. Arkenstone specimen, ex Howard Belsky collection, now in the Matthew Tannenbaum collection; Joe Budd photo.**

Figure 14. **Ludlamite crystal group, 2.5 cm, from the Blackbird mine. Glen and Ruth Evans collection, now in the College of Idaho collection; Allan Young photo.**

Figure 15. **Ludlamite crystal, 2.3 cm, from the Blackbird mine. Allan Young collection (ex Beth Gordon collection); Allan Young photo.**



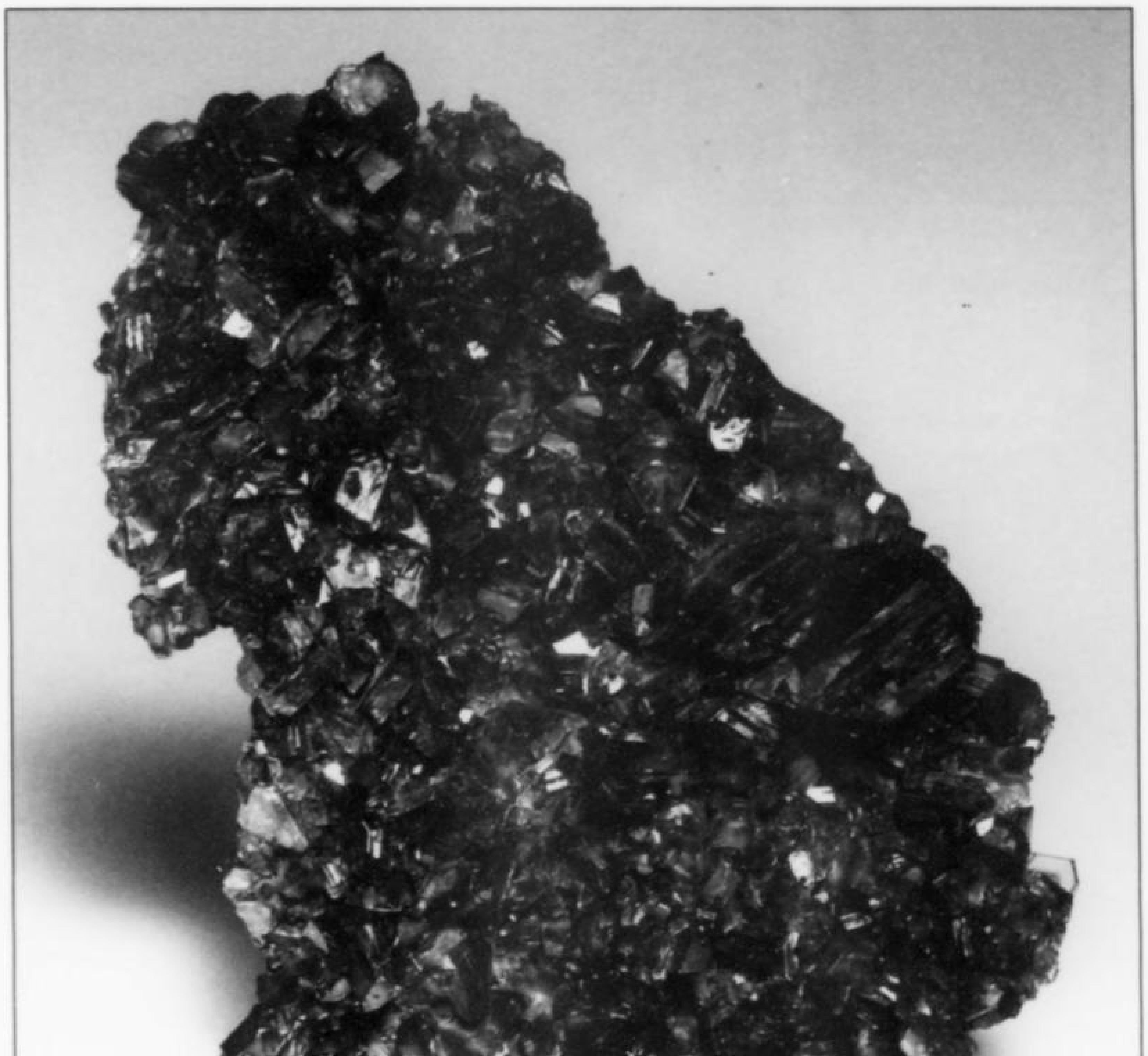
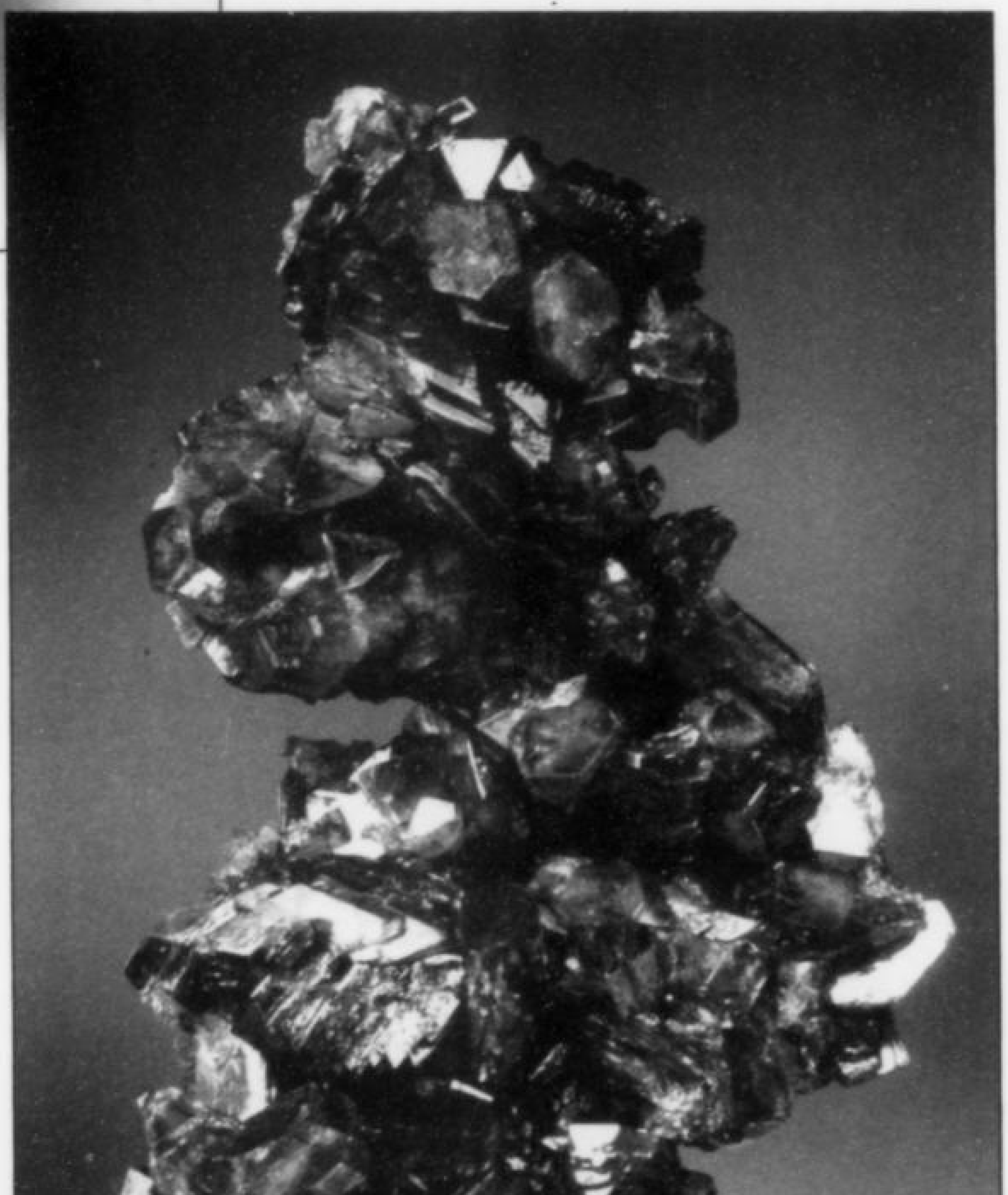


Figure 16. Ludlamite on botryoidal siderite with pyrite, 8.0 cm, from the Blackbird mine. Glen and Ruth Evans collection, now in the College of Idaho collection; Allan Young photo.

Figure 17. Ludlamite crystal druse of the type referred to by the miners as "frog eggs," 4.5 cm, from the Blackbird mine. Mark Jeffers collection; Allan Young photo.

Figure 18. **Ludlamite crystals on matrix, 3.3 cm, from the Blackbird mine. Mark Jeffers collection; Allan Young photo.**

Figure 19. **Ludlamite crystal cluster, 8.1 cm, from the Blackbird mine. Kevin Brown collection; Joe Budd photo.**



some may reach 2.5 cm (Ream, 2004; Glass and Vhay, 1949; Bill James, personal communication, 2008).

Quartz SiO_2

While commonly found in association with ludlamite and vivianite, few good specimens of quartz crystals are known from the Blackbird mine. Transparent quartz crystals to over 10 cm long have been reported, some with inclusions of brassy pyrite cubes (Ream, 2004; Norm Radford, personal communication, 2005).

Siderite $Fe^{2+}CO_3$

Small masses of translucent, pale brown rhombohedral crystals of siderite associated with vivianite are occasionally seen in specimens from the Chicago zone (Cole, 1956). Siderite also occurs as botryoidal masses with radiating structure in association with ludlamite crystals (personal observation).

Vivianite $Fe_3^{2+}(PO_4)_2 \cdot 8H_2O$

Some of the world's finest specimens of vivianite were found at the Blackbird mine as crystals in shades of pink, green, grayish blue, purple and purplish black, as well as colorless. Fresh, unaltered specimens are colorless to very pale green but they oxidize progressively to darker green, blue, brown, dark bluish black and purplish black on exposure to light. (Colorless Bolivian vivianite crystals have been observed turning green in just 15 minutes when exposed to full sunlight; Petrov, 2002). However, auto-oxidation without the aid of light probably occurs *in situ* as well. The unique

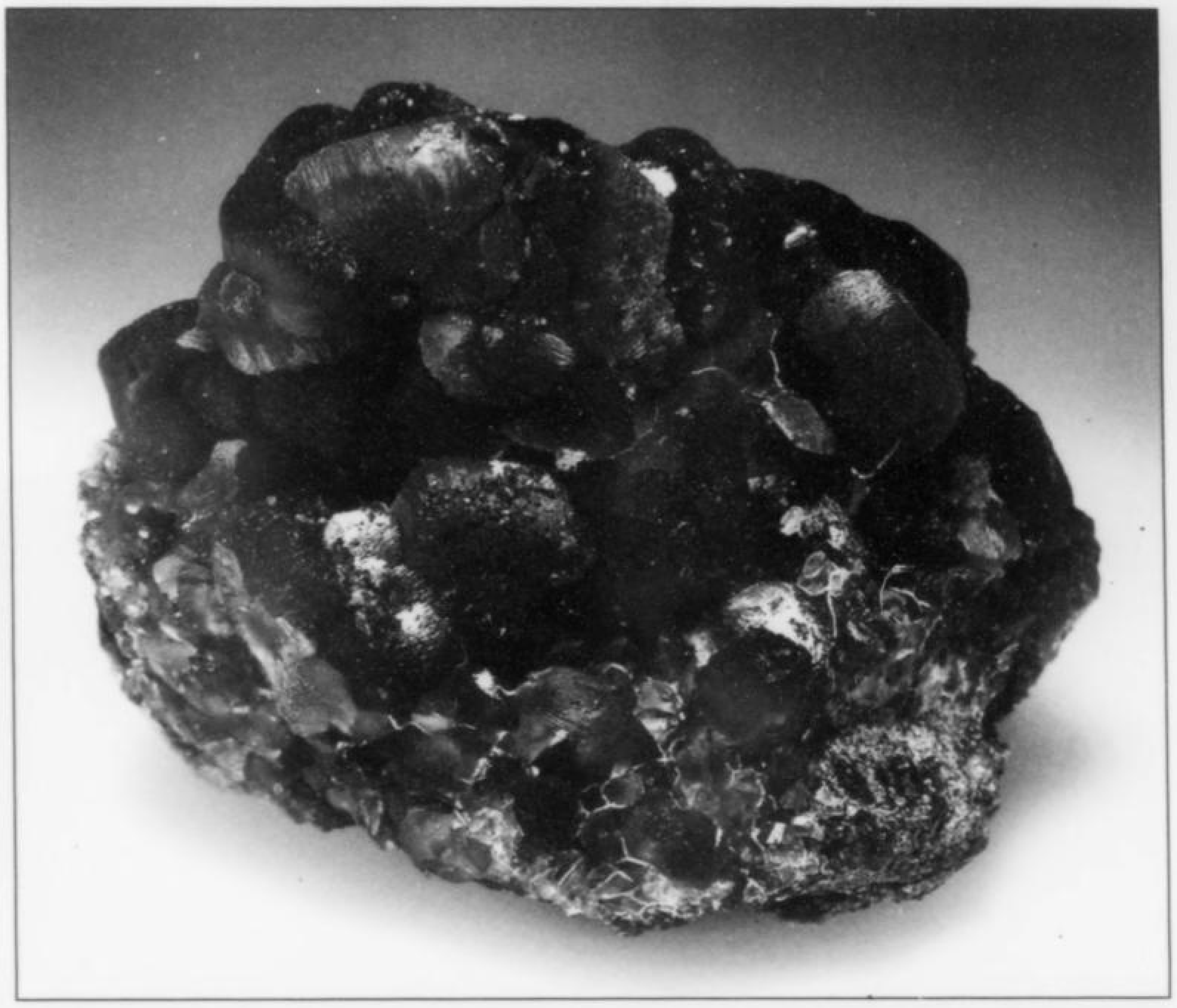


Figure 20. **Siderite crystal group, 2.5 cm, from the Blackbird mine. Allan Young collection and photo.**

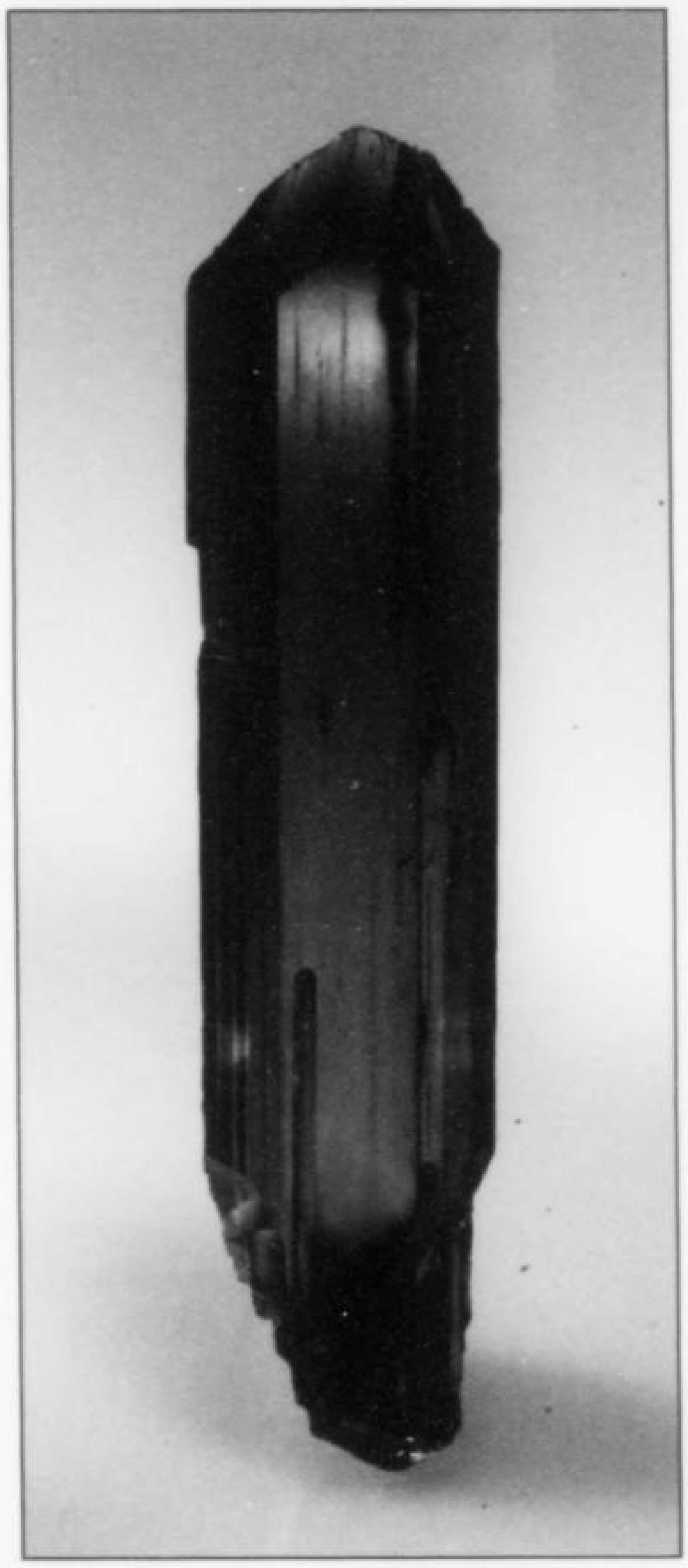


Figure 21. **Vivianite crystal, 3.3 cm, from the Blackbird mine. Allan Young collection and photo.**

Figure 22. **Vivianite crystals to 1.2 cm on matrix, from the Blackbird mine. Allan Young collection (ex Jim and Dawn Minette collection); Allan Young photo.**

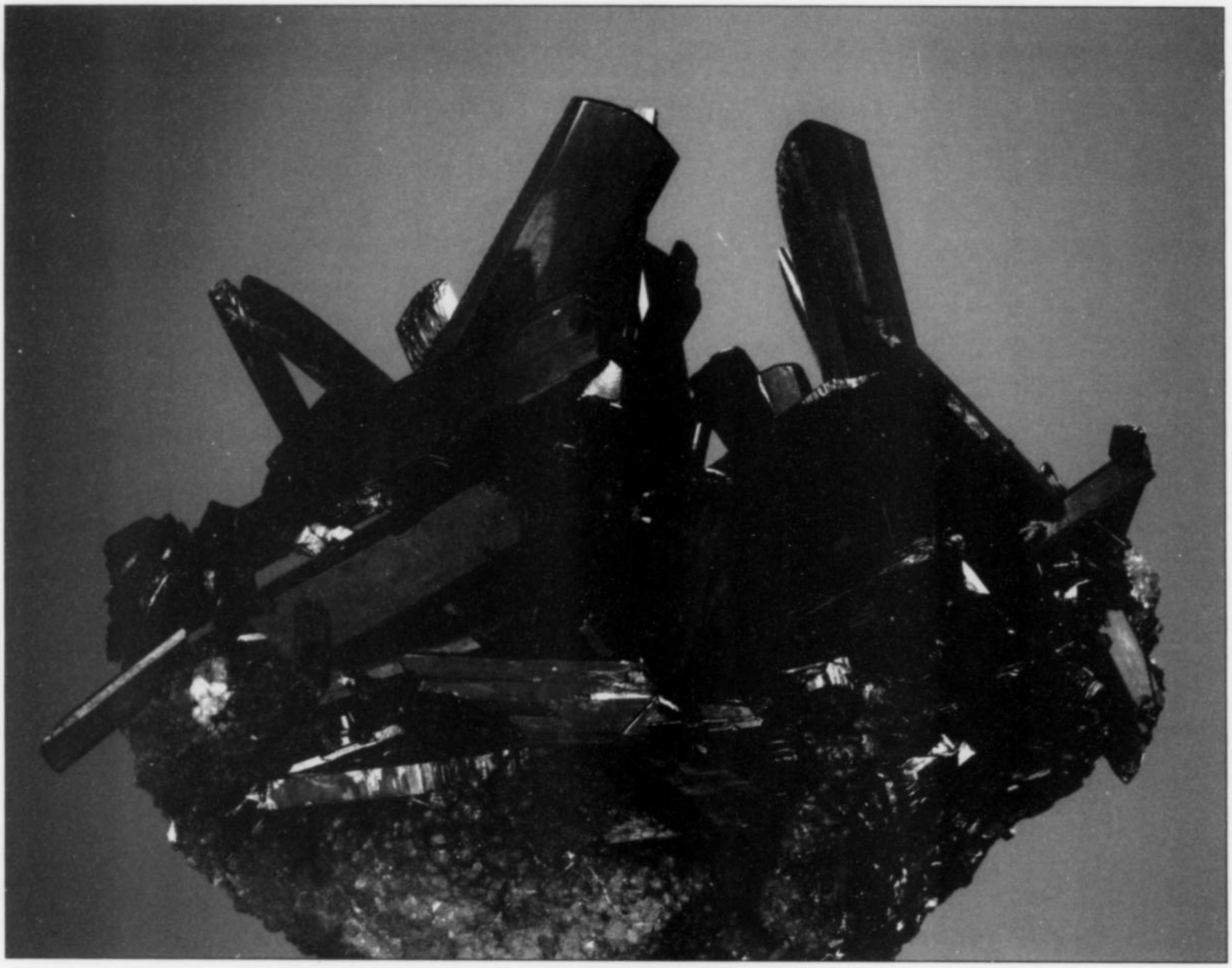


Figure 23. **Vivianite crystal group on matrix, 9.6 cm, from the Blackbird mine. Kevin Brown collection; Joe Budd photo.**

Figure 24. **Vivianite crystals to 1.8 cm on siderite, from the Blackbird mine. Allan Young collection and photo.**

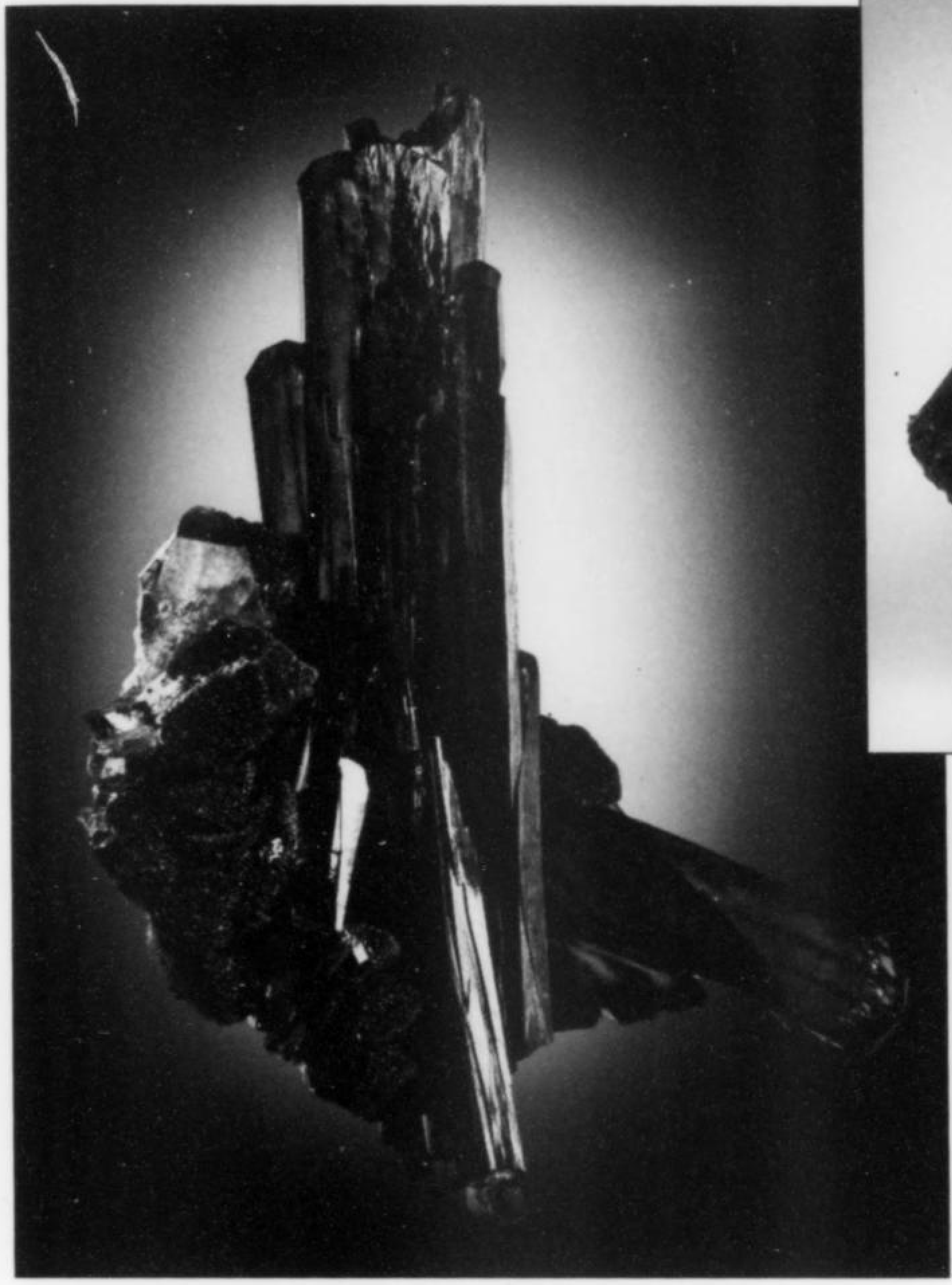


Figure 25. **Vivianite crystals with ludlamite, 5.1 cm, from the Blackbird mine. Arkenstone specimen, ex Arch Oboler collection; Joe Budd photo.**

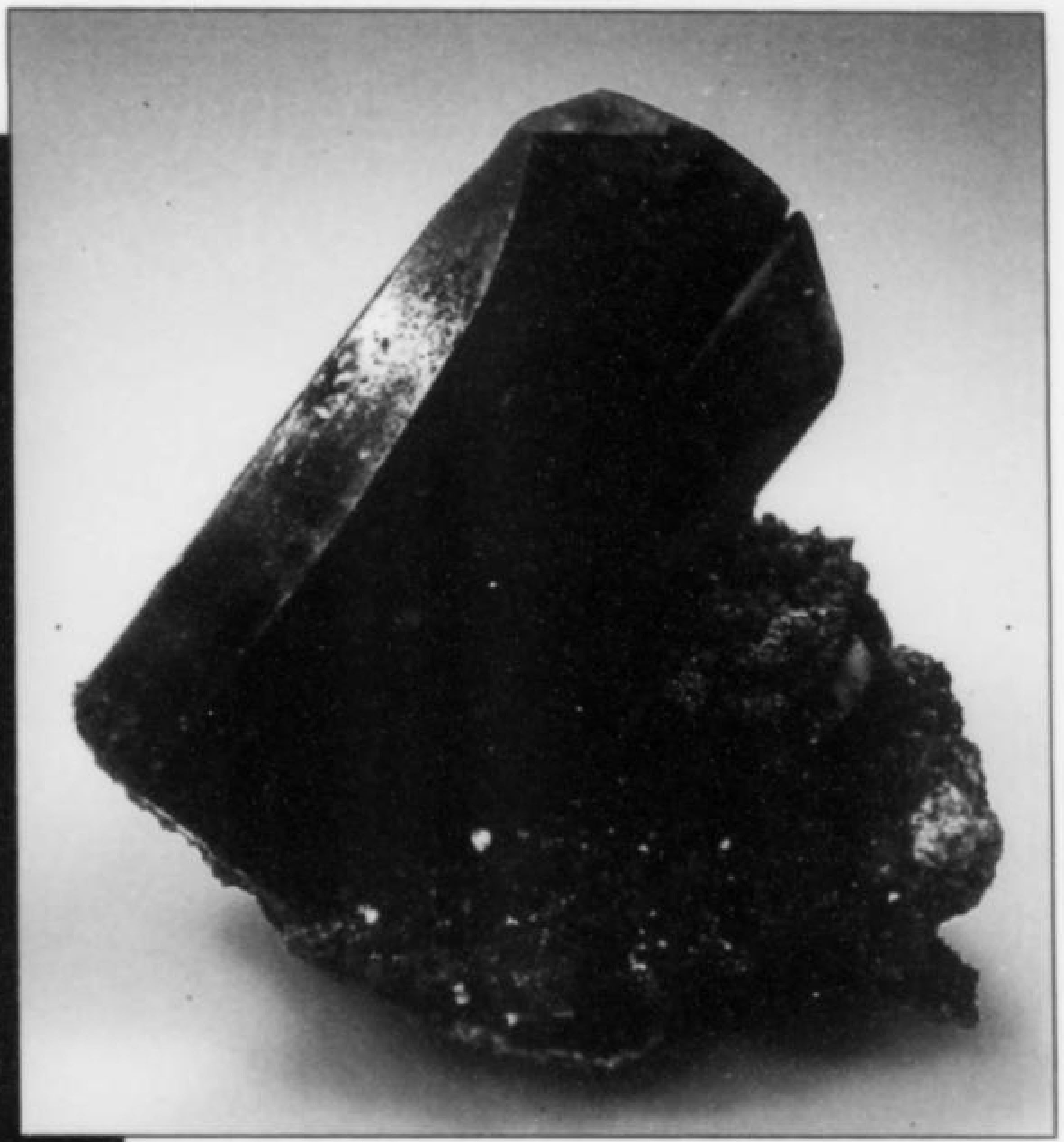


Figure 26. **Vivianite crystal 2.0 cm long on siderite, from the Blackbird mine. Glen and Ruth Evans collection, now in the College of Idaho collection; Allan Young photo.**

deep purple color of some Blackbird mine vivianite is characteristic of the locality, making Blackbird mine specimens easy to recognize. However, green crystals were found more abundantly than purple; colorless crystals were the rarest (Ream, 2004; Bill James, personal communication, 2008). Green vivianite crystals up to 22 cm in length have been reported, whereas purple crystals rarely exceed 7 cm (Bill James, personal communication, 2008). It is not uncommon for single crystals to show both purple and green zones.

Vivianite specimens from the Blackbird mine commonly exhibit elongated and blade-like crystals. They occur as singles and as groups on dark altered schist and on white quartz. Individual crystals, when damaged or bent, show vertical parting parallel to the *b* face. Crystals may form loosely or tightly-packed groups. Crystals found in narrow fractures were typically contacted when not oriented parallel to the fracture.

As with the ludlamite specimens, the partially oxidized sulfide-bearing wall rock which forms the matrix is typically not stable and will disintegrate when wet (Ream, 2004). Cleaning the matrix in common dish soap has, however, been reported to have halted the disintegration process (Mark Jeffers, personal communication, 2009). Associations include ludlamite, quartz and siderite.

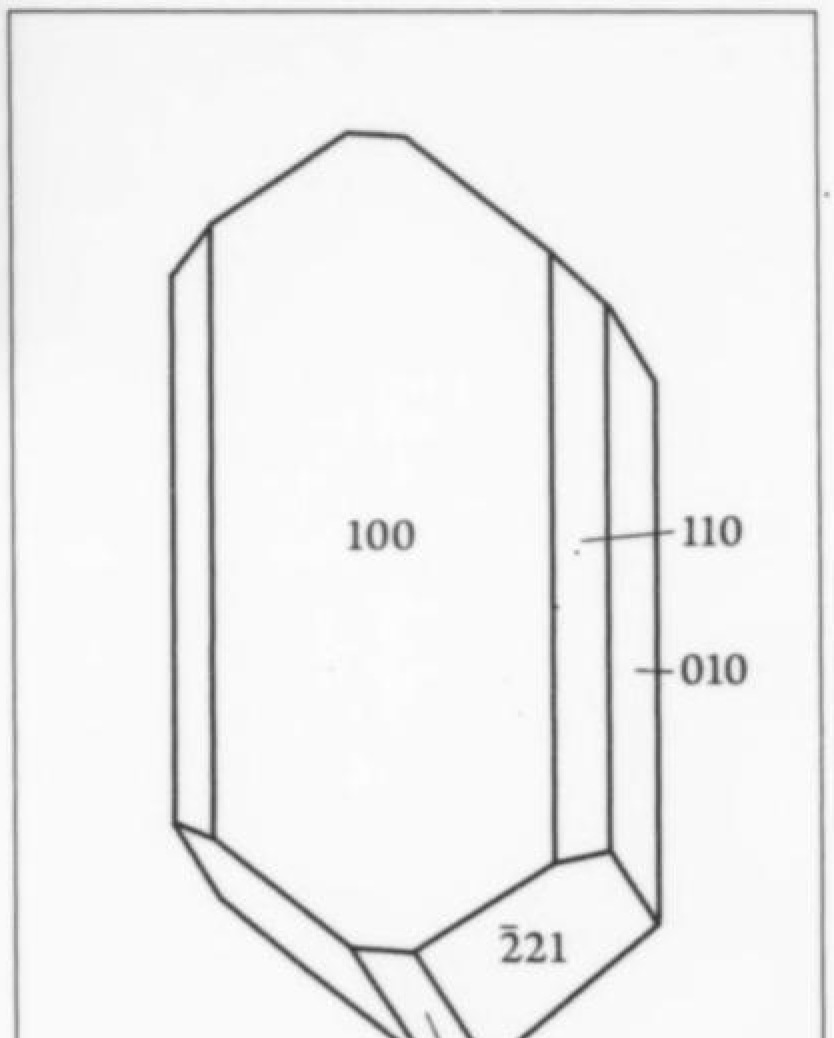


Figure 27. **Crystal drawing of vivianite from the Blackbird mine (Palache *et al.*, 1951).**

CONCLUSIONS

Most Blackbird mine ludlamite and vivianite specimens which exist today were collected during the 1950s from stopes in the Chicago ore zone and, in lesser quantities, from the Brown Bear ore zone. While there are probably more specimens to be found in areas that have not yet been mined, long-term environmental remediation commitments make it unlikely that there will be a resumption of mining at the Blackbird mine any time soon. However, on an adjacent property northwest of the Blackbird mine, one mining company has recently announced plans to develop a new underground cobalt mine, perhaps beginning as early as the fall of 2011 (*Mining Engineering*, 2010). Whether this proposed mine has the potential to produce ludlamite and vivianite of a quality and quantity comparable to that of specimens from the Blackbird remains to be seen.

ACKNOWLEDGMENTS

Many thanks to Norm Radford, Ben Sheppard, Jim Riggan and Bill James, who provided valuable firsthand information regarding the collection and occurrence of minerals in the Blackbird mine. Thanks also to Earl Bennett and Rock Currier, who kindly reviewed the manuscript, and to Wendell Wilson for encouragement and advice.

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The Weisseck Summit Cleft

Lungau, Salzburg, Austria

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Reinhold Bacher[2]
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Weisseck Mountain has been known as a locality for rare but fine fluorite specimens since the mid-1800s or earlier. Seven years of work (from 2000 to 2006) by a group of Austrian collectors excavating a system of clefts and veins near the summit resulted in the discovery of a number of fluorite pockets and numerous beautiful specimens.

INTRODUCTION

We (MG and RB) are *Stoansucha*, the Austrian equivalent of the German *Steinsucher* ("stone searchers"), the Swiss *Strahlers,* and the French *cristalliers*. Like our German, Swiss and French counterparts, we enjoy working the mountain clefts for minerals out of love for the place and what lies within. Walking from daybreak up the steep inclines, climbing daunting peaks, carrying heavy loads, and working in cramped and dangerous spaces with the simplest of tools are all part of the fun of collecting in the Alps; though we may become dirty, cold and weary in the process, we thoroughly enjoy the search for crystal treasures to satisfy ourselves and the collectors who covet our finds. One of our favorite areas to collect is Weisseck (Weißeck) Mountain, where we and our collecting partners have made some exciting finds. This article details our work at one area near the summit, where we have found excellent fluorite specimens.

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LOCATION

Weisseck Mountain (peak elevation 2,711 meters) is located on the western side of the mountain range known as the Lower Tauerns (Niedere Tauern), a part of the eastern Austrian Alps. The peak is 20 km northwest of Sankt Michael in the Lungau district, Salzburg province, Austria. The Lower Tauern lies between the Enns and Mur rivers, and extends 120 km westward to the headwaters of the two rivers. The Tauern Autobahn (A10/E55) crosses the range at the Radstädter Tauern (pass; 5,705 feet), providing access to Weisseck from Sankt Michael or Radstadt. The Lower Tauerns are divided into the Radstädter Tauern (including the high point, Weisseck Mountain) on the western end, the Schladminger Tauern, Rottenmanner Tauern, Wölzer Tauern and the Seckauer Tauern on the eastern end.

The Lower Tauerns are a result of the collision of the African and European plates, an event which began in the Jurassic and continues today. A nappe or thrust sheet structure of schists and limestones created by this event typifies the geology of the area. The white, karst (cavern-filled) Felsgestalt limestone unit in the Lower Tauerns has been found to host fluorite mineralization at Weisseck Moun-

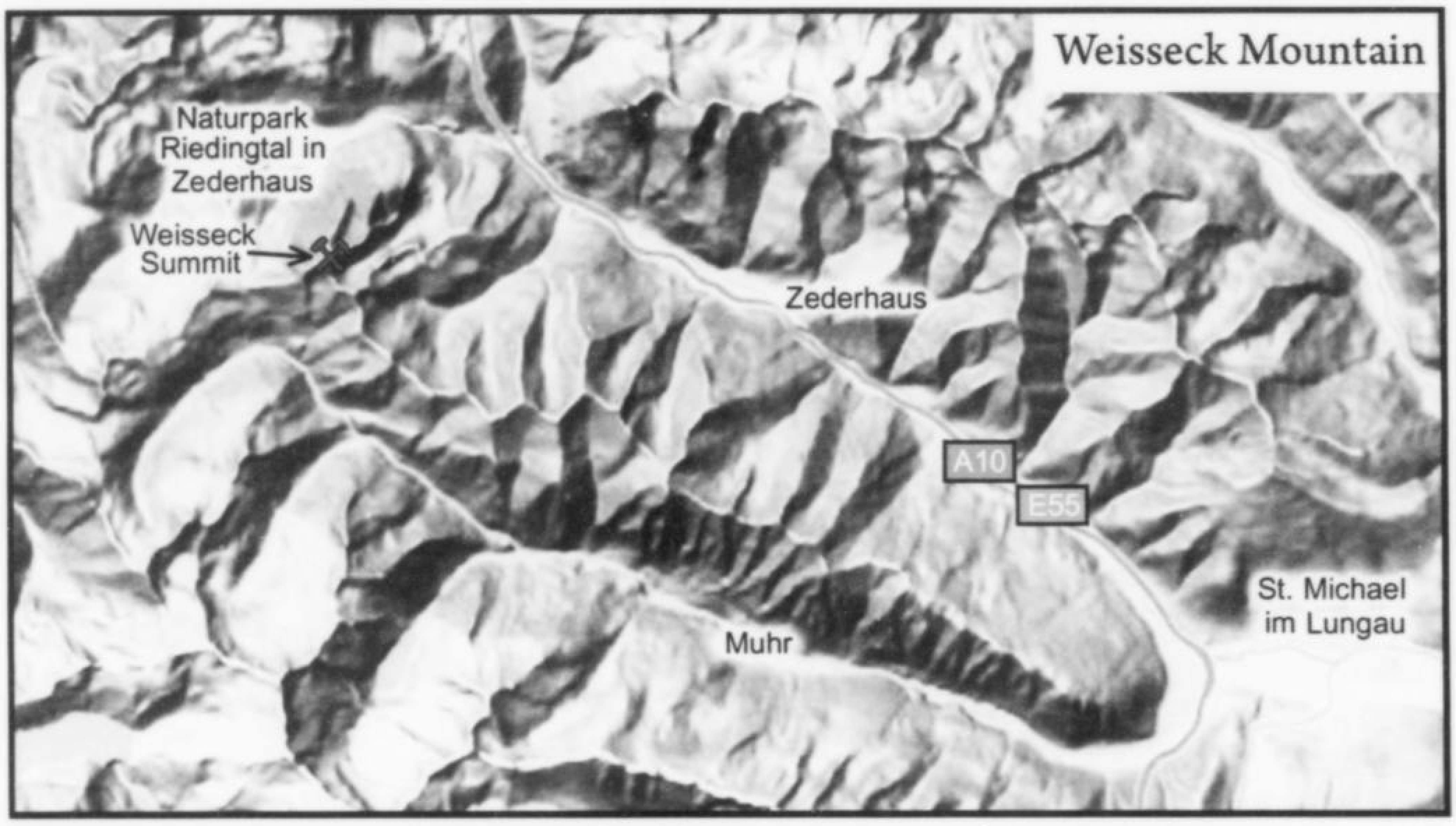


Figure 1. **Location maps showing Weisseck Mountain (above) and its location in the Austrian province of Salzburg (left).**

tain. The white (*weiss*) color of the limestone gave the mountain its name. Dissolution of the limestone created openings in which the fluorite crystals have formed.

HISTORY

The Weisseck Mountain area has long been famous for fine fluorite specimens. The first volume of Viktor von Zepharovich's *Mineralogisches Lexicon für das Kaiserthum Österreich* ("Mineralogical Lexicon of the Austrian Empire") (1859; covering the years 1790–1857) mentions pale blue to violet-blue fluorite cubes from Weisseck. Ludwig Ritter von Köchel's *Die Mineralien des Herzogthumes Salzburgs* ("The Minerals of the Dukedom of Salzburg") (1859) also mentions fluorite discoveries at Weisseck Mountain. The mineral collections of the House of Nature museum in Salzburg and the Museum of Natural History in Vienna contain documented crystals from the classic finds of the 19th century. Provenance questions existed even in those early days, as von Köchel regarded certain specimens labeled "Konigstuhlhorn, Rauris" as more likely being from Weisseck, indicating his depth of knowledge concerning the morphology of the area's specimens.

Since those early explorations, additional cavities in the hard limestone and dolomite marbles of the area have continued to be discovered. In the 1980s, a group of Viennese collectors discovered a fluorite pocket near Lake Rieding on the northwest flank of Weisseck Mountain, 600 meters below the summit. The fluorite they recovered is in the form of green and violet cubes, most with matte luster and measuring 2 to 3 cm on edge, intergrown and as individual crystals on a limestone matrix. A few exceptional specimens showing crystals to 5 cm with bright luster were also recovered, along with some fluorite of an unusual aquamarine color. Later, along the Rieding Gap leading to the summit, Walter Petzelberger found stepped, zoned fluorites of a fine blue color (Fig. 3).

THE SUMMIT CLEFT—FIRST YEAR

In 1996 two *Stoansucha* from Lungau, Walter Petzelberger and Martin Brunnthaler, began new exploration and development of Weisseck's *gipfelkluft* or "summit cleft." The Weisseck gipfelkluft is a long vein or watercourse in karst rock that has been eroded by rainwater. The cleft had been worked years ago by unknown parties, who had emptied a 7-meter opening very near the summit. Examining this excavation, Walter probed a sandy area at the end of the pocket with his pickaxe. Encountering no resistance, he pushed the sand aside but found nothing of interest (Fig. 9). The two left, other projects called, and four years passed before they returned to the same cleft in 2000.

Entering, they found that the area Walter had checked with his axe was again filled with sand. This sand typically gathers where water runs down through openings in the limestone, indicating areas where minerals may have formed. While not a guarantee of a find, it usually points toward at least the potential of crystallized specimens. This discovery convinced them to pursue the pocket and dig in earnest. Almost immediately they uncovered a few small crystals; though damaged, these crystals pointed the way and encouraged them to continue.

Over many trips they worked the hard limestone on hands and knees, using only hammer and chisel. One man would clear debris, placing it in small plastic buckets and pushing it past his body in

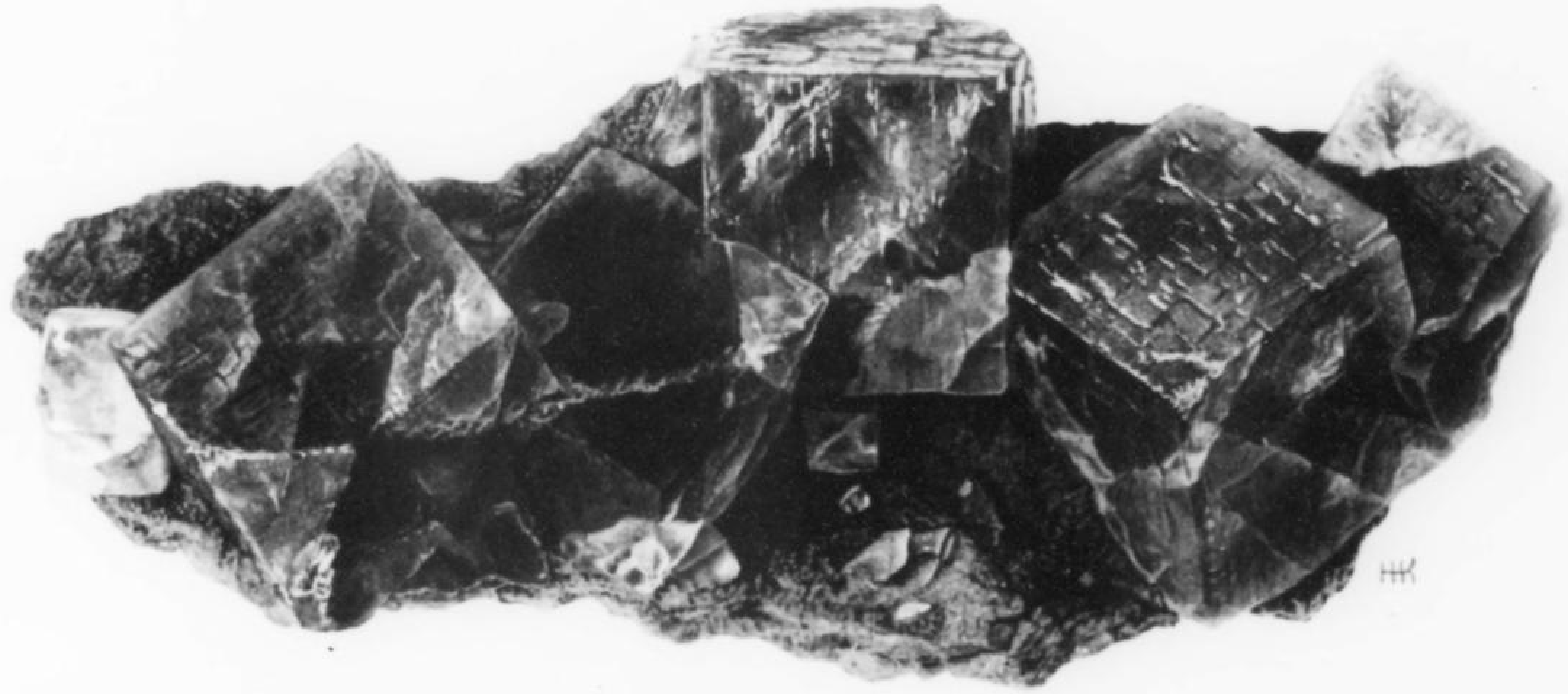


Figure 2. **Fluorite crystals on matrix, 12 cm, from Weisseck Mountain. Collection of the Natural History Museum, Vienna; watercolor painting by Hildegard Könighofer (1988).**

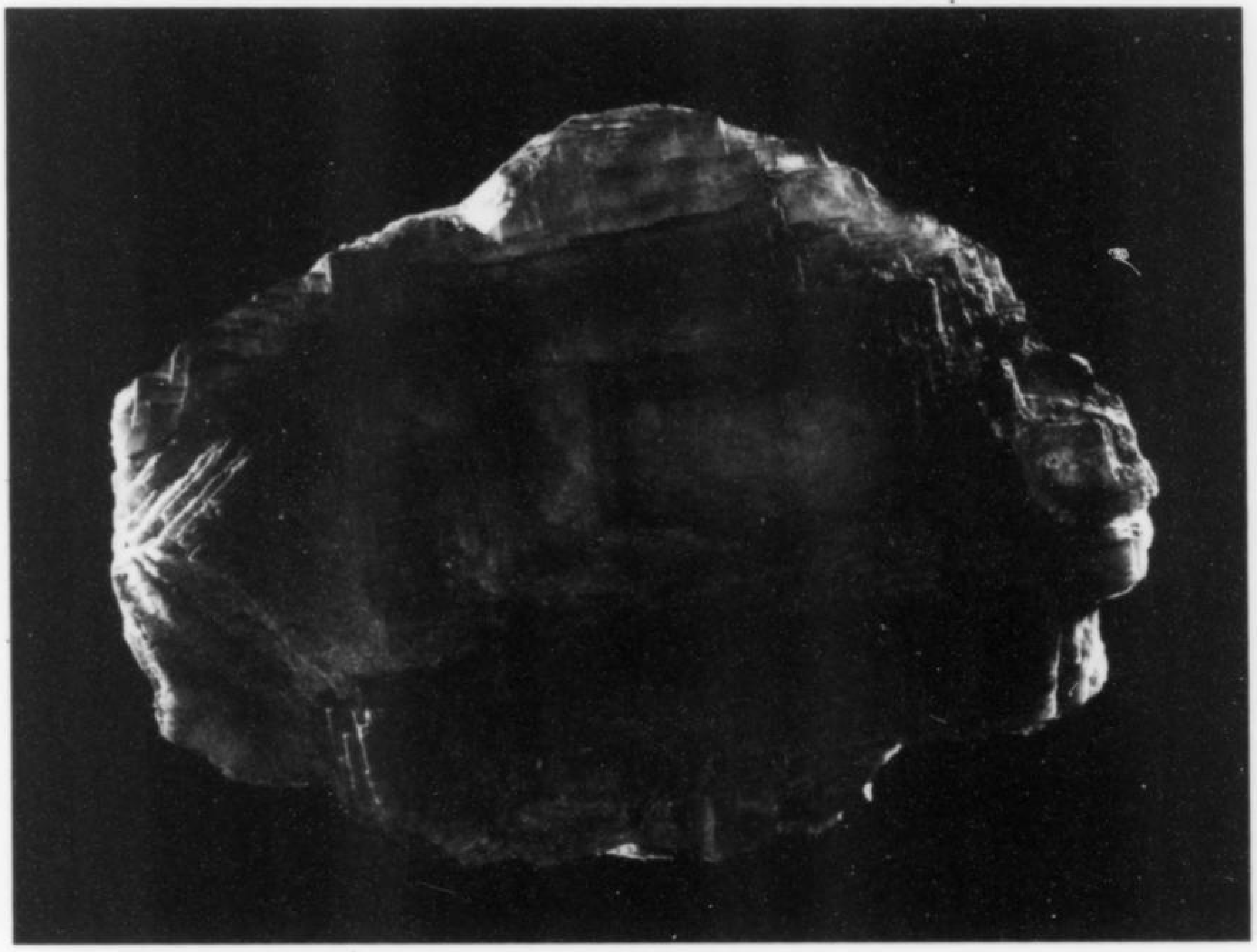


Figure 3. **Deep blue fluorite, 10.5 cm, an old find by Walter Petzelberger from the Rieding Gap near the summit. Reinhold Bacher collection; Anton Watzl, Sr. photo.**

the cramped space to the man behind him who would then carry the bucket outside and empty it on the tailings pile. In this primitive and laborious way tons of material were removed from the cleft. They worked their way deeper, following the cleft, always hoping to encounter an opening where euhedral crystals had formed. As the passage became narrower they were forced to lie prone, working with their hammer and chisel until the opening was just wide enough for one man to crawl through. Approximately 15 meters into the cleft they made their first find: some plates of cubic fluorite crystals to 1.5 cm, with dark violet centers and paler outer zones, on a bed of fine quartz needles (Fig. 4). Only a few specimens were recovered, but the pair was energized by this find of good specimens, and consequently they recruited other collectors including one of the authors (Reinhold Bacher), a longtime local *Stoansucha*, to help speed the work.

Following a horizontal vein of fluorite, a second entryway was created above the original (Fig. 9). This allowed the group to close the original entrance and use the lower section as a dump, saving time and energy while clearing the main shaft.

SECOND YEAR

Continuing work in the spring of 2001, they finished clearing the narrow spot where the plates of fluorites were found, then followed the fluorite traces upward at a steep 45° angle, placing candles along the way to monitor oxygen content in the air. This section

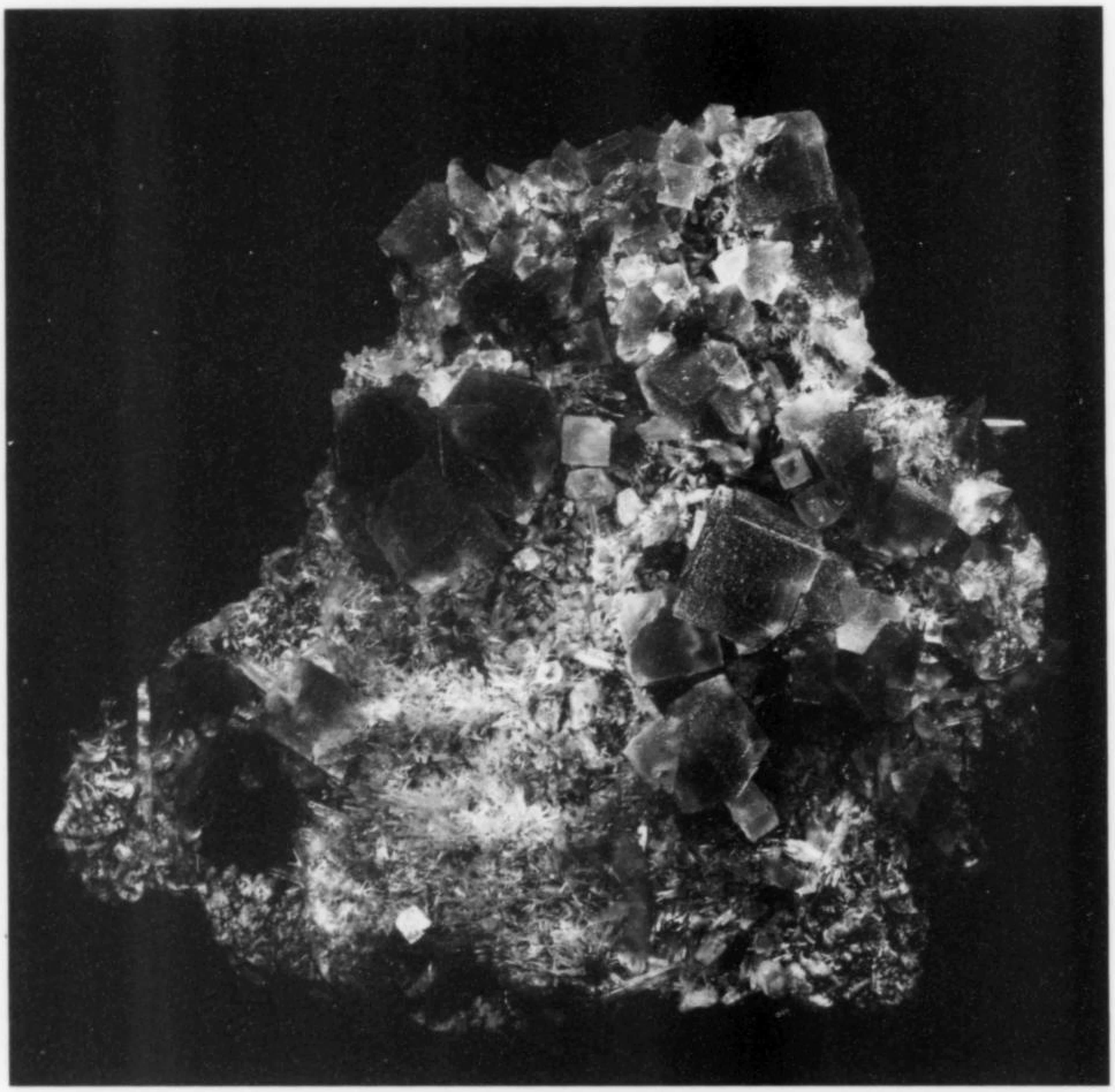


Figure 4. **Fluorite (dark violet cores and pale blue outer zones) with quartz, 12 cm, from the Weisseck Summit cleft. Martin Grüll collection; Anton Watzl, Sr. photo.**

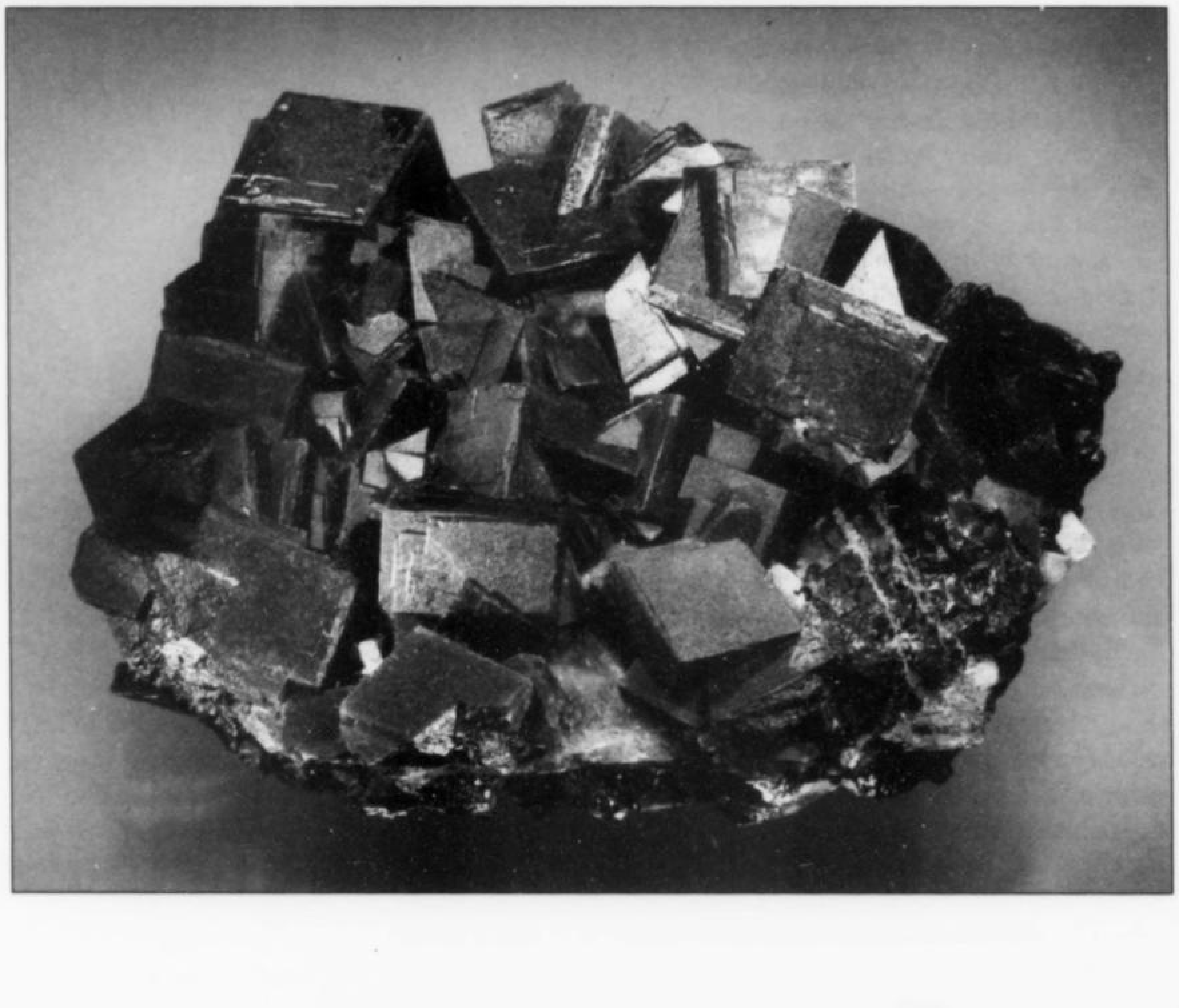


Figure 5. **Fluorite crystals on matrix, 12.1 cm, from the Weisseck Summit cleft. Martin Grüll collection; Anton Watzl, Sr. photo.**

***Figure 6.* The Rieding Gap, on the way down from the summit. Martin Grüll photo.**

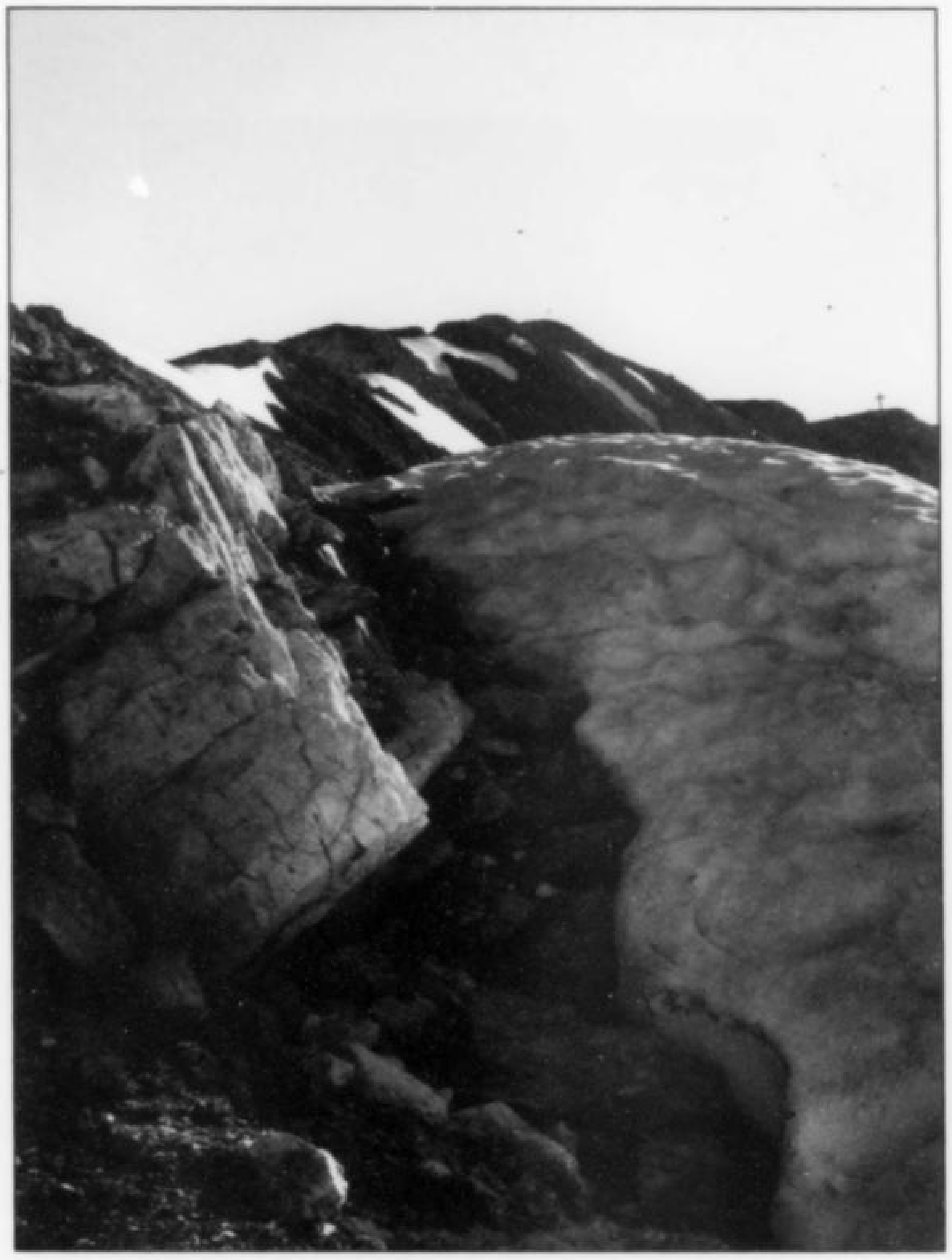


***Figure 7.* The Rieding Gap going up. On the horizon at far right is the cross on the peak of Weisseck Mountain, looking north to the summit from the Rieding Gap. Reinhold Bacher photo.**

is confined: the cleft walls are lined with sharp rock edges making any passage through difficult.

They discovered a vein of massive fluorite branching off just above the narrowest spot, and began excavating along that vein as well as in the main upwardly branching section of the cleft. Seldom were all three people (Petzelberger, Brunnthaler and Bacher) present at the site at the same time. Though working in cooperation, they usually worked alone or in pairs, depending upon when each was available. One might work the main shaft while others pursued alternate areas. In this way the cleft was excavated in two directions during the summer of 2001.

Working in the side tunnel, they discovered nearly black cubes of fluorite up to 2.1 cm associated with quartz and calcite (Fig. 5), indicating that this area was worth further exploration. On the upward raise they found stepped fluorite crystals of various sizes in shades of blue and violet, heavily etched and usually damaged in the debris at the bottom of open spaces where water had been running through. They knew the pieces were being transported from somewhere above them in the vein, but how far above?

Over 20 meters of the cleft were cleared during this second year of work, but nothing of significance was found. All believed they were working toward the origin of the crystals which had been encountered in the tunnel throughout the summer. They also knew they were approaching the point in the raise where they would intersect the surface. Had the pocket been totally eroded away, and would they simply follow the vein until it broke out on the surface? Or was a pocket just ahead?

With both channels of excavation showing promise, excitement was high as the second season ended.

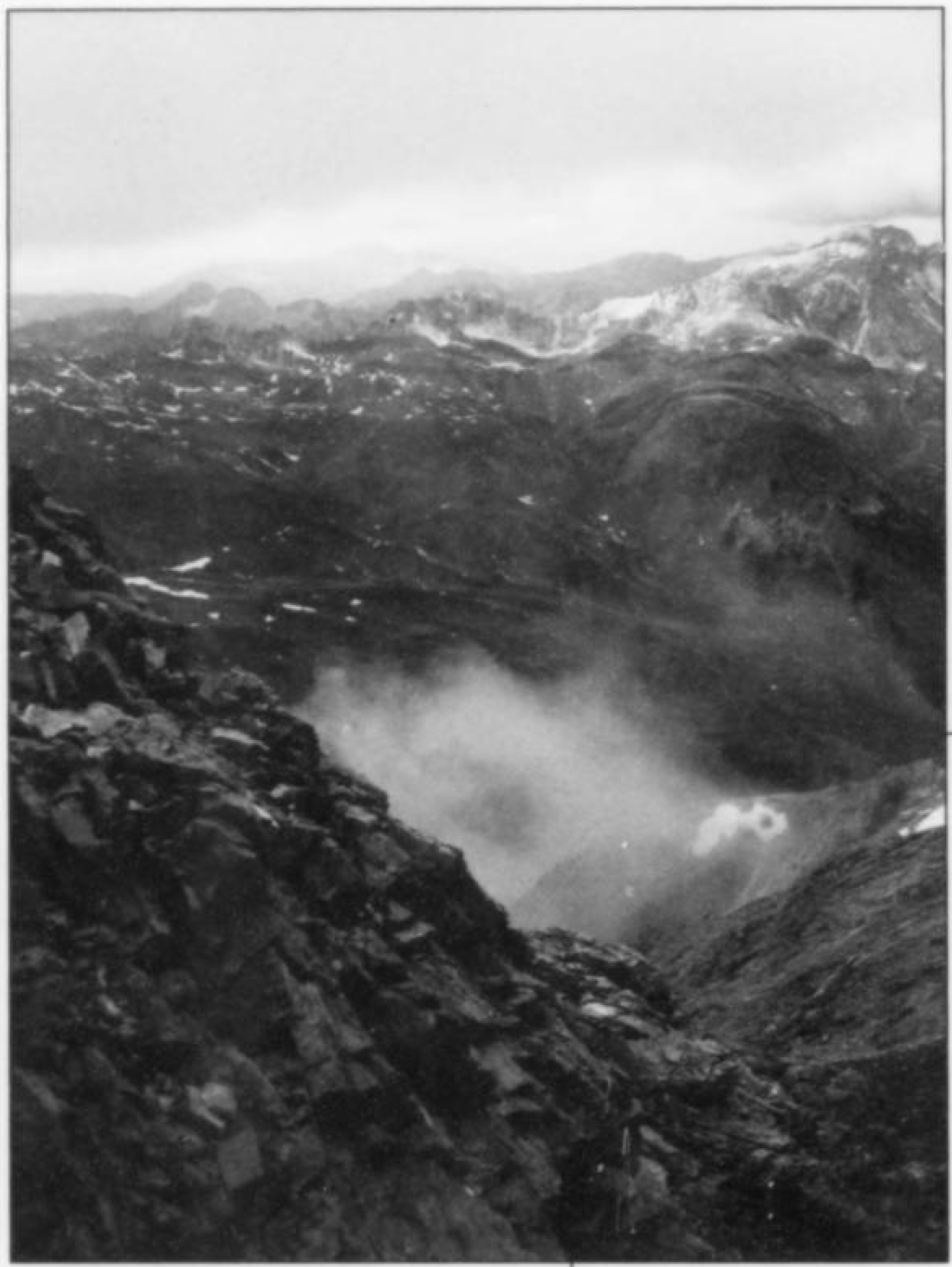


Figure 8. **Looking down into the precipitous Hölle ("Hell") area from near the summit. Robert Kunze photo.**

diately began to collect the visible crystals: step-faced violet to black crystals up to 13 cm, some in groups, some singles, mostly found in the rubble on the cavern floor; dark cubes to 3 cm; green stepped pieces; and a small number of sharp, green, 3-cm crystals (Figs. 12, 13 and 14). Most of the specimens recovered show some damage, although a few pieces were still attached to the walls and were later carefully removed with less damage. Undamaged specimens were rare, and the digging was difficult. The material being excavated in the cavern was not solid rock but rock debris and fine-grained weathered host rock compacted by years of running water. Removal of this material was challenging because care had to be taken to avoid damaging any specimens buried in the mixture. Later discoveries included dark cubic single crystals and partially dissolved green specimens.

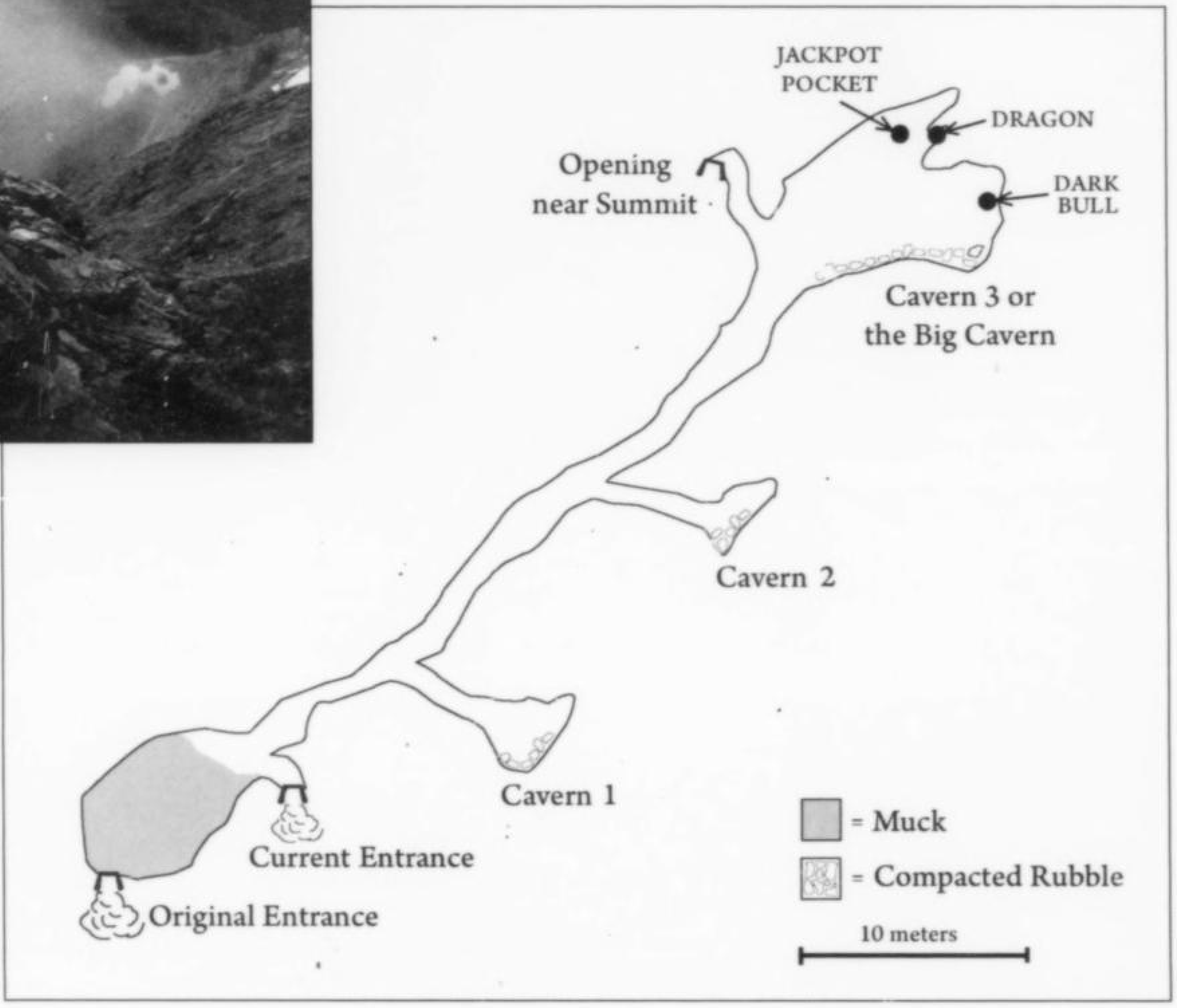


Figure 9. **Vertical section through the Weisseck Summit cleft, showing the locations of the major pockets and specimens. Map by Gerhard Kocher.**

THIRD YEAR

As 2002 began, Walter worked in the side branch and uncovered a small 1.5 × 2-meter cavern which they named Cavern One. This pocket was partially lined with dark purple, sharp-edged fluorite cubes and pale brown to yellow calcite crystals to 1 cm running in bands over the fluorite (Fig. 11). Occasionally wonderful little white barite roses up to 5 mm were found. Buried in the floor material were black fluorite cubes with step-like faces, pale violet and step-faced cubes, and very dark, sharp-edged cubes. Unfortunately most specimens in Cavern One had been detached by tectonic activity and were damaged. Only a few floaters were found. Once the pocket was cleared no further discoveries were made in Cavern One.

Back along the main branch, after clearing a short, steep crawlway, they finally uncovered a large cavern (Fig. 10). The open area measures 1 × 3 × 8 meters, with a debris floor and fluorite bands running along the walls. Martin would later say that, "Wherever fluorite bands run through the stone you can absolutely expect to find a treasure." They named it The Big Cavern, and work imme-

FOURTH YEAR

The 2003 season began with the team clearing the area above the Big Cavern where, following a vein, they broke through to the surface (Fig. 9) (a section of that channel has since collapsed).

In late summer, as the quality and quantity of the find became evident, interpersonal relationships came into play. Disputes between the original discoverers forced a breakup of the team. Petzelberger and Bacher continued to work together on the Summit Cleft while Brunnthaler dug alone for a short period before stopping. Afterwards another author of this article, Martin Grüll from Linz, joined the team. He had collected in the Rauris Valley for many years seeking classic Alpine minerals, and had met Reinhold Bacher through his interest in Austrian fluorite.

FINDING THE "DARK BULL"

As the collecting season was ending in the fall of 2003, Reinhold decided to visit the mine with his childhood friend, Gerhard Kocher, a mining history expert. This was really more of a casual sightseeing

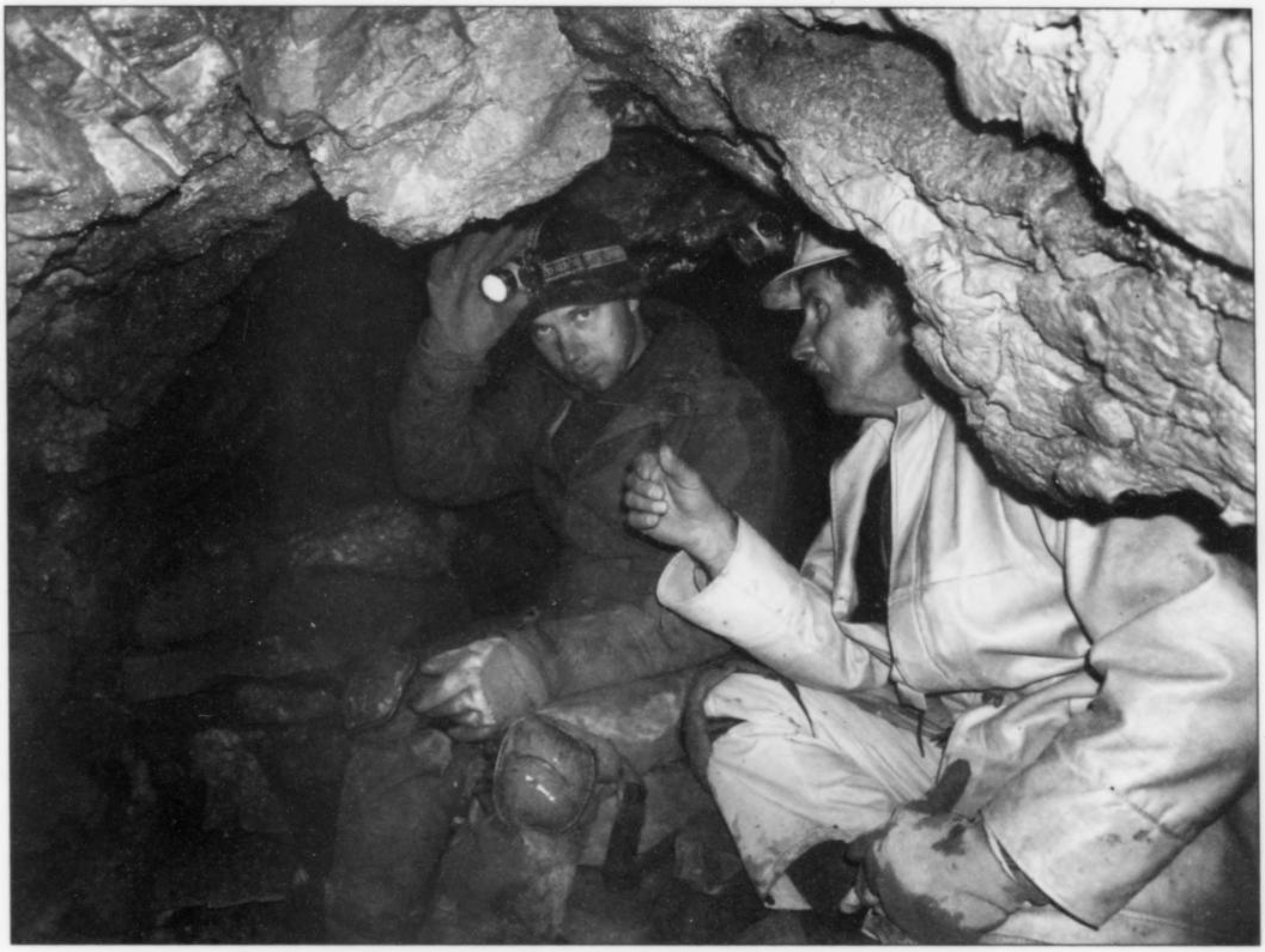


Figure 10. **Reinhold Bacher (left) and Hans Leitner in the Big Cavern.**

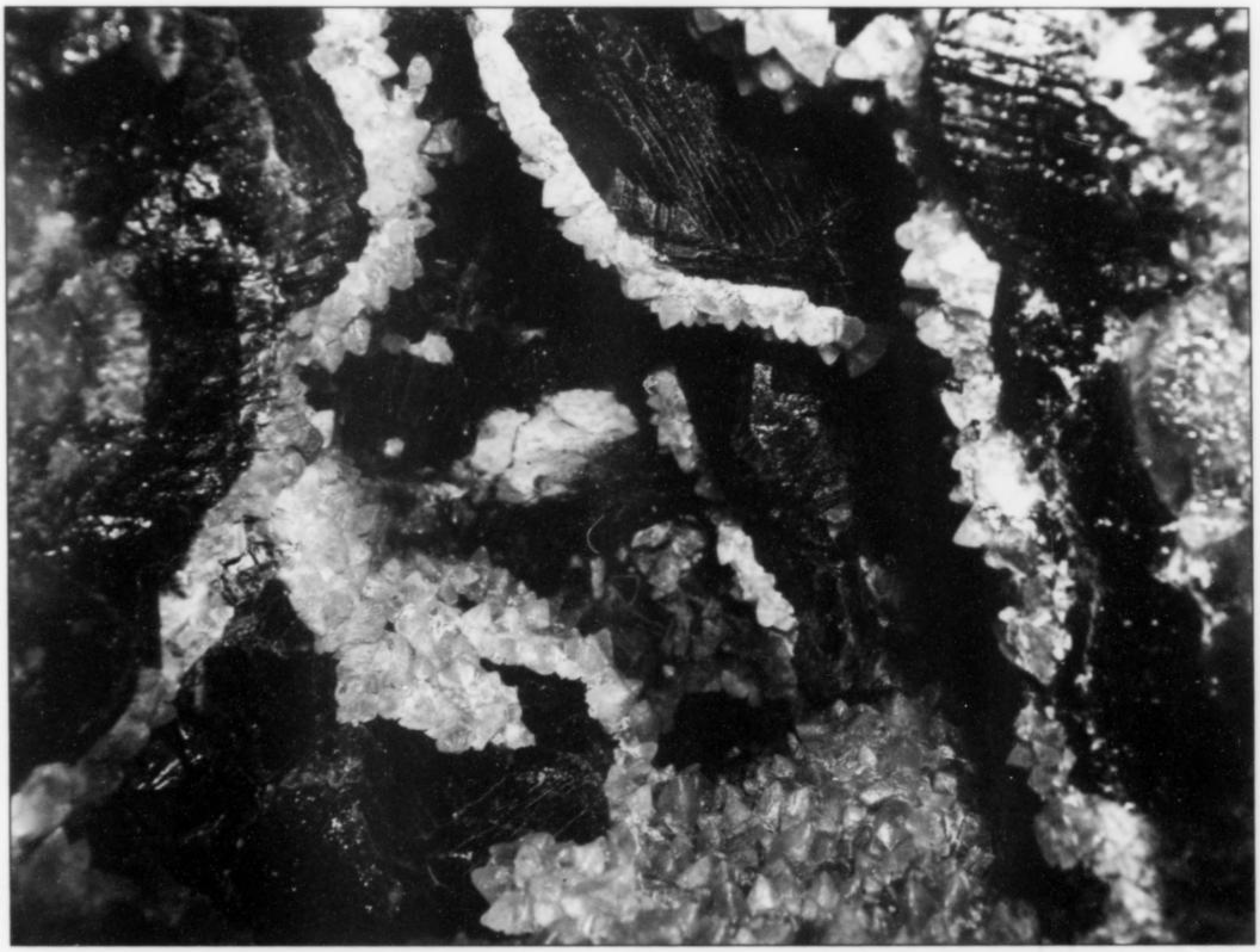


Figure 11. **Fluorite and calcite crystals in situ in Cavern 1. Reinhold Bacher photo.**

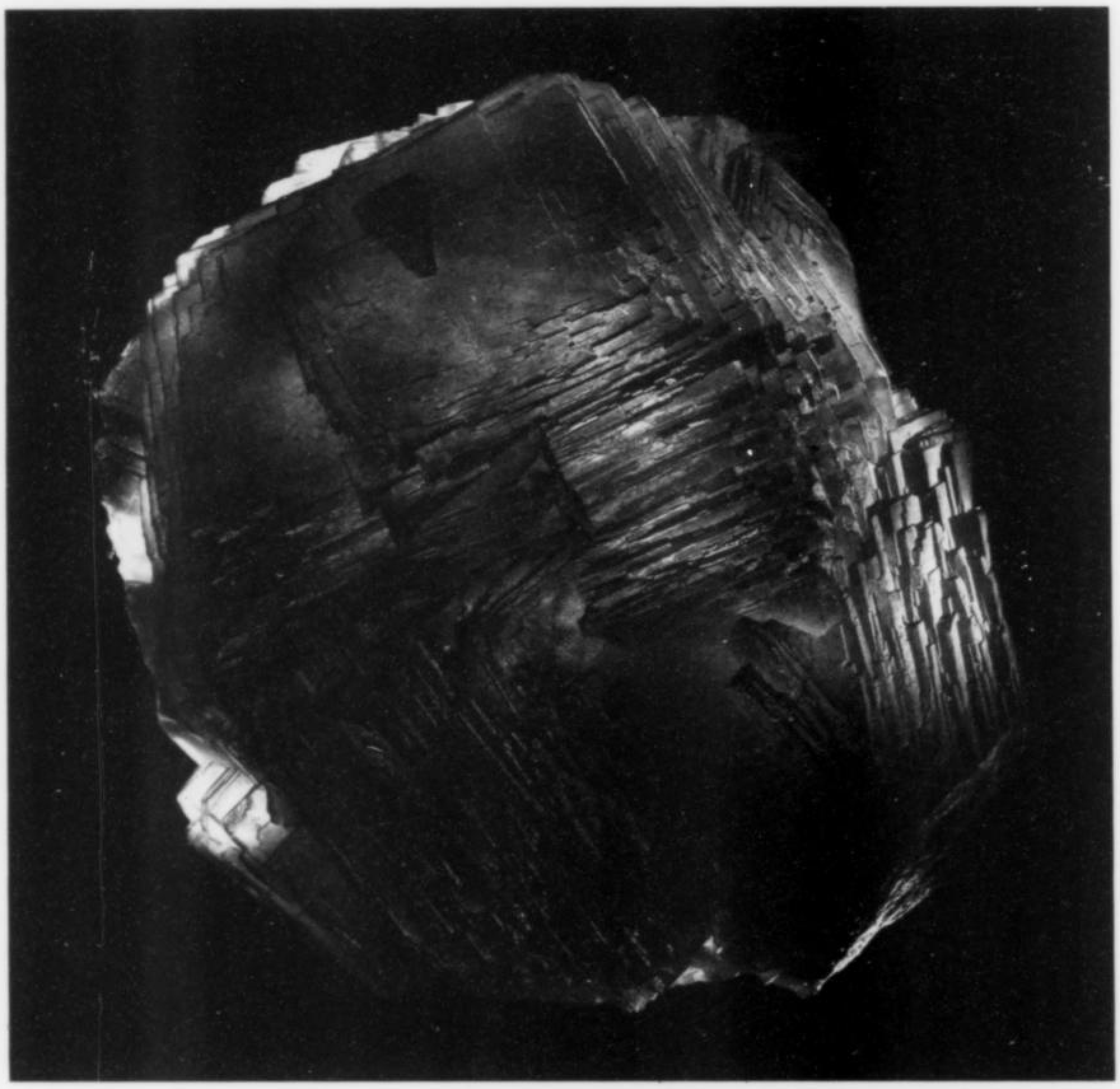


Figure 12. **Fluorite crystal cluster, 14.1 cm, from the Big Cavern. Reinhold Bacher collection; Anton Watzl, Sr. photo (backlit to show internal color).**

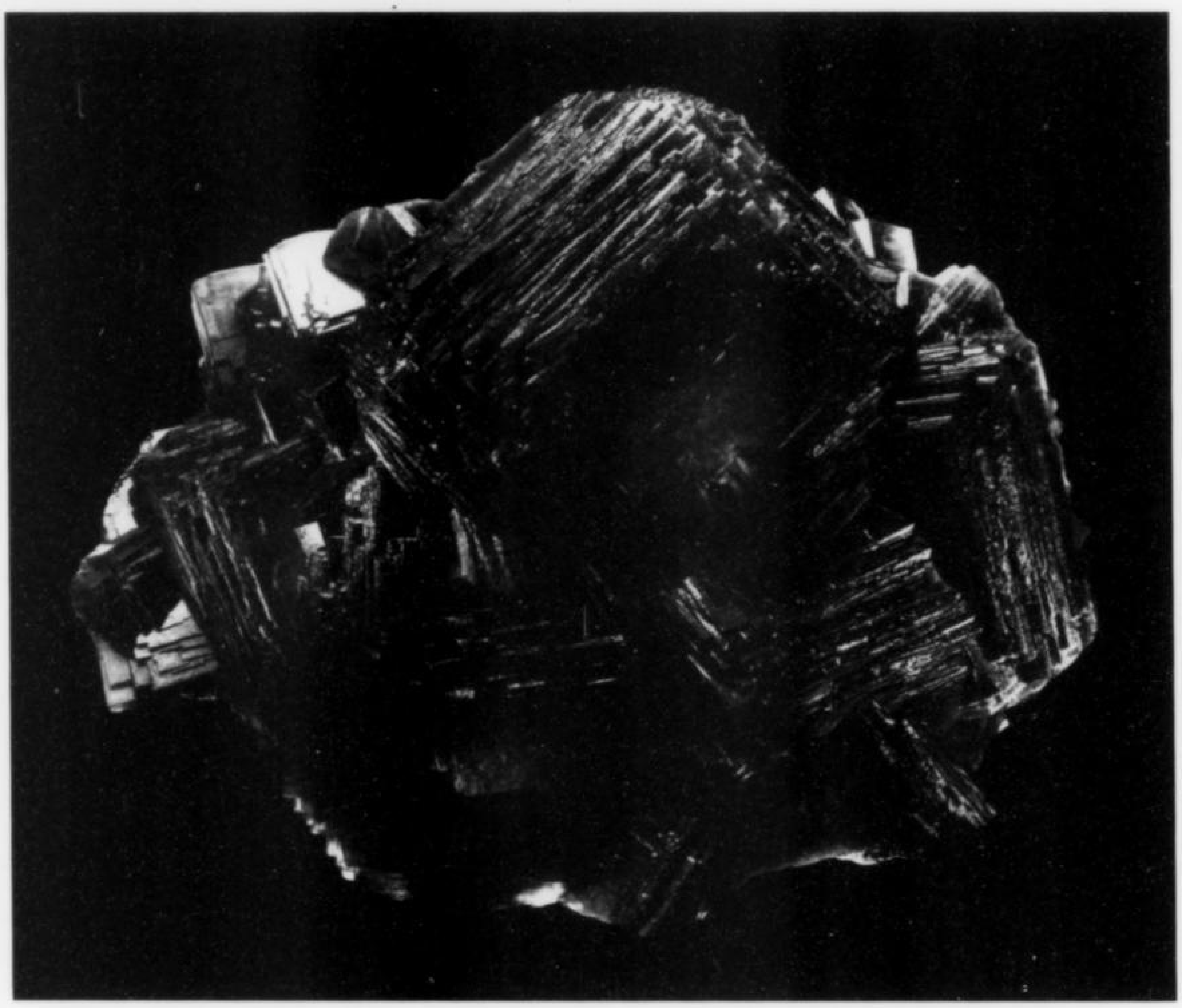


Figure 13. **Fluorite crystal cluster, 15.5 cm, from the Big Cavern. Reinhold Bacher collection; Anton Watzl, Sr. photo (backlit to show internal color).**

trip than a serious collecting excursion but, true to their natures, they had stashed digging tools in their bags. By 5 a.m. they were on their way up the Mur Valley, past the old Arsenhouse where a fee of 3 Euros had to be paid to travel 4 km farther to the road's end at the Murritzen parking lot barrier.

From there the two men proceeded on foot and hiked an hour through the forest to the first landmark, the Stickler Hut, where the path steepened up the south side of the mountain leading to the Rieding Gap. At the Gap, an hour and a half into the climb, they could see Lake Rieding embedded in the rugged, craggy rock faces and shining like an emerald below them, with the Tauerns in a panorama beyond.

The Rieding Gap is a dangerous, narrow ridge. The climb up requires a high degree of physical conditioning. The route steepens and breathing becomes labored (Fig. 7). The last few meters flatten toward the summit which overlooks an area known as Hölle ("Hell") because of the precipitous rock faces on the east and south sides of the summit (Fig. 8). Just before reaching the cross marking the top, Reinhold turned and began working his way down an area where surefootedness and no fear of heights is essential. One misstep on this loose and unstable ground will land you several hundred meters below, badly injured or dead.

Fifty meters down is the original opening used by Petzelberger and Brunnthaler to enter the mine (Fig. 9). The space at the old mouth now serves as a storage and staging area, and there Reinhold and Gerhard placed their backpacks and changed into work clothes.

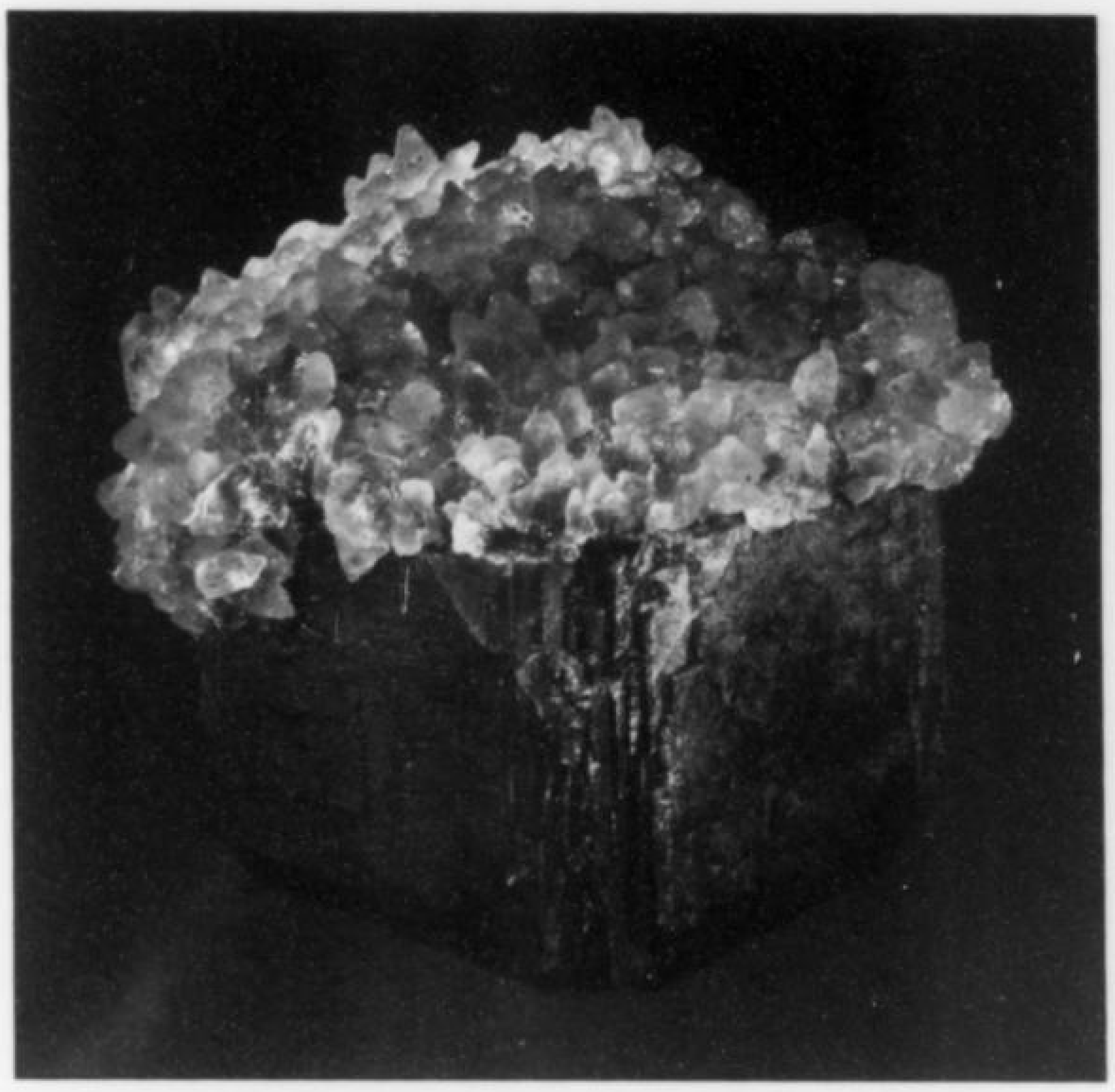


***Figure 14.* Fluorite floater crystal with calcite, 4.7 cm, from the Big Cavern, a meter or two behind where the "Dark Bull" specimen was found. Reinhold Bacher collection; Anton Watzl, Sr. photo.**

***Figure 15.* The "Dark Bull" fluorite specimen, 40 cm and weighing 51 kg, from the Big Cavern, shown resting on a bench for scale. Reinhold Bacher collection; Anton Watzl, Sr. photo.**

Into the cleft they plunged. Within a few meters they were crawling and then, having been forced to their bellies, they were passing previous pockets which glimmered slightly from the leavings of those earlier finds. They passed the point where Reinhold had cleared the passage during his first year in the mine and then headed up the sharp 45° turn. The opening is rough with sharp edges and irregularities; both were grateful to have their knee and elbow pads. Movement was cumbersome and exhausting, making them thankful for the good ventilation the mine now possesses (thanks to having broken out at the surface above). Still, the threat of unstable rocks is a real danger and is always with the Stoansucha.

Helmet lamps illuminated the ground only a short distance ahead, while the space continued to narrow, causing physical and, at times, psychological discomfort. They reached a crossway and suddenly encountered a bit more space near the opening of Cavern One. For 15 or so meters they moved comfortably, but then were forced back to crawling in an 8-meter section. Remnants of past finds and possible indicators of future pockets were all through this area.

The final stretch was ahead. Both entered the steep crawlway leading to the Big Cavern. Formed by dissolution of the carbonate country rock, such caverns are typical of the area's karst geology and important to the formation of desirable fluorite crystals. Out came the tools and both started digging on one side of the floor at the back of the Big Cavern. After digging half a meter down they hit a small fluorite crystal and soon after that a large crystal surface began to emerge. Reinhold, working this area, was spurred on by the thrill of his find and dug quickly, exposing more of the crystal until a 50-kg (110-pound) specimen had been freed. The high quality of the fluorite and its overall form dictated that it should remain in one piece rather than being broken into smaller, more manageable pieces. Reinhold immediately resolved to find a way to bring it out of the mine and down the mountain intact, in spite of the obvious obstacles he would face.

The large fluorite was carefully packed for protection, and Reinhold began the long task of moving it out of the mine. He pushed it in front of him less than half a meter at a time, crawling, pushing, crawling, pushing, over some 45 meters of rough ground, turns, inclines, declines, and tight spaces until he reached the outside. Once clear of the mine the piece was wrapped and stowed in a backpack along with some of their gear, creating a 65-kg load of dead weight that Reinhold would have to carry down the mountain. "Down" is a relative term, for the first task in the descent was a tortuous ascent on the rubble-strewn slope leading up to the summit and the trail home. It was a daunting task requiring an act of sheer will power for Reinhold to make it up to the top of Weisseck with the specimen (Fig. 15).

That extreme expenditure of energy made Reinhold realize that the descent would have to be accomplished in stages. He would travel 200 meters looking for an acceptable spot to set down his burdensome treasure, rest for five minutes, and then move on. The passage over Rieding Gap was punishing, and reaching each of the familiar landmarks seemed to take an eternity (Fig. 6). By the end of the trek he could go no more than 50 meters at a time, followed by a 10 or 15-minute rest, but by then the glorious and successful end was in sight.

On recounting this story, Reinhold was asked if he would do it again. He began to shake his head no, but in typical Stoansucha fashion ended up simply saying "I couldn't leave such a specimen behind." He named it the "Dark Bull," and it sits proudly in his collection today.

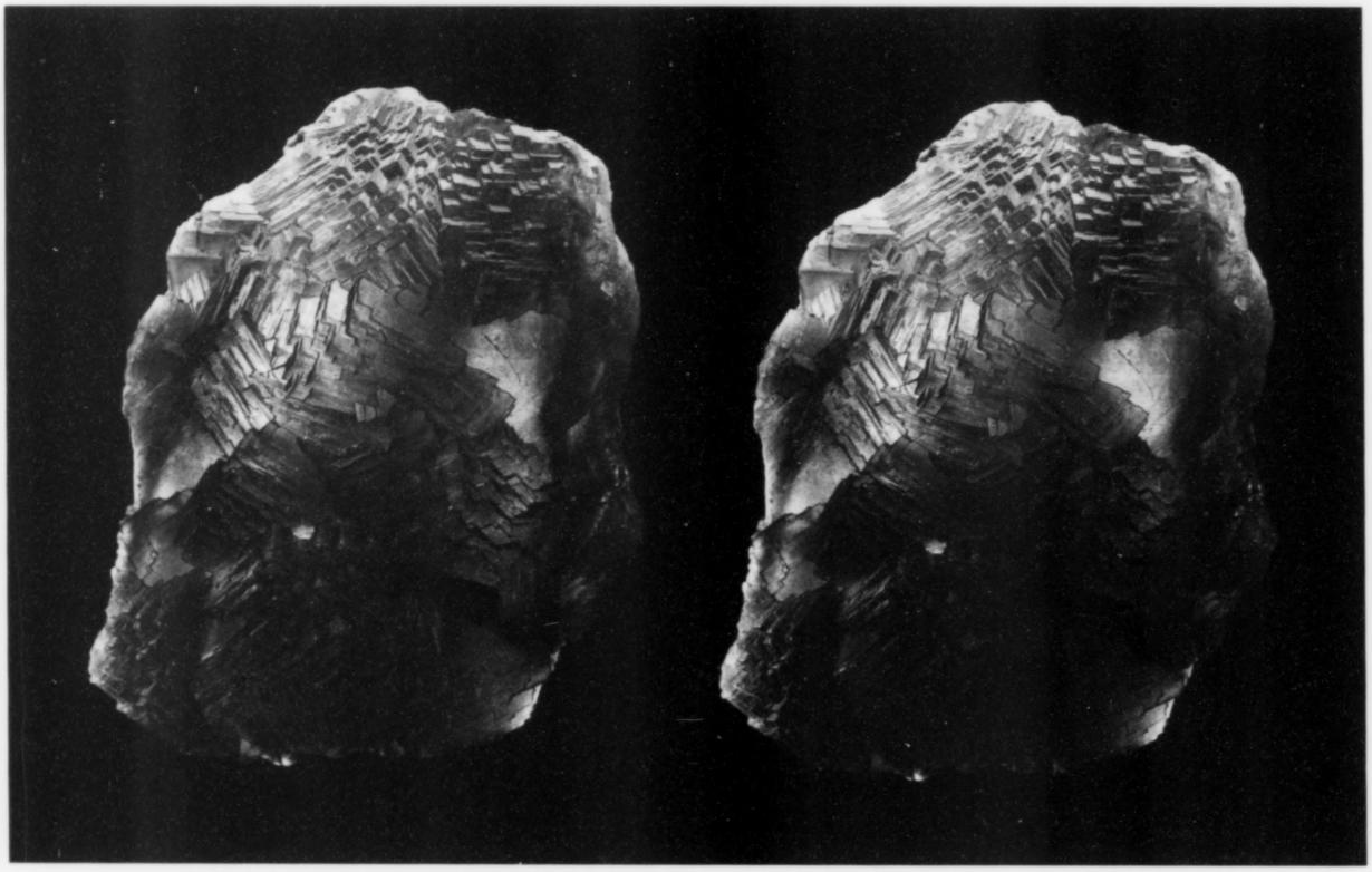


Figure 16. **Fluorite crystal cluster, 15.2 cm, from the "Jackpot pocket," shown in daylight (left) and fluorescent light (right). Paradise Woods collection; Anton Watzl, Sr. photo.**

FIFTH YEAR

Other finds were made during the 2004 season. In the upper section of the cavern where the "Dark Bull" was discovered, a 40-cm solid band of what seemed at first to be violet to black fluorite was uncovered. Close examination in the sunlight showed an unbelievable range of colors which vary depending on the light source. The same piece can appear blue, green, or violet depending on whether it is illuminated by sunlight, incandescent light or fluorescent light (Fig. 16).

Reinhold followed the band and opened a second leg on the roof of the Big Cavern. In this vein he uncovered a large opening containing specimen-quality crystals. Their location in the fluorite vein had protected them from erosional deterioration caused by moving water in the caverns, preserving the crystals undamaged, sharp and glossy. These crystals have parquet-like blue and green tones with a hint of violet in the outermost edges. Only four good specimens were recovered, the largest 7.4 cm in the longest dimension, and the best measuring 5.6 cm. Reinhold's excitement on finding these was so great that he named this the "Jackpot pocket" (Figs. 17 and 18).

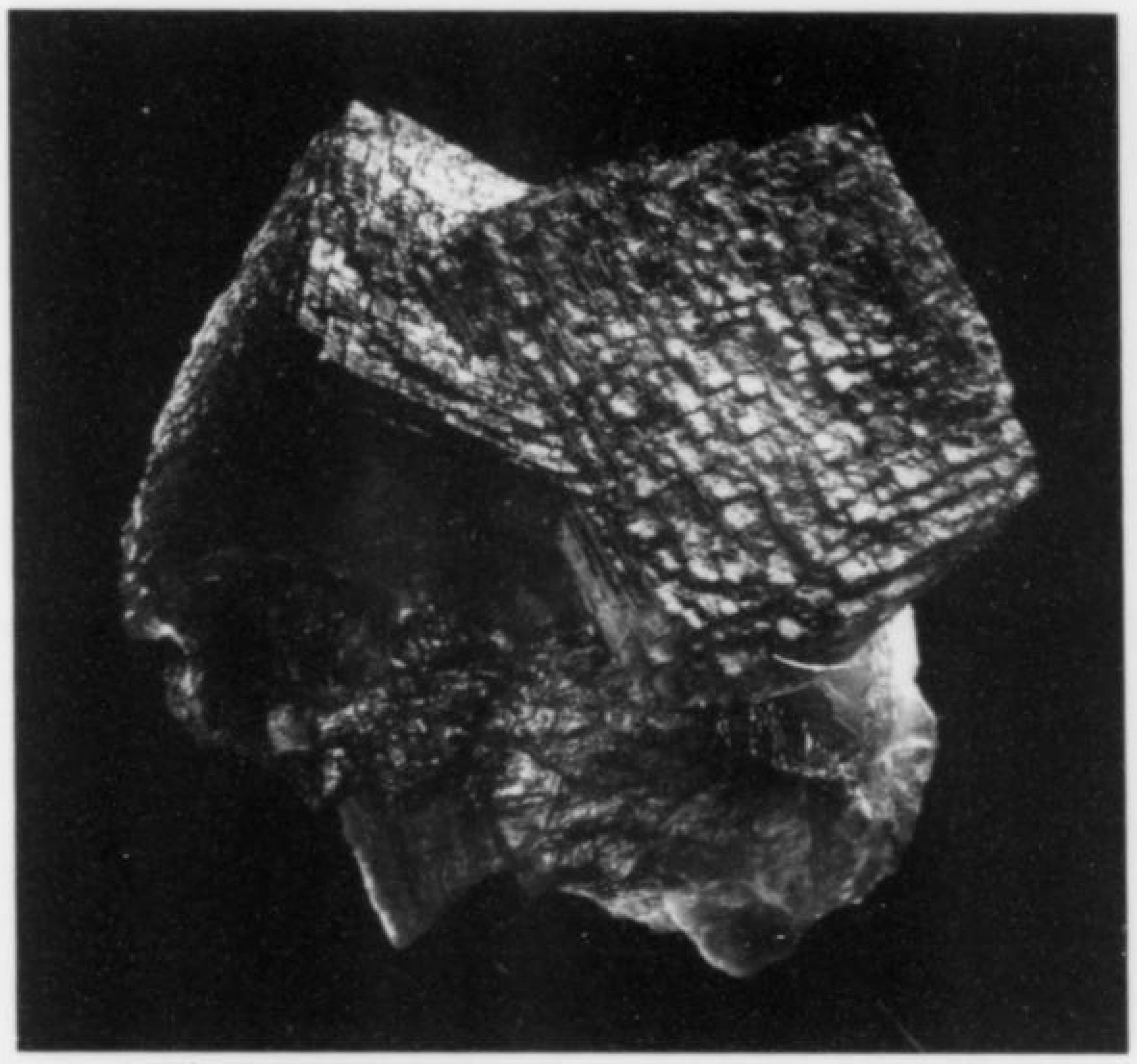


Figure 17. **Fluorite crystal cluster, 5.6 m, from the "Jackpot pocket." Reinhold Bacher collection; Anton Watzl, Sr. photo.**

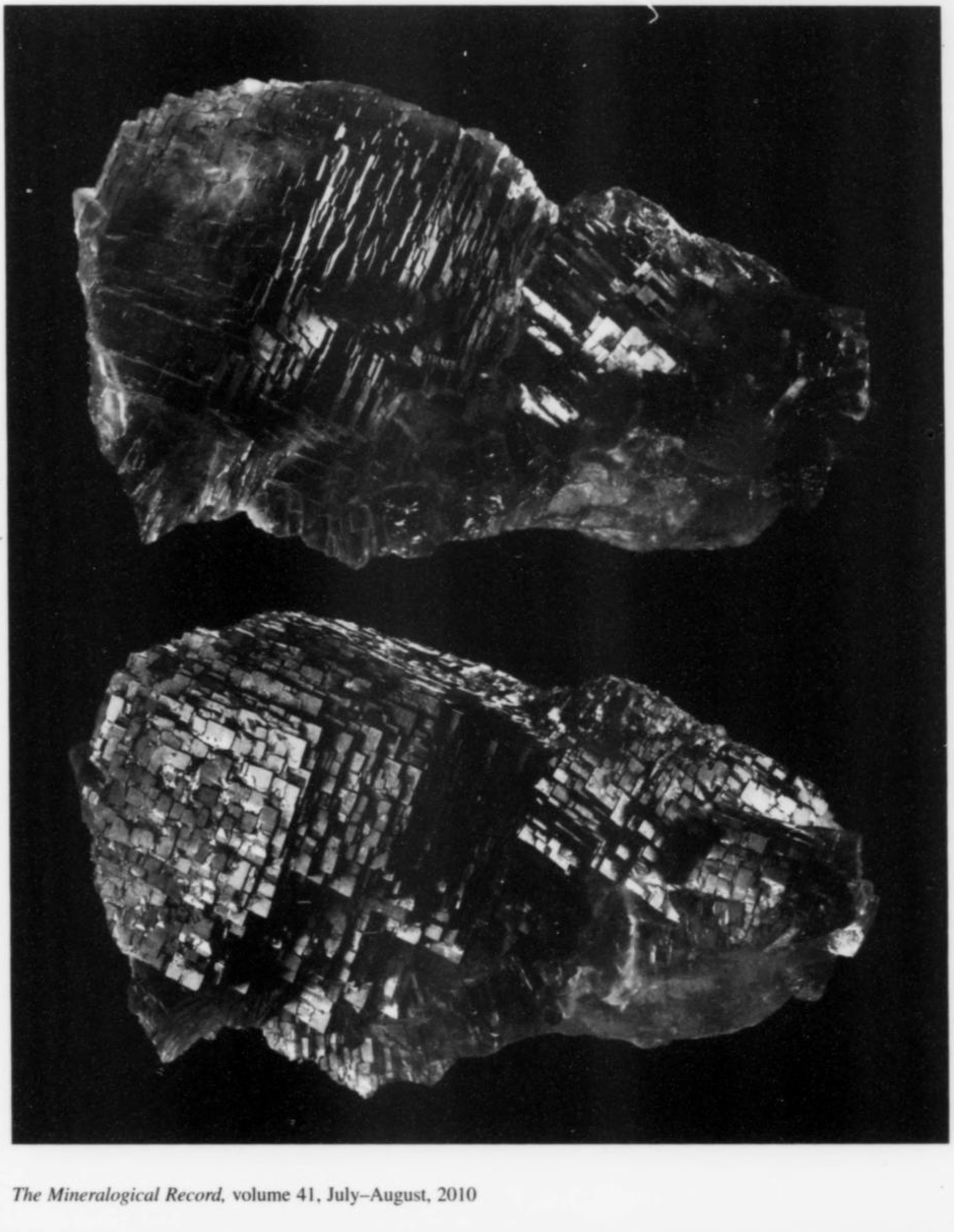


Figure 18. **Fluorite crystal cluster, 7.8 cm, from the "Jackpot pocket." Anton Watzl, Sr. collection and photo; shown backlit (above) and front lit (below).**

Figure 19. **Green fluorite crystal cluster, 10.6 cm, from the Big Cavern near the "Dragon pocket." Reinhold Bacher collection; Anton Watzl, Sr. photo.**

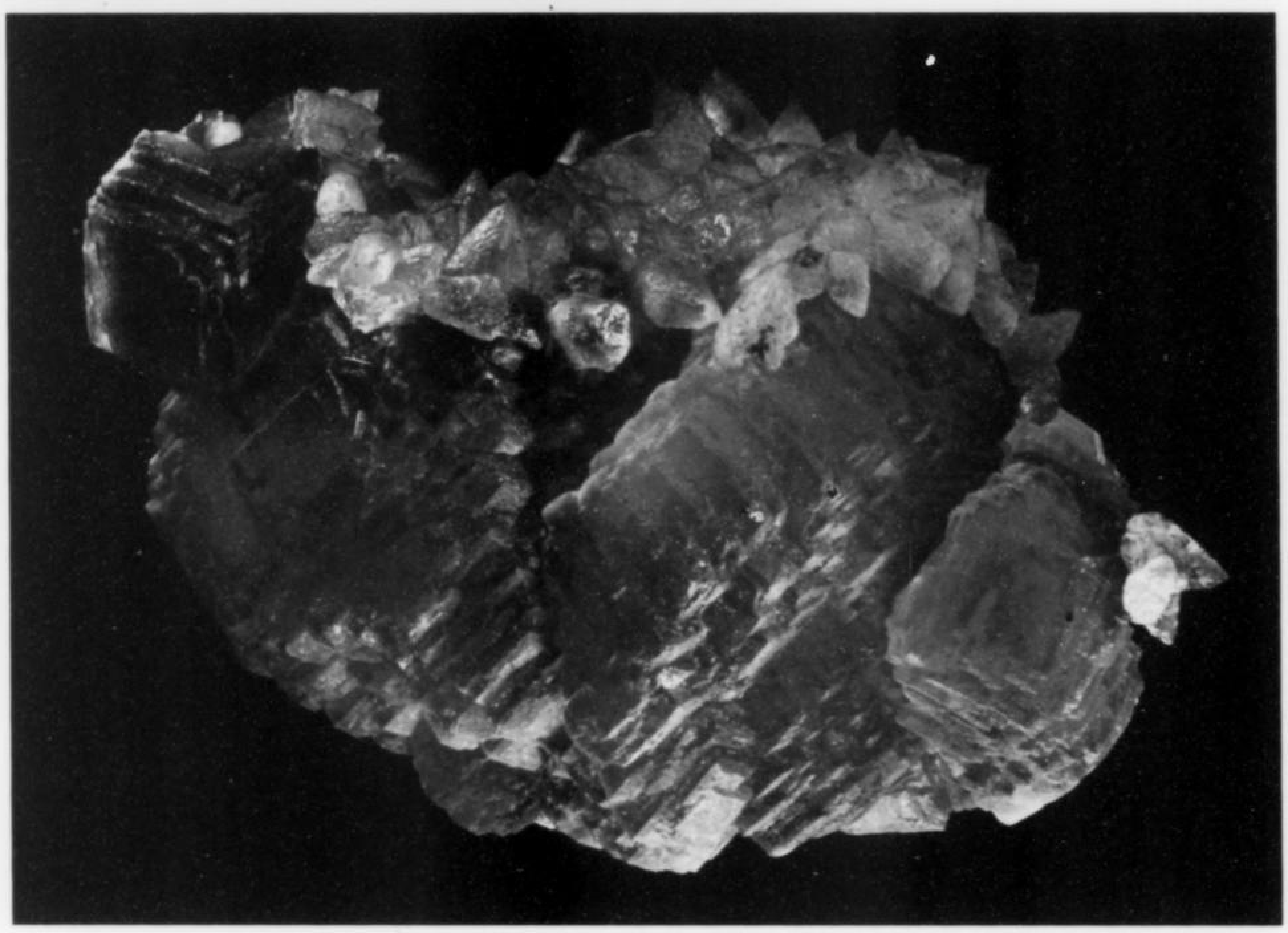


Figure 20. **Green fluorite crystal cluster with blue/purple fluorite cube and calcite crystals ("the Dragon"), 13.1 cm, from the Big Cavern. Reinhold Bacher collection; Anton Watzl, Sr. photo.**

SIXTH YEAR

In October 2005 Reinhold, working alone, made another discovery. Following the seam behind the Jackpot Pocket led him to another opening. He cleared the channel, initially finding little, until on one trip, as he reached for a tool, his light fell upon a crack he had not noticed before. Peering in, he saw the sparkle of green fluorite, unusual in an area where almost all the fluorite has a blue or violet cast. He examined the opening to determine how best to retrieve the crystals. Usually the rock surrounding a pocket is removed and then the pocket is broken open, but the dolomite surrounding the pocket was very hard, and Reinhold decided to try to remove pieces from the pocket through the small opening. With barely sufficient room for the chisel in the small pocket he struck a few soft blows and was able to remove two fine specimens of green fluorite, a true rarity at this locality (Fig. 19). The largest resembles a dragon with a body of green crystals, head of a single violet cube, and back armored with spines of yellowish calcite (Fig. 20).

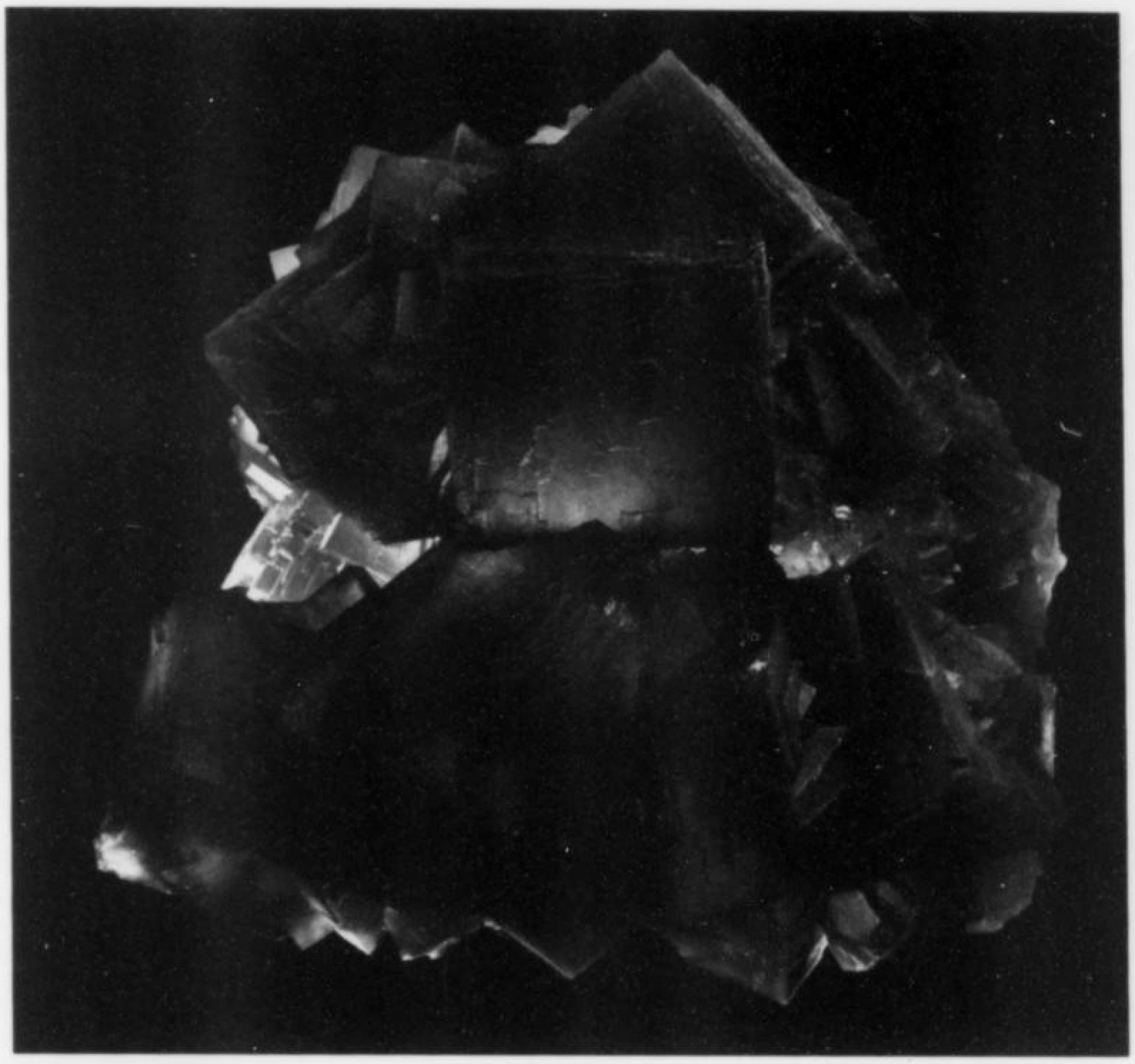
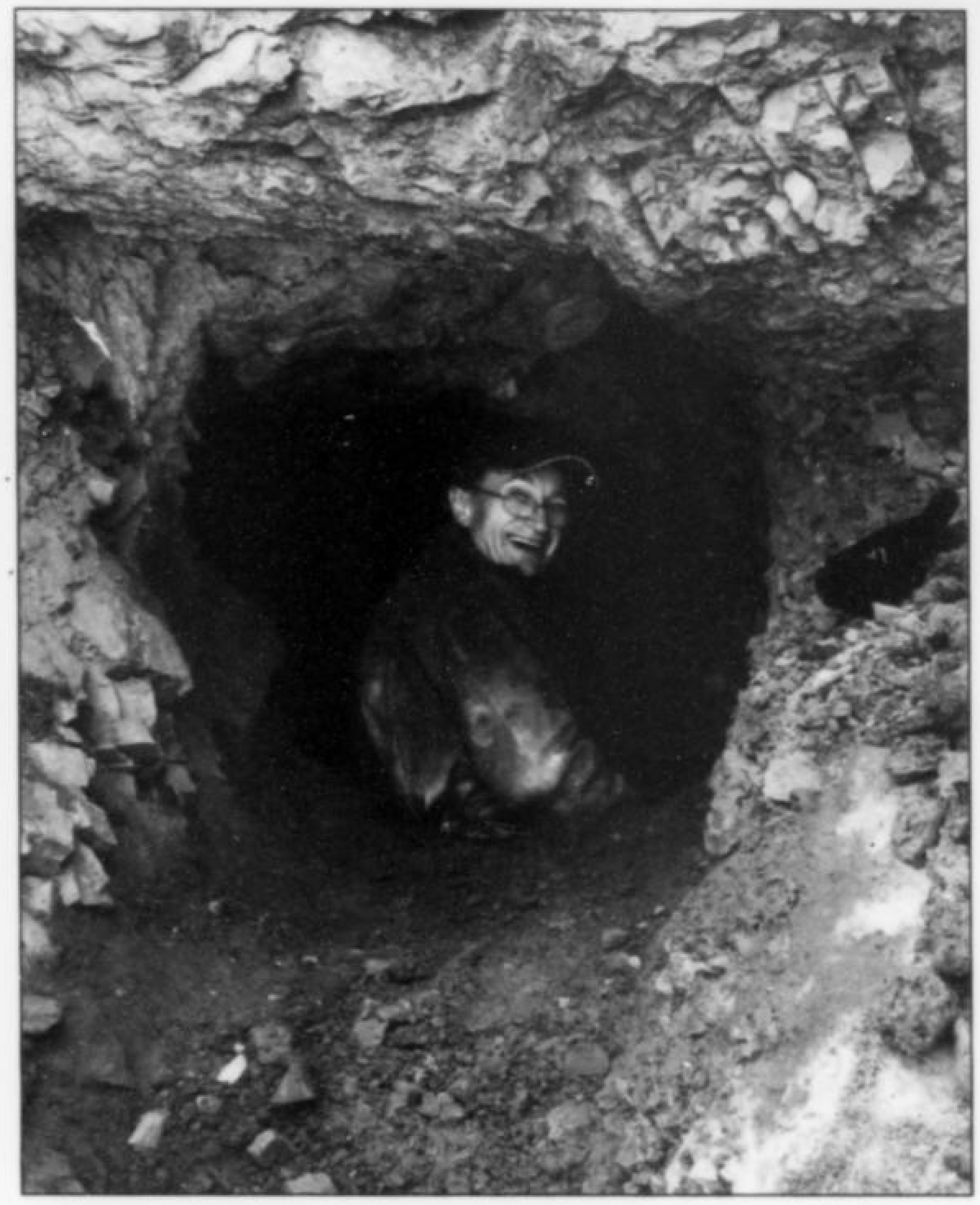


Figure 21. **Fluorite crystal cluster, 11 cm, from Cavern 2. Paradise Woods collection; Anton Watzl, Sr. photo, backlit to show internal color.**

Figure 22. **The late Walter Petzelberger, to whom we dedicate this article, in a pocket near Lake Rieding, October 2006. Gerhard Aschacher photo.**



SEVENTH YEAR

The 2006 season saw the addition of Hans Leitner to the Summit Cleft work group, to assist where needed. One day while Reinhold was in the mine alone, crawling up the tunnel between Cavern One and the Big Cavern, he decided to work on a seam he had spotted previously. There he opened a section of the wall revealing a pocket slightly smaller than Cavern One; this was soon named Cavern Two. This cavern yielded four 20-cm fluorite specimens, ten 10-cm specimens, and some smaller fluorites of a deep violet core surrounded by a pale blue zone and a lilac-colored outer layer (Fig. 21).

TODAY

Often the recounting of such finds leaves readers envisioning an abundance of mineral wonders in such occurrences and envying the exciting life of an explorer. Lest such thoughts linger long, it is important to understand that for each "find" there are countless unsuccessful or preparatory trips. Weeks of climbing up often go by with nary the hint of victory. Empty backpacks and hopes for future success are all that come down the mountain.

When finds do occur, joy is tempered by thoughts of the long days of work and the constant possibility of sudden danger. It is not uncommon for the Stoansucha, deep within the mine, to be unaware of rapid changes in the weather that are all too common. Downpours can flood the mine, drastic temperature drops can threaten the collector with hypothermia, and most frightening of all is the ever-present threat of cave-ins.

Weisseck Mountain and the surrounding area are now under strictly enforced and monitored rules prohibiting most mineral collecting. Anyone caught collecting in this area illegally faces high fines. Reinhold holds one of only two valid, difficult-to-obtain permits that allow work in this area, and has registered his current team of Hans Leitner and Martin Grüll (they are allowed to collect under Reinhold's permit). The work of those few who are allowed to collect is carefully documented and scientifically reviewed to ensure that all such efforts contribute to the knowledge of the area.

The Summit Cleft mine is no longer productive, though minor individual crystals can still be found. With effort and luck, perhaps another small vein could be developed but the days of significant finds belong to the past; the major veins have all been thoroughly worked. So the Stoansucha of the Weisseck move on, discovering new finds and facing new adventures.

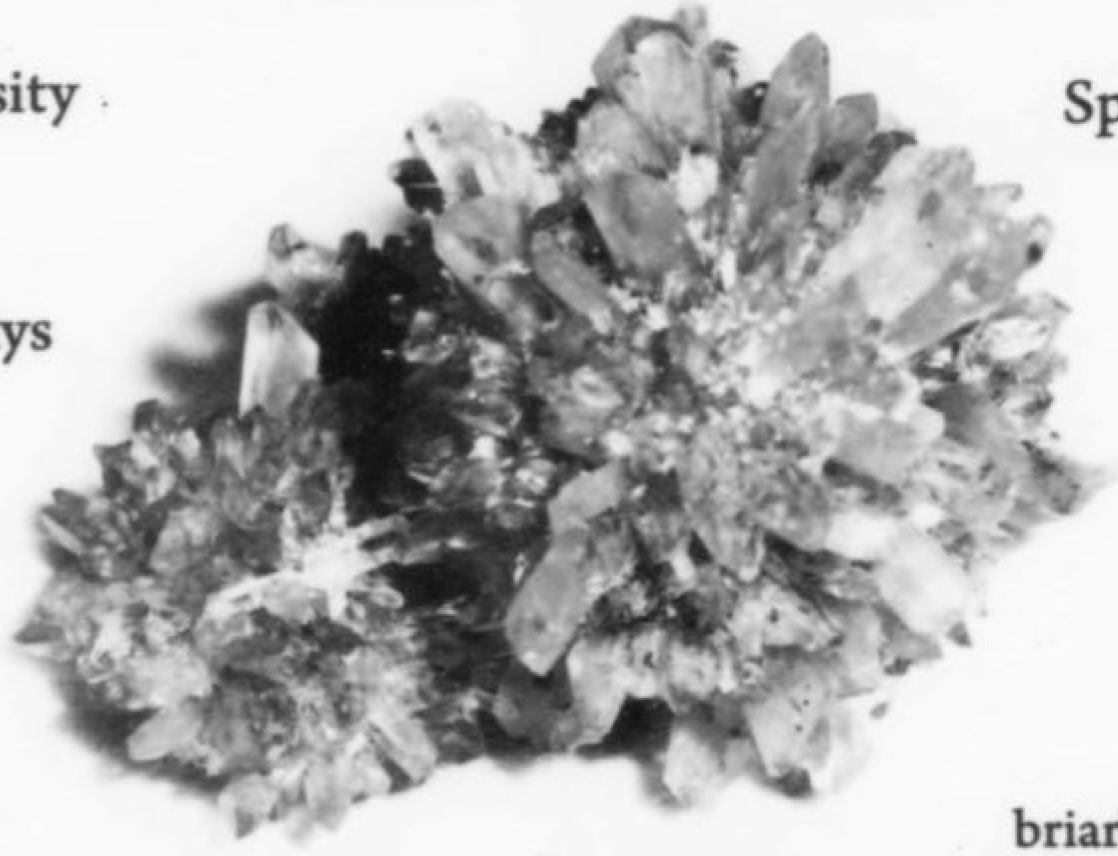
Walter and Reinhold continued their association until 2008 when Walter died unexpectedly only a few days before a planned journey to the mountains with Reinhold. This article is dedicated to Walter Petzelberger and his work on Weisseck Mountain (Fig. 22).

ADDENDUM

This commentary tells the story of the contemporary and substantial fluorite finds in the Weisseck Summit Cleft. The mountains mesmerize us. We are stone seekers and we are compelled to search for the treasures held by the mountain. We know of no Stoansucha who is drawn to the mountains solely for minerals. The beauty of the Alps holds us captive. The expanse and solitude of the Alpine limestone landscape has us under a spell that seems to demand that we climb and search and dig, with or without any reward. We cannot deny that it is a passion, and one that we embrace with joy.

ACKNOWLEDGMENTS

We extend our appreciation to Gerhard Kocher for his drawing of the Summit Cleft map; to Anton Watzl, Sr. for his outstanding mineral photographs; to Tanya Graw for her translations; and finally to R for his many suggestions.



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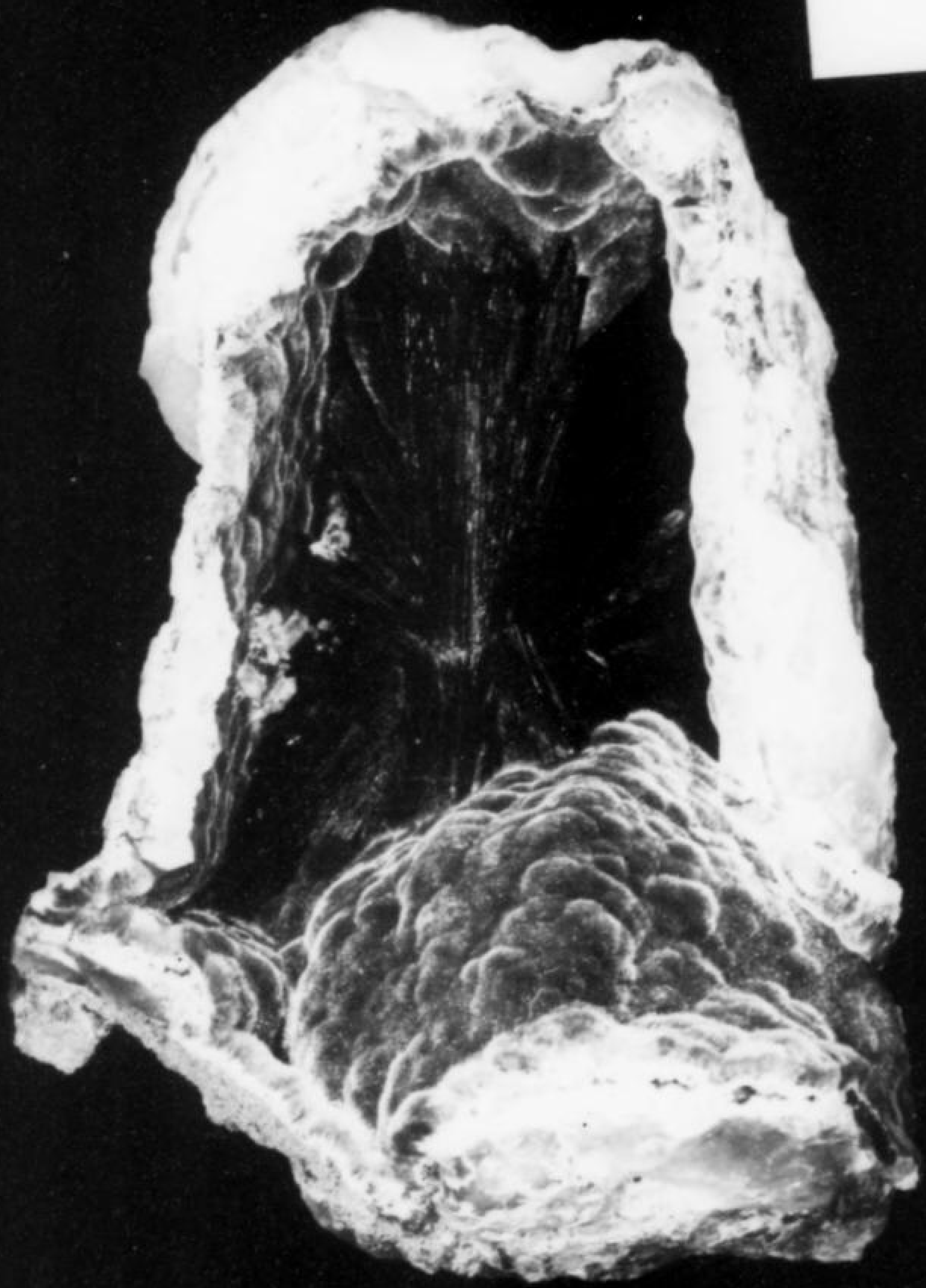

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