the Mineralogical Record

Volume Twenty-seven, Number Six
November–December 1996
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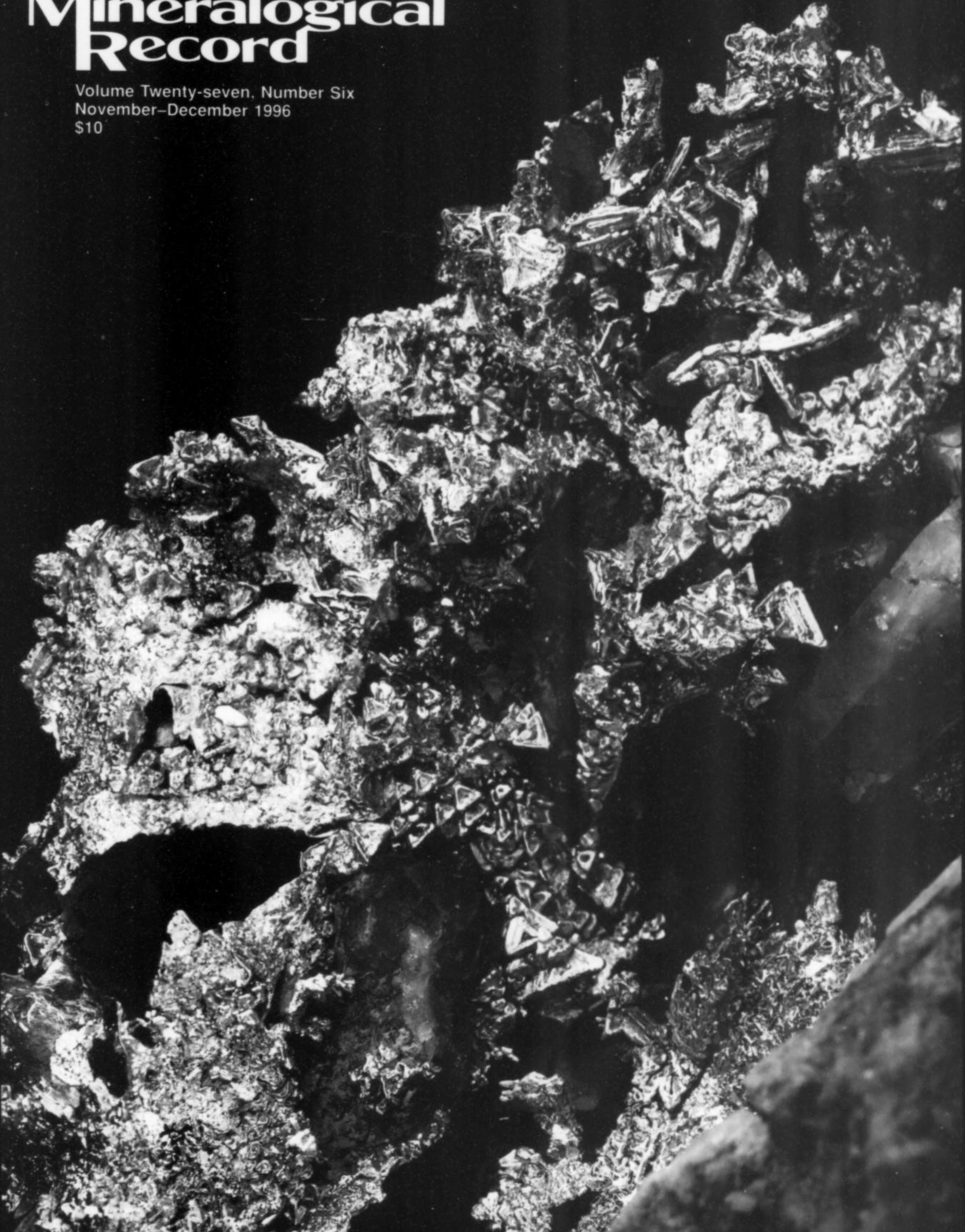



How and Where to Find Them.

THE MINERALOGICAL RECORD

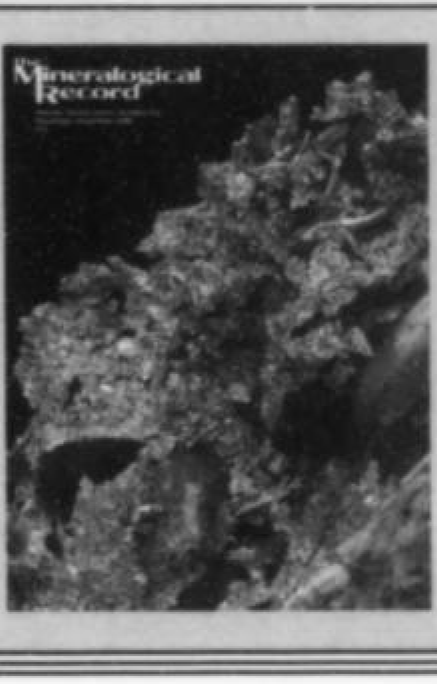
November–December 1996 Volume Twenty-seven, Number Six

Articles

Columns

What's new in minerals

Microminerals



COVER: GOLD with quartz on matrix, about 13 cm tall as shown, from the Colorado Quartz mine near Mariposa, California; Bryan Lees specimen; Jeff Scovil photo. See the article beginning on page 429 for more information.

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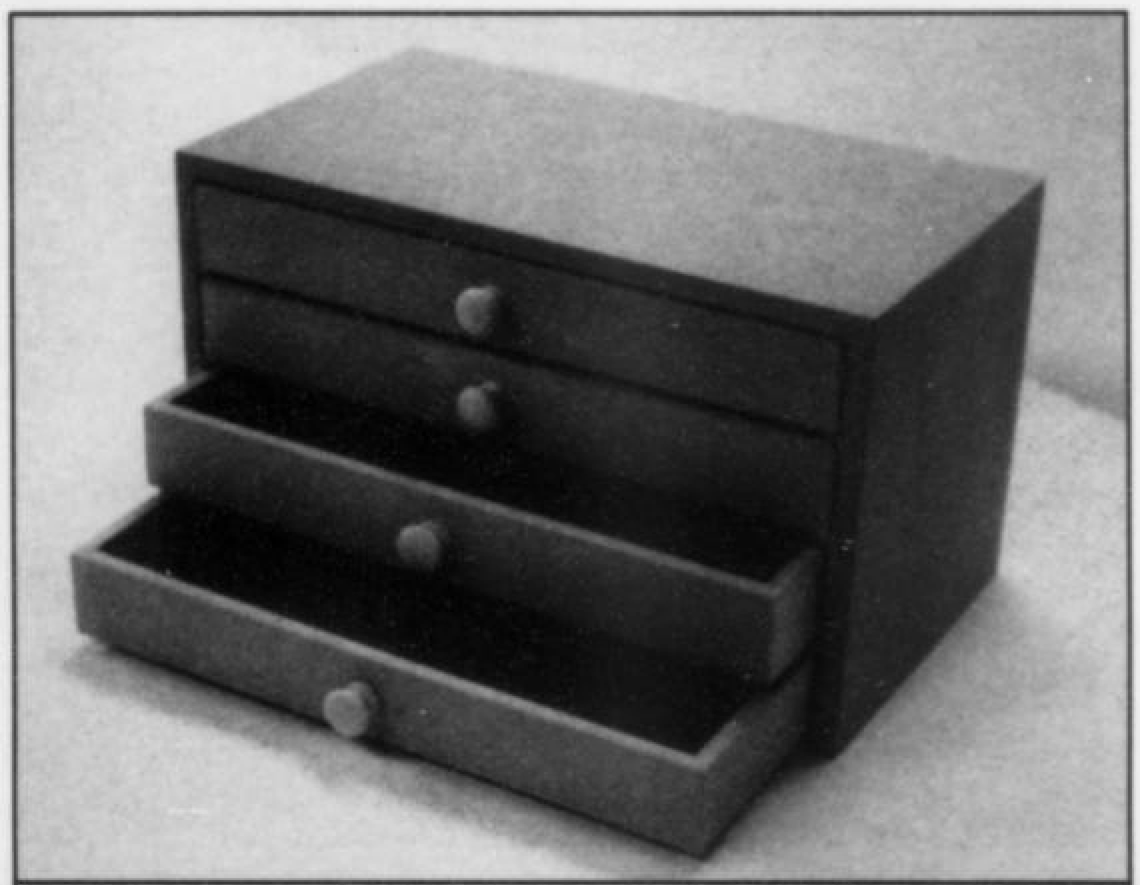
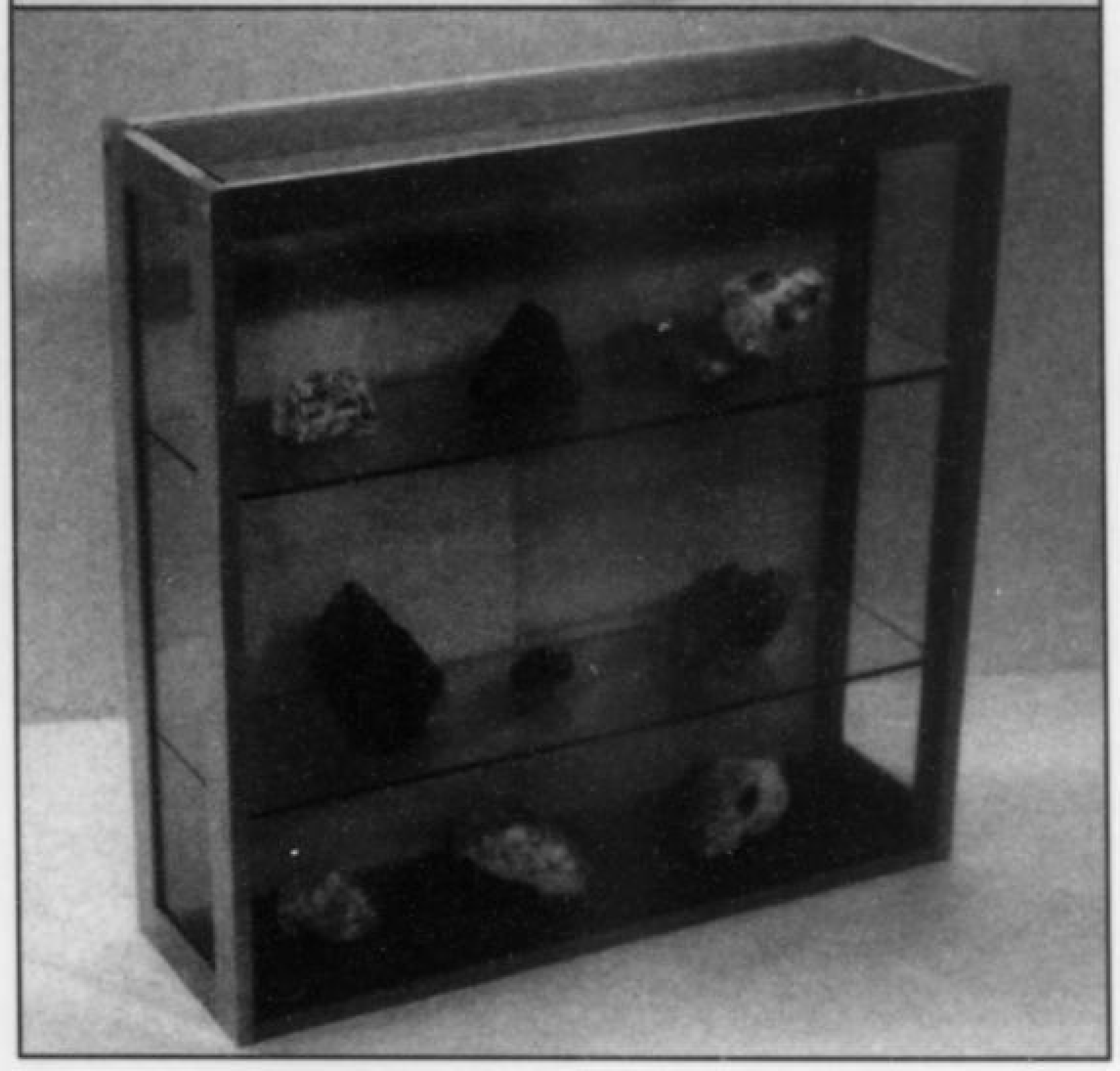
notes from the EDITOR





MINERAL CASES (IV)

Our featured supplier of mineral storage and display cases for this issue is Doug Wall (41 Peacock Circle, Washingtonville, NY 10992; Tel: 914-651-0700). Doug is a professional cabinet-maker by trade, and also a long-time mineral collector (great combination). He makes two cabinets, a four-drawer "perky" cabinet and a glass display case.

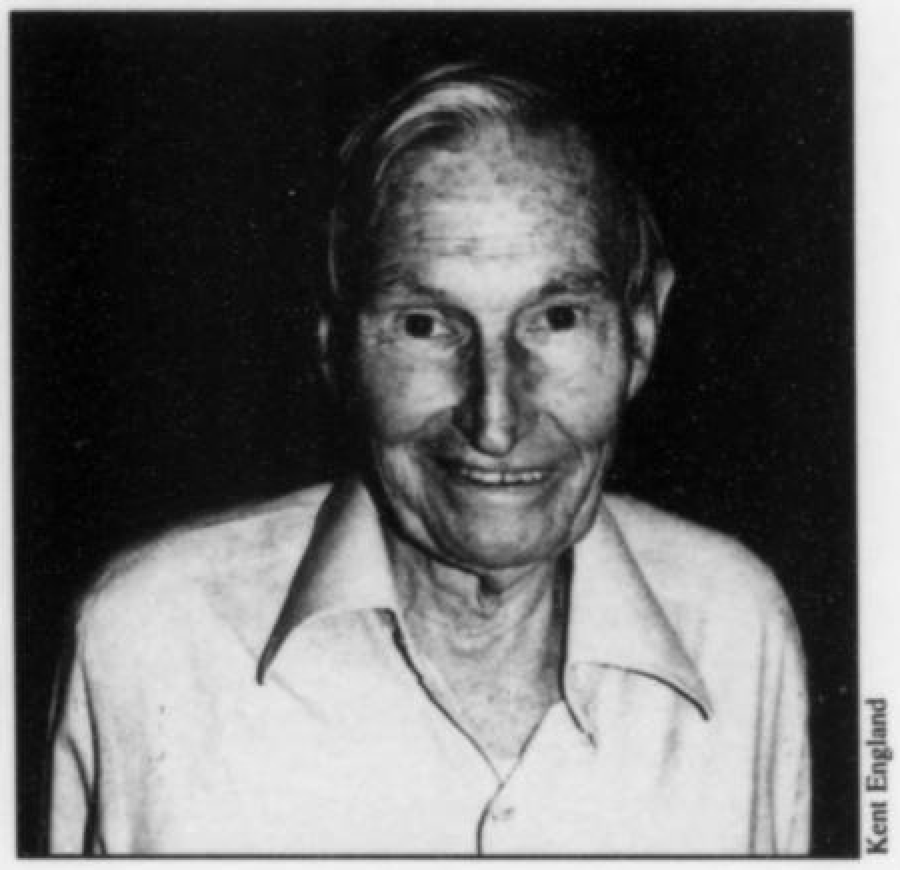
The four-drawer model, designed to hold standard 1.25-inch thumbnail perky boxes, measures 9 x 9 inches and is 16 inches long. It is supplied unfinished, in a utilitarian hardboard that can be stained, painted, varnished, papered or left natural. Priced for the collector wanting to invest primarily in minerals rather than cabinetry, it costs only $40! (The perky boxes needed to fill it cost more by themselves!)

The glass display cabinet is 9 inches deep and measures 30 x 30 inches. The frame and base are solid maple; the sides, top and shelves are tempered glass. It can be supplied with a fixed glass front and white sliding doors on the back, or a solid white back with sliding glass panels on the front. Both models can sit on a table or be suspended on shelf brackets. No lighting is deemed necessary because of the glass sides, top and front. These two models are each $265.

UPS shipping is available, or you can see Doug in person at the Franklin, New Jersey, Show and the Sterling Hill Mine Show. Incidentally, Doug also does custom cabinetry in any size and design, with a wide choice of woods available.

TGMS WHOLESALE SHOW

Are you a mineral dealer planning to visit the wholesale section of the forthcoming Tucson Gem and Mineral Show in February? If so, you had better get there *early*. The wholesale show is no longer at all concurrent with the retail show! The wholesale room in the North Exhibition Hall at the Tucson Convention Center will open on February 7, and will close on February 11. (The retail show will not open to the public until February 13.) Hours will be 10 a.m. to 5 p.m. daily, but closing at 4 p.m. on the last day. The good news is that admission is *free* if you can substantiate your dealer status; and available booth space has been greatly increased to accommodate more sellers. Marty Zinn's Executive Inn and Ramada shows will be opening earlier too: Feb. 4 instead of Feb. 7.



Kent England

Albert H. Chapman
(1912–1996)

NOTICES

Died, Albert H. Chapman, 84, the dean of Australian mineral collectors.

At the age of 12 Chapman became interested in amygdaloidal minerals found in road gravel, and in the many odd rock types found among the ballast dumped by ships on the banks of the Parramatta River. In the 1930's he and a collector friend (the only two in Sydney) collected zeolites at the Prospect quarry, enriching their own collections while also gathering trading material to exchange with curators at the Australian Museum and the Geological and Mining Museum in Sydney. Those curators (Tom Hodge-Smith, Oliver Chalmers and George Card) were his mentors, ever ready with guidance, encouragement and technical information.

Chapman's collection grew in size and quality throughout the succeeding decades. His training as a master carpenter, and his strong artistic bent, seemed to give him a connoisseur's appreciation of the beauty and sculptural quality of fine mineral specimens. At the same time he developed a sound working knowledge of mineralogy and a competent diagnostic ability, balancing his finely honed aesthetic sense with a solid scientific foundation.

Over the years Chapman ("Chappy," as his friends called him) maintained an extensive correspondence with major collectors and curators worldwide, carried out transactions with the leading museums, and traveled widely across Australia, America and Europe. He served as a guide, philosopher and friend to generations of Australian mineral collectors, sharing his knowledge, wisdom and friendship in a way that set standards for collecting and imparted intelligent aims which have significantly elevated the hobby in Australia.

Chapman's magnificent collection of Australian and worldwide minerals, among the finest private mineral collections in the world, was purchased by the Government of New South Wales for $1 million and presented to The Earth Exchange Museum; when the Museum closed last year, his collection was transferred to the Australian Museum where it is preserved today.

Died, Rebecca (Beckie) Bird, 94, in Tucson. Beckie Bird, an enthusiastic collector and supporter of mineralogy, was known to a great many people, and was a regular attendee of the Tucson Gem and Mineral Show until well into her 90's. She was born on January 16, 1902 in Boston, the daughter of artist and egyptologist Joseph Lindon Smith (1863–1950) and Corinna Haven Putnam, an author and Islamic scholar; she was also a grand-niece of the geologist and explorer Raphael Pumpelly (1837–1923).

Beckie attended the Windsor School in Boston, and graduated from Westover School in Middlebury, Connecticut. After graduation she attended La Grand Chaumiere School of Art in Paris, before accompanying her father on an artistic tour of the Middle and Far East. They visited the temples at Luxor and Karnak in Egypt, followed by India, Siam, Java and the Temple of Ankor Wat in Cambodia.

An artist herself, her best work was portraiture in soft pencil and sepia. Her subjects were diverse, from Native Americans in Arizona to the leaders of Boston Society, Swiss mountaineers and German street people.

Beckie was married to Frederic V. G. Bird, also an enthusiastic mineral collector, for 35 years until his death in 1988. They were avid skiers and mountain climbers, and spent many hours together collecting valuable and rare minerals in France, Switzerland, New Hampshire, New Jersey, Colorado and Arizona. Together they built a substantial, varied and beautiful collection.

Fred and Beckie divided their year between residences in Ouray, Colorado, and Cabris, France. Since Fred's death Beckie has lived in Tucson, where she exhibited specimens each year at the Tucson Show, and enthusiastically supported the Arizona-Sonora Desert Museum (especially archeological research).

Until failing eyesight limited her activities, Beckie remained an avid field collector, venturing underground down the ladders and shafts of the 79 mine when she was a spry 90 years old. Her wonderful stories of a time long passed will be missed by all who knew her.

John Mediz

Demolished, The Desert Inn, Tucson, Arizona: venerable venue for mineral venders as the site of one of the nation's first mineral satellite shows.

In the mid-1960's the first-ever "satellite mineral show" opened at the Holiday Inn South, in conjunction with the Tucson Gem and Mineral Society's Show. The TGMS Show (started in 1955) was then being held in a large quonset building at the Pima County Rodeo and Fairgrounds on South Sixth Avenue. When it had grown so large that there was no longer any room for wholesale dealers, the motel was commandeered by dealers as the unofficial overflow area for sales. By 1968 dealer activity in the Holiday Inn and other local motels had grown so alarmingly that the TGMS felt compelled to legally register the show name to prevent its unauthorized use by the concurrent motel shows.

In 1972 the TGMS show was moved to the newly built Tucson Convention Center, and many of the satellite mineral dealers took up residence then in the nearby Desert Inn. It was relatively fresh and new in those days, having opened in 1961; it had a nice pool and interior hallways, and it was within walking distance of the Convention Center. The TGMS and a new mineral magazine called the *Mineralogical Record* hosted a reception at the Desert Inn on Saturday night of the Show that year. A slide competition was held in the mezzanine ballroom, and Smithsonian curator Paul Desautels served as auctioneer for the first of many annual auctions to benefit the *Mineralogical Record*. The following year the auction was moved to the Convention Center too, but the Desert Inn remained the focus of motel mineral dealing amid a growing number of other satellite shows. To a generation of mineral collectors and dealers from around the world, the Desert Inn was the perennial hang-out, party-spot, poker parlor and haggling corner where old friends met, deals were cut, and millions of dollars in fine mineral specimens changed hands.

The years took their toll on the Desert Inn: the elevator wore out (no doubt due in part to the thousands of pounds of specimens it hauled up to the second floor and back), the plumbing deteriorated (with the help of many dealers who used to fill sinks and bathtubs with acid to clean specimens), the carpeting began to show the stains of bizarre chemical spills and crushed minerals of all sorts, and even the walls became gouged and scratched by tables and rocks and luggage dollies moving around tons of stock. Repairs and remodeling failed to keep up.

In the end, the Desert Inn was condemned, ostensibly for a freeway-widening project, but everyone agreed it was time for the old place to go. Just a shabby shadow of its former self by February 1996, its closing by the city was temporarily rescinded to allow one more mineral show. By that time the focus of sales for the serious mineral collector had moved to the Executive Inn a couple of miles away. The building was finally torn down a few months later.

For those of us who called it home every February, the Desert Inn was an important part of the history of mineral collecting. The friends made there, and the connections established, have enriched many lives, businesses and collections. The minerals seen there over the years constituted an education in themselves, and will remain in the minds of many as a part of our mineral culture and heritage.

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THE ALVA SILVER MINE

SILVER GLEN, ALVA SCOTLAND

Stephen Moreton
85 Hamnett Court
Birchwood, Warrington
Cheshire, WA3 7PN, England

A little-known, long-abandoned mine in central Scotland has recently yielded some remarkable specimens of crystallized native silver. Its history is every bit as remarkable. The deposit, first opened in 1715, ranks as the richest bonanza of native silver ever found in Britain.

INTRODUCTION

When mineralogists are asked to name European localities for crystallized native silver, most will list well-known mining districts such as Norway's Kongsberg and Germany's Harz Mountains. Very few will even have heard of Scotland's Ochil Hills, yet a small but spectacular find there in 1715 yielded dendritic silver as beautiful as that from many of the more famous continental mines. In the same year, Britain was wracked by a bloody uprising as two would-be monarchs competed for the throne—George I, Elector of Hanover, on the government's side and James Edward Stuart, "The Old Pretender," son of the deposed James II, heading the Jacobite rebels. This coincidence led to a remarkable sequence of events involving fortunes made and lost, buried treasure, betrayal, deals with the Hanoverian government, and a diversity of charming and not so charming characters.

HISTORY

The central character of the story was Sir John Erskine, who lived at Alva House at the foot of the Ochil Hills, about 10 kilometers east of Stirling in central Scotland. A distant descendant of the great Scottish hero Robert Bruce (who slaughtered the English in 1314 at Bannockburn—one of the few times Scotland actually won a battle against its southern neighbor), he was born around 1672, the second son of Sir Charles Erskine and his wife Dame Christian Dundas. According to John Ramsay of Ochtertyre, "He was a man of wit and genius, but the heat and volatility of his fancy would not be regulated by prudential considerations" (Allardyce, 1888). His elder brother, Sir James, was killed at the battle of Landen in 1693. His brothers included Dr. Robert Erskine (1677–1718), physician to and favorite of Czar Peter the Great of Russia, and Charles Erskine, Lord Tinwald, later Lord Justice-Clerk, who shall enter the story later.

Figure 1. **Sir John Erskine (ca. 1672–1739) of Alva near Stirling in central Scotland (from an old painting whereabouts now unknown). K. J. H. MacKay photo.**

Figure 2. **The Hon. Catherine, Lady Erskine (from an old painting, whereabouts now unknown). K. J. H. MacKay photo.**

In 1714, Sir John brought a miner from Leadhills to survey his estate at Alva for minerals. Around Christmas he found a promising mineral vein in a small glen just 10 minutes walk from Alva House. Mining commenced early in 1715. The work had barely begun when the miners noticed strings of a metallic ore which, when followed, led to a mass of solid ore. Analysis of this proved it to be extraordinarily rich in silver, 14 ounces of ore yielding 12 ounces of the metal according to Duncan (1796) who said that the ore consisted of native silver, adhering "in slender strings to the spar, in a variety of fanciful and irregular forms."

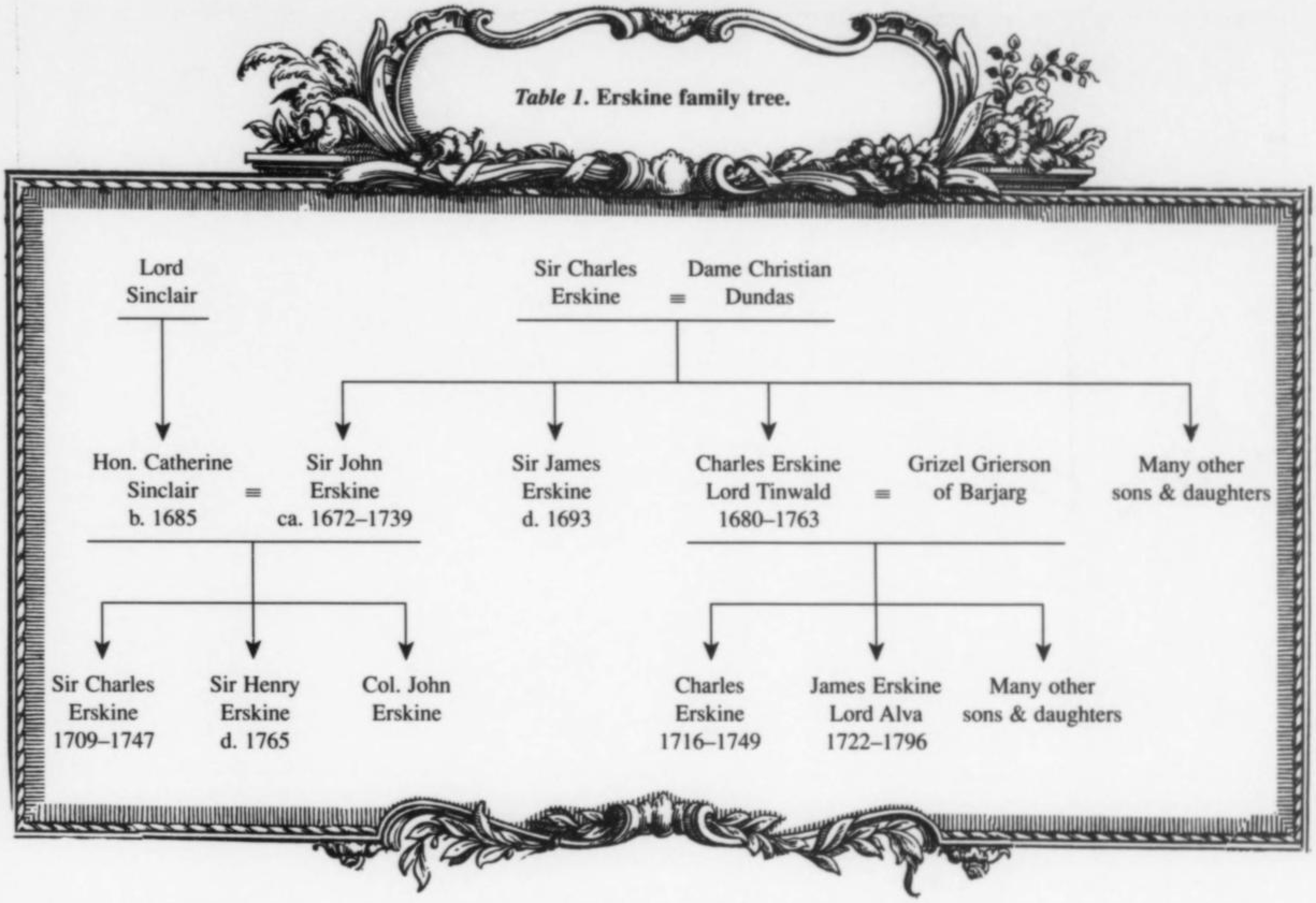
At this same time the Jacobite rebellion was breaking out and Sir John's cousin, the Earl of Mar, was organizing the rebels. Sir John too supported the cause, and he went off to join the uprising, leaving his wife, the Hon. Catherine, second daughter of Lord Sinclair, in charge of the mine. Sir John seems to have spent much of the rebellion in Europe, as we shall see, rather than in combat alongside the Earl.

After raising the Standard at Braemar in September 1715 the Earl headed south to confront the government forces led by the Duke of Argyll. The two armies clashed at Sheriffmuir about 8 km north of Stirling on Sunday the 13th of November. The churches were silent that day, and the minister of Alva sent a message to Alva House that "There wad be nae Sabbath the day" (Hynd, 1981).

The battle was indecisive, and when the rebels heard that their comrades in England had been defeated that same day at the battle of Preston things must have looked gloomy. Sir John, however, was safe in France. While he was away, Lady Erskine tended the wounded from the battle, employed spies for the rebels and, of course, supervised the working of the mine. To operate the mine, the Erskines had employed one James Hamilton to oversee the labors of the workmen. When the rebellion broke out the mine had penetrated a mere 4 or 5 yards underground and had produced only 134 ounces of silver, but during the rebellion Mr. Hamilton and his men were busy. Acting under Lady Erskine's orders they dug out, in the space of three or four months, some 40 tons of ore and buried it in barrels near the gate of Alva House for safekeeping (Hamilton, 1716).

While Lady Erskine was taking care of this wealth, Sir John was busy in Europe gun-running and gold-smuggling for the rebels. There he remained for several months, and was frequently hard up for cash despite repeated attempts by his wife to make arrangements for £100 to be passed on to him. In her letters Lady Erskine assures her husband that the estate is in good order, the hedges and ditches maintained and the crops sown but she avoids any direct mention of the silver mine, perhaps in case her letters should fall into the wrong hands. There are, however, veiled references. Lines like, "Mr. Nabit does not employ old H or any of his profession at present" and, "It is yet impossible to tell what money Mr. Nabit will be worth, his reputation amongst the common sort is so high

Table 1. **Erskine family tree.**



that no body credits it" (Erskine, 1716a) seem quite innocent until one realizes that "Nabit" (nowadays "Nebit") is the name of the hill on which the mine is situated.

Sir John's predicament looked grim. He was deeply involved in the uprising and was a wanted man. Ironically it was to be a betrayal by mine manager James Hamilton that was to provide Sir John with a pardon and permission to return home. On June 18th, Lady Erskine had written to her husband ". . . James went away three months agoe, for he turnd wrong in the head and would not stay" (Erskine, 1716b). Hamilton traveled to London and deposited an affidavit dated July 3, 1716 with the Lord Mayor of London, Sir Charles Peers (Hamilton, 1716). This affidavit gave details of the silver mine. He took with him some samples of the ore which aroused much interest on account of their great richness.

This upset Lady Erskine greatly, and on July 8th she wrote to her husband, "It ha's grievd me very much, and it is no small satisfaction that it has not failed by any neglect of mine but he certainly designed to comitt the villainy and went away with that veiu for nothing I could doe could make him stay" (Erskine, 1716c). However, the Erskines and their friends were quick to turn this to their advantage. They exploited an old Scottish law that said that a tenth of the proceeds from any mine of gold or silver was to go to the crown. It was argued that Sir John had more knowledge of the silver mine than anyone else and that if he were pardoned and allowed to return he could resume mining with 10% of the revenue going to the government.

The government agreed and decided to send someone to inspect the mine and report on it. At first Sir Isaac Newton, Master of the Mint, who had assayed some of Hamilton's samples of ore and described them as "exceeding rich," was asked. He declined on the grounds that he was "unacquainted with these matters" (Newton, 1721). The government decided to send an expert from the king's silver mines in Germany instead. So it was that one Dr. Justus Brandshagen was given instructions to travel to Alva and inspect the mine. He was to be accompanied by James Hamilton and James' brother Thomas, and was to be paid a pound a day and the Hamiltons half this.

Brandshagen set sail on September 10th and 23 days later, after a stormy voyage in which his ship lost two masts, he arrived in Scotland. In Edinburgh, on October 15, 1716, he met the Earl of Lauderdale who informed him that Sir John had obtained his pardon on condition that he show Dr. Brandshagen the mine. They decided to wait until Sir John returned to Scotland before proceeding to Alva.

The inspection of the mine began on Tuesday, November 13. A detailed journal (Lauderdale *et al.*, 1716) described what followed. The Earl of Lauderdale, John Haldane of Gleneagles (Sir John's brother-in-law), William Drummond (Warden of the Mint at Edinburgh), Dr. Brandshagen and James Hamilton met in Alva House. Sir John then took the gentlemen out to the site of the mine only to find that it had been filled in with earth and rubble. Accordingly, six local workmen were employed at ten pence a day to clear the debris from the workings. The men were expected to provide their own tools for the task.

The following day, while some of the men were busily engaged in excavating the mine, James Hamilton and two workmen were called to Alva House for the purpose of exhuming the 40 tons of ore said by Hamilton to have been buried there. Mr. Hamilton indicated the spot—on the northwest side of the house, near the gate—and said that there was but 6 inches of soil on top of the barrels of ore. The men set to work but after digging to over a yard depth in two places in the already loose and disturbed soil with

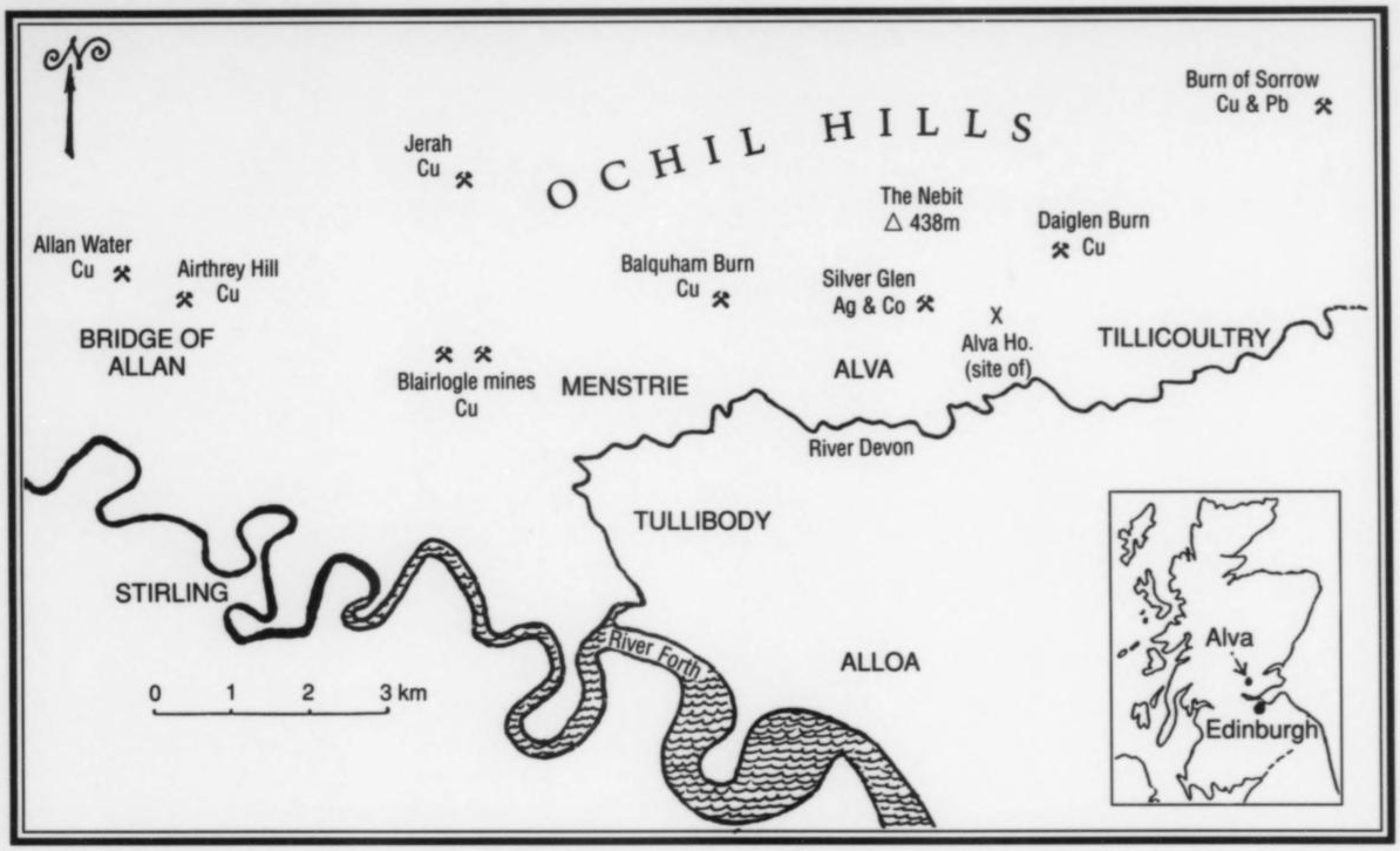


Figure 3. **Locality map.**

only a few fragments of ore to show for their efforts it was apparent that the casks of ore had gone.

At this point Sir John guided the men to his garden and showed them a spot where he said his servants had told him there was some remaining ore buried. Being late in the day the excavation of this spot was postponed until the following morning when the Doctor, together with the Hamilton brothers and the workmen accompanied Sir John and his servants into the garden. There the men dug and rapidly uncovered six small casks filled to the brim. The contents were emptied out and were found to consist of little more than worthless waste rock from the mine. The servants, upon being questioned, said that the other casks had from time to time been dug up and taken away but to where they knew not. Curiously, this matter seems not to have been pursued further by the authorities, nor is there any indication that Lady Erskine was questioned.

In the following weeks, the mine was cleared and furnaces constructed for assaying the ore. The Earl of Lauderdale, together with Mr. Haldane and Mr. Drummond, returned to Alva on January 2, 1717 and, accompanied by the Doctor and the Hamiltons, went to the mine, where the Hamilton brothers took samples of ore from six separate parts of the mine. Portions of these samples were dispatched to London while the remainder were assayed over the following days by the Doctor and James Hamilton. While not approaching the legendary 12 ounces of silver in 14 ounces of ore the assays were nevertheless extremely encouraging, giving up to 6% silver. Dr. Brandshagen said of the ore:

> I found it of an extraordinary nature, such as to my knowledge few or none like have ever been seen in Europe. It consists of sulphur, arsnic [*sic*], copper, tinn [*sic*], iron, some lead, and good silver. Of all these the silver is only to be regarded, for the other minerals and metals contained in the ore are of little value, and not worth the charges to separate and keep them. (Brandshagen, 1717)

The Doctor seems to have been well pleased with his treatment, for in his report to the Lords of the Treasury he wrote:

> Sir John Areskine . . . has all along been not only particularly civil and kind to me, by procuring me and my family and the Hamiltons good lodging and accomodation near the mine, in the minister of Alva's house, but likewise in accomodating us sometimes with necessary tools, with work people, and with a house where we built the furnaces and made the assayes, and he contributed in everything to facilitate and carry on this business. (Brandshagen, 1717)

The government too was satisfied and allowed Sir John to stay; the mine was worked for several more years. Gradually the remaining ore diminished and gave way to poorer ores of copper and lead that were uneconomical to work, and the mine was abandoned.

With his fortune from the mine (reputed to be £40,000 to £50,000 which, at the prevailing price of 5s 2d an ounce, would correspond to 5 or 6 tons of silver), Sir John embarked on ambitious improvements to his estate. He planted the hill behind his house with native and exotic trees, made extensive enclosures and agricultural improvements and, at great expense, dug a canal to facilitate the transportation of coal from pits along the River Devon to the River Forth. When a neighbor remarked, "Sir John, all this is

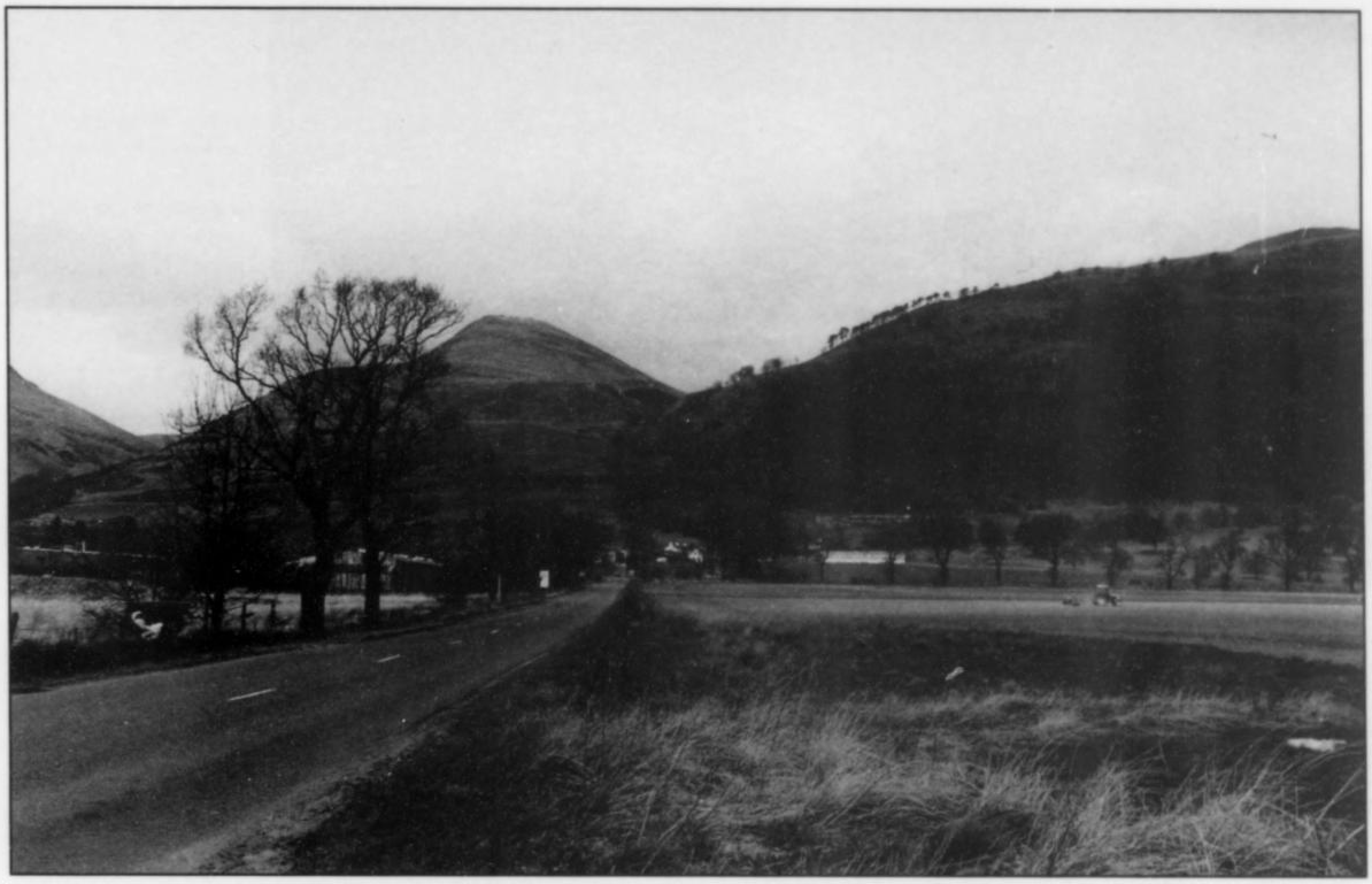


Figure 4. **The Silver Glen, Alva. The mine site, now overgrown, is in the exact center of the photo. The hill to the left is "The Nebit." Note the walled garden at right, once part of the grounds of Alva House. Author's photo.**

Figure 5. **Workings in the vicinity of the Alva mine.**

very fine and very practicable, but it would require a princely fortune," Sir John replied, "George, when I first formed my scheme of policy for this place, I was drawing such sums out of the mine that I could not help looking upon the Elector of Hanover as a small man" (Allardyce, 1888a).

In 1739 Sir John died after a fall from his horse. The estate passed first to his eldest son Charles, who was killed at the battle of Laffeldt, and then to the next eldest, Sir Henry or Harry Erskine, baronet, Member of Parliament, and later lieutenant-general in the army. He sold the estate to his father's brother Charles (Lord Tinwald) in about 1749.

Charles, Lord Tinwald (1680–1763), was the ablest of the brothers. Pursuing a career in the legal profession, he rose to Lord Justice-Clerk in 1748. Ramsay of Ochtertyre described him as "possessed of excellent talents, which were improved by culture, and set off to great advantage by graceful persuasive eloquence in a strain peculiarly his own." He was witty, polite, even-tempered and his oratorical skills earned him the nickname "Sweet-lips" (Allardyce, 1888).

He also shared some of Sir John's speculative spirit. He suggested, "If one could turn over the Ochils like a bee-hive, something might be got worth while" (Allardyce, 1888). So it was that in about 1758 he, together with some relatives and friends, formed a company to rework the silver mine which had lain idle for many years. Their workmen followed the course of the vein for a good

Figure 6. **Silver in 90° arborescent growths to 2 cm, on matrix with black clinosafflorite. Brian Stocks collection; author's photo.**

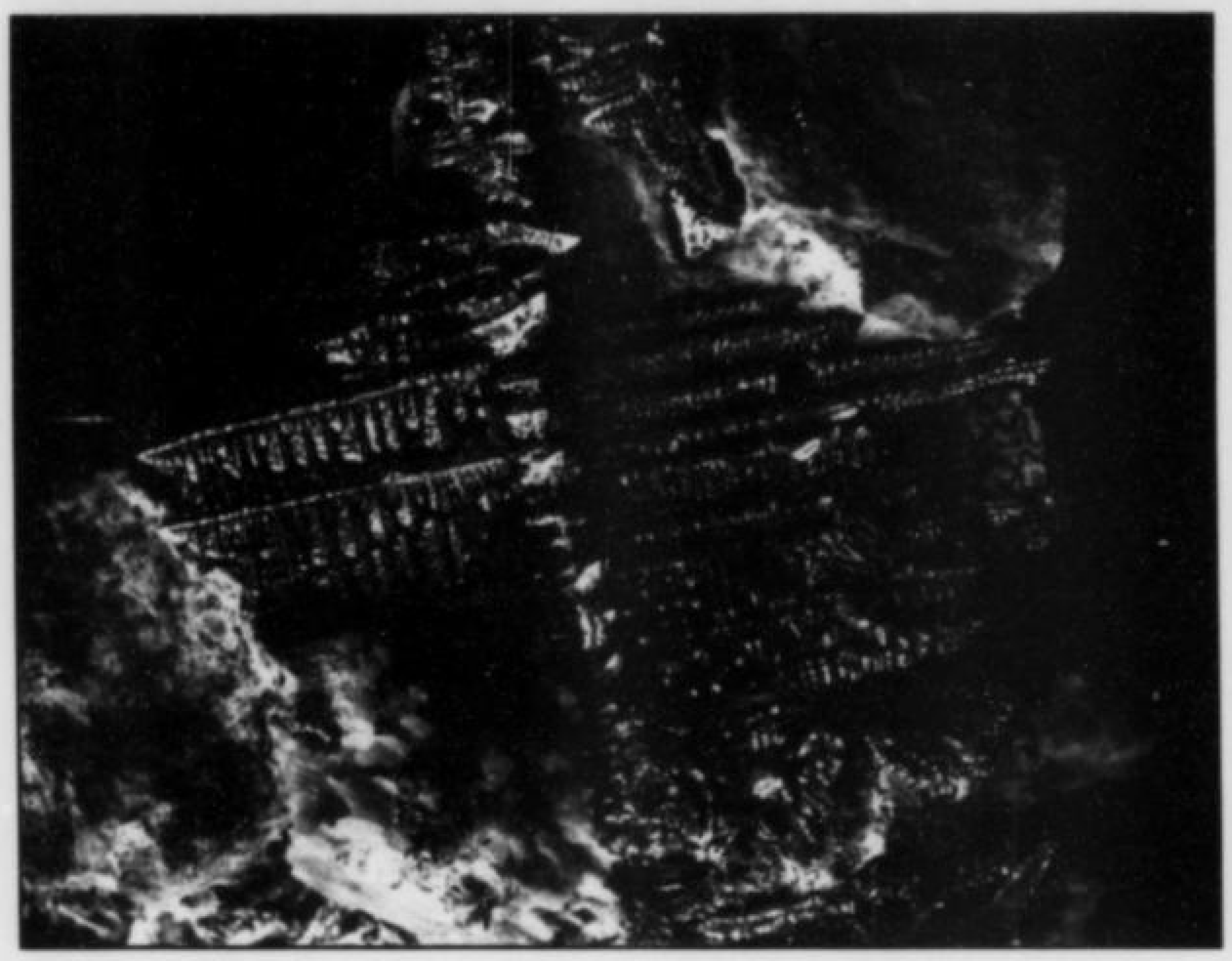


Figure 7. **Silver in arborescent habit branching at 90°. The parallel growth measures 1.5 cm. Author's collection and photo.**

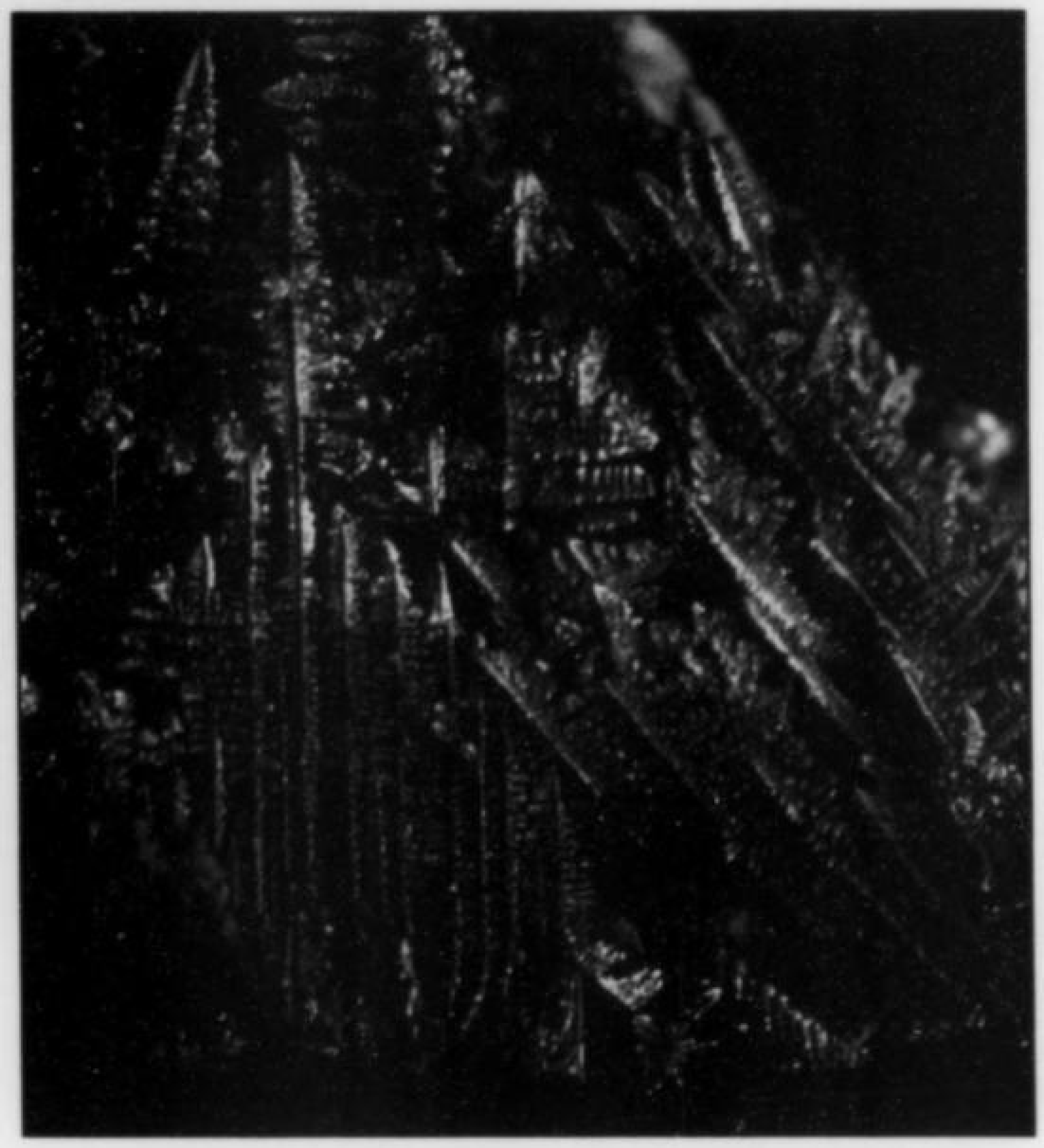


Figure 8. **Silver in 90° arborescent growths to 2 cm. Brian Stocks collection; author's photo.**

Figure 9. **Silver, a 0.4-mm crystal resembling a signpost. Author's collection; D. I. Green photo.**

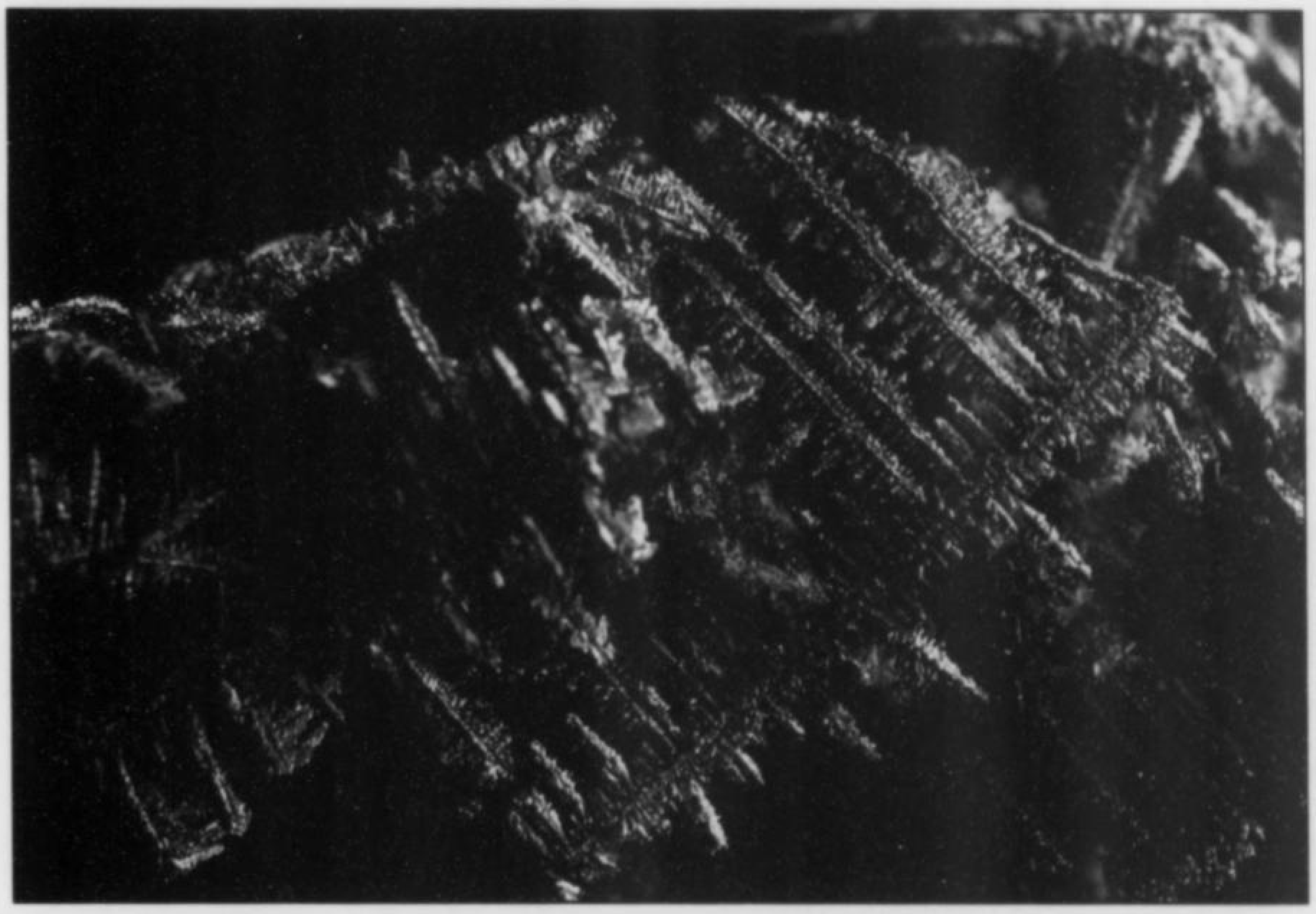


Figure 10. **Silver in arborescent habit branching at 90°. The specimen as shown measures 3 cm across. Author's collection and photo.**

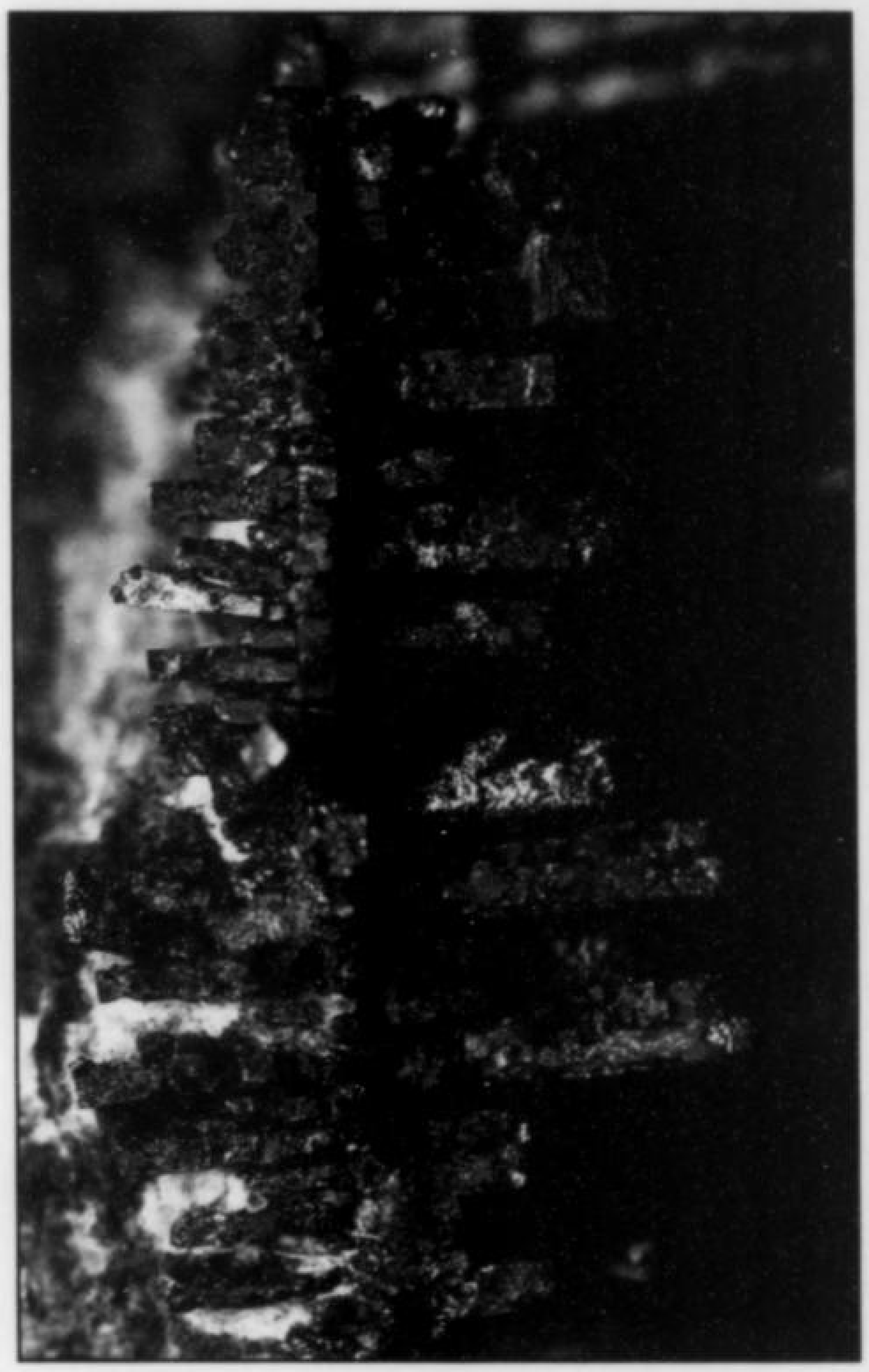


Figure 12. **Silver in distinctly cubic arborescent growth branching at 90°. The dendrite measures 8 mm, and shows partial dissolution, a typical feature of Alva silver. Author's collection; D. I. Green photo.**

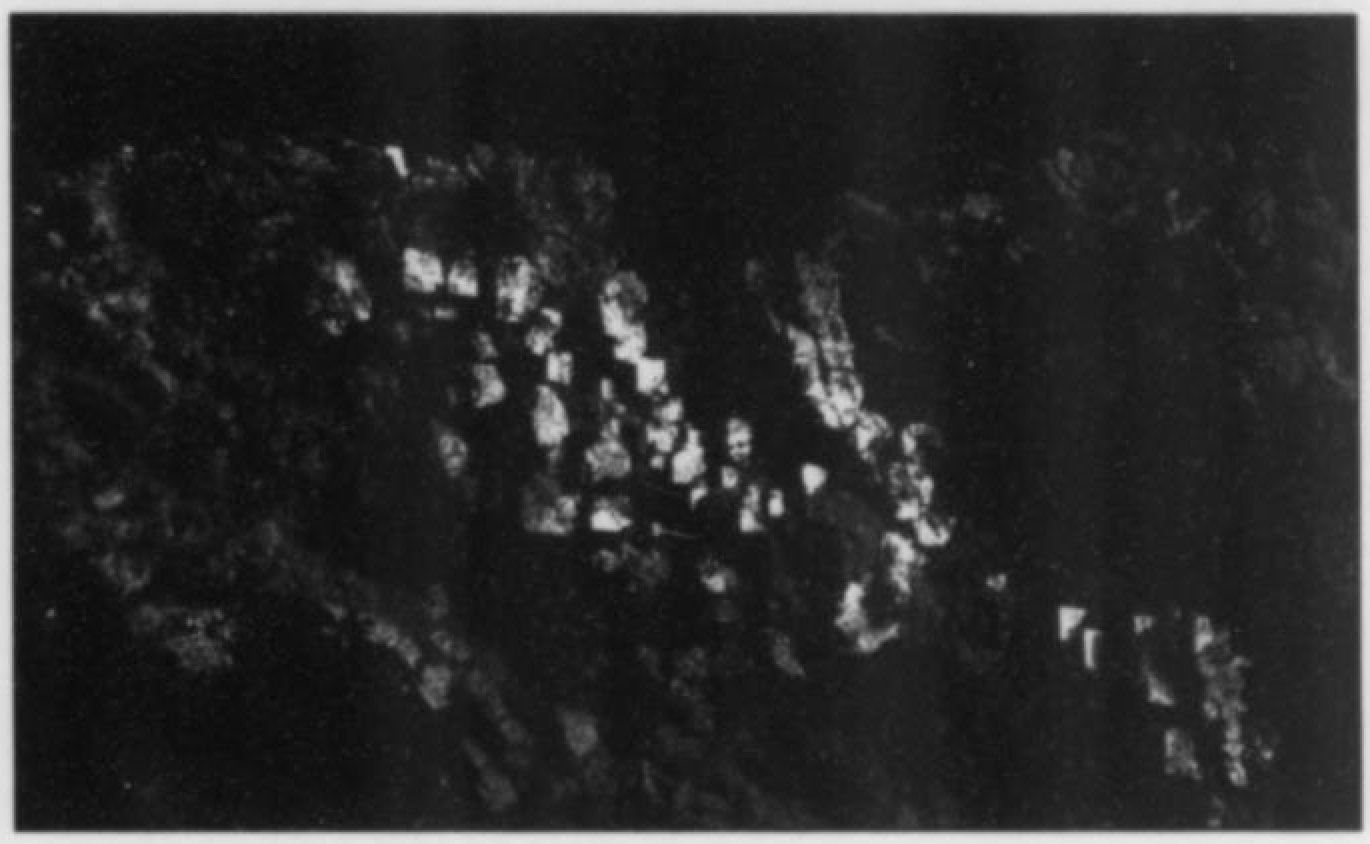


Figure 11. **Silver in 1-mm parallel crystals. Author's collection and photo.**

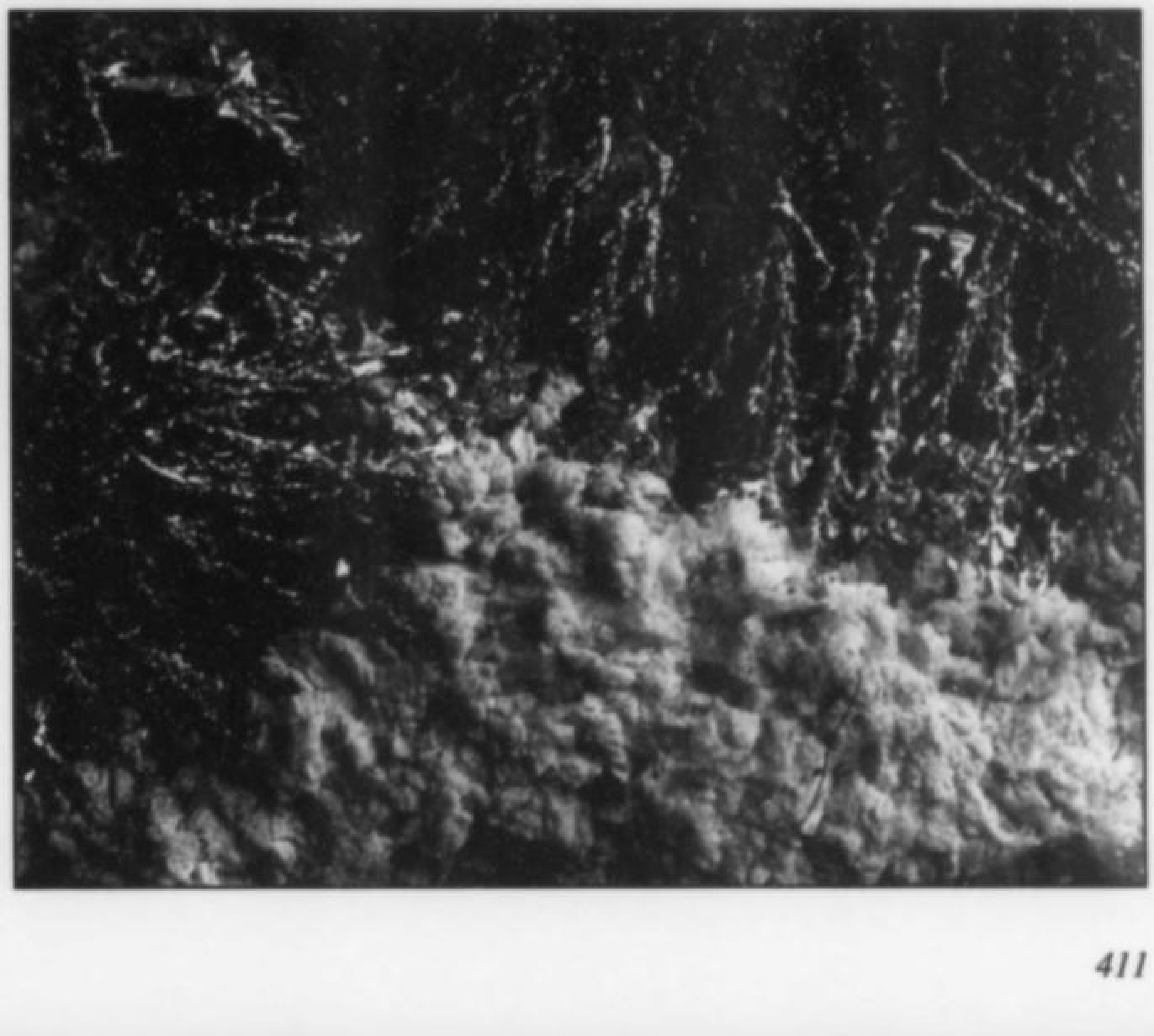


Figure 13. **Silver in mossy dendritic growths to 4 mm on matrix. Author's collection and photo.**

***Figure 14.* Entrance to the main silver mine. Author's photo.**

distance beyond the site of the original bonanza. They also explored several other promising veins in the glen.

In spite of the extent of these endeavors only traces of silver were found; in addition, the workings kept flooding. It was resolved to drive a tunnel into the hillside lower down the glen to drain the upper workings. This had progressed only a short distance when the miners encountered what at first they took to be a second bonanza. A large mass of bright pink ore, "the colour of peach blossom," was found. A sample was sent to the eminent Scottish chemist Joseph Black who identified it as an ore of cobalt (Black, 1759).

Further samples were sent to a Mr. Nicholas Crisp in London who carried out many assays and described it as "a good cobalt ore" and said it was comparable to that obtained from the mines of Saxony—the main supplier at the time. "The Cobalt vein," he said, "contains very good lead, very good Copper and three different kinds or such of very good Cobalt" (Crisp, 1762). These ores all contained silver—up to "29 lb in the tonn Wt." (Crisp, 1761a) and this silver in turn contained "Gold in some considerable quantity" (Crisp, 1761b). This ore was extracted and sold to a company near Edinburgh who used it to produce a deep blue color on porcelain.

After Charles' death in 1763, the estate passed to his second son James, Lord Alva. (The first son, Charles, had been killed when he jumped out of a window in London while delirious with a fever.) James continued working the mines and, when it was observed that the waste from Sir John's workings from about 40 years earlier also contained cobalt, he ordered this to be recovered. In 51 days of washing and picking the waste, two miners, John Weir and James Logan, filled seven casks with cobalt ore and recovered "a small box of silver" which "did not exceed a stone* weight." For this work they were paid two pounds and eleven shillings (Anonymous, 1766).

As with the silver, the cobalt deposit was soon exhausted. The work was continued for a considerable distance beyond the site of the discovery but no more was found. The company was also running into financial trouble. One of the partners, Sir Henry Erskine, died in 1765 and another, Mr. Crisp, despite his initial enthusiasm, stopped paying his contributions. In 1768 another shareholder, John Stephenson of Hull, wrote to Lord Alva, "It has been great concern to me to find our Cobalt company decline to nothing" (Stephenson, 1768) and later another partner, Leith merchant Alexander Shirreff, pulled out. By now incurring a substantial loss, the mines were abandoned again.

In the 1770's, Lord Alva sold the estate to the immensely wealthy John Johnstone. His family made many improvements to the estate but did not attempt to reopen the mines. The Johnstone line ended with Miss Carolin Johnstone, who died in 1920. Unfortunately she overspent and when she died the sale of the house contents and the estate was insufficient to clear her debts. Sadly the huge house could not be sold and was demolished during the Second World War.

GEOLOGY AND GEOGRAPHY

The Ochils are a range of hills composed of Devonian andesitic lavas, tuffs and agglomerates running eastward from Stirling into north Fife, central Scotland. Their southern flank is bounded by a steep fault scarp—the Ochil Fault—to the south of which lie flat Carboniferous coal-bearing strata. Several quartz-dolerite dikes were intruded into the plane of the Ochil Fault in late Carboniferous times (Francis *et al.*, 1970).

The western end of the Ochils has a long history of trial mines, mostly for copper, driven into barite veins along the steep south-facing fault scarp. The eastern extremity, in Fife, is famed for its abundance of fine agates. Alluvial gold and cinnabar are widespread, especially in the central area around Glendevon.

At Alva the silver occurred in a northeast-trending vein on the west bank (not the east bank as incorrectly stated by previous authors such as Francis *et al.*, 1970; Dickie and Forster, 1974; Hall *et al.*, 1982; and Parnell, 1988) of a small stream—the Silver Burn—in the Silver Glen, on the steep southern flank of the Ochils and about a kilometer east of Alva. The vein is hosted by an andesitic lava and is about 130 meters north of a quartz-dolerite intrusion along the Ochil Fault.

MINERALOGY

Virtually the only silver mineral present is the native metal. Electron microprobe investigations have detected minute grains of an unnamed Ag-Bi-selenide (Parnell, 1988). Associated primary metallic ores are massive and disseminated cobalt and nickel arsenides (mostly clinosafflorite and rammelsbergite, identified by X-ray diffraction and electron microprobe analysis) and copper sulfides (mostly chalcocite) in a gangue of dolomite, coarse tabular barite and calcite. These are currently the subject of research at the University of Edinburgh and Manchester Museum; full details will be published in due course. Oxidation in the dump has produced stains and efflorescences of erythrite, tyrolite, annabergite, malachite and, rarely, conichalcite and picropharmacolite. Of all these

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*A "stone" was equivalent to 14 pounds.

only the silver has been found as specimens of interest to the collector, although the clinosafflorite, being an extremely rare mineral, also merits a description.

Clinosafflorite (Co,Fe,Ni)As$_2$

The principal primary cobalt arsenide mineral present in the silver mine dump is clinosafflorite. This rare, monoclinic polymorph of safflorite (CoAs$_2$) is known from only a few other locations worldwide: the Nord mine, Sweden (Burke and Zakrzewski, 1983), several deposits in the Bou Azzer region, Morocco (Vinogradova *et al.*, 1980) and the type locality, Cobalt, Ontario (Radcliffe and Berry, 1971). At Alva it occurs disseminated and massive in dolomite/barite gangue as irregular, metallic gray masses superficially altered to erythrite and sometimes exhibiting coloform and stellate habits. It commonly encrusts silver and sometimes shows evidence of fracturing and shattering, presumably due to movement along the fault.

Silver Ag

The silver is almost invariably well-crystallized, nearly always as dendrites, typically 2 to 5 mm long but in some cases up to 3 cm. An 18th-century specimen in the Hunterian Museum, Glasgow (specimen M953), has dendrites to 4 cm. The dendrites branch at 90° and are commonly terminated by four-sided pyramids, but also rarely by flat squares or rectangles. Cubes to 1 mm and branching mossy forms also occur occasionally but only one tiny specimen of filiform silver like that from the famous Kongsberg mines has been found, with curved wires to 0.75 mm long and 0.15 mm thick over an area of about 3 square millimeters.

The matrix is usually dolomite, sometimes barite, rarely calcite. Clinosafflorite commonly encrusts the silver. A peculiar feature of some specimens is the presence of dendritic patterns in matrix occurring parallel to or in alignment with silver dendrites and occasionally containing corroded relict silver. These represent areas where the silver has been dissolved and replaced by matrix. Energy-dispersive analysis of these detects only Co, As, Fe and Ca.

The accompanying photographs have been selected to show the range of habits that occur. Matrix has been removed with acid to reveal the silver. (Orthophosphoric acid is preferred for this purpose because stronger acids liberate hydrogen sulfide which blackens the silver.) When found, specimens are normally erythrite-stained with only the shiny tips of silver dendrites visible.

CURRENT SITUATION

Recent excavations in the mine dump have yielded scores of small (and a few large, up to 100 grams) specimens of silver-bearing ore from a small area which appears to have escaped being reworked by the cobalt miners. These excavations culminated in a four-day dig in May 1994 by the Royal Museum of Scotland using a mechanical digger and washing in a sluice the richest portions of the dump. During this time around 20 to 30 specimens of silver were recovered.

Specimens nowadays are virtually unobtainable, the small silver-bearing part of the dump having been systematically excavated and exhausted. The site is now owned by the Woodland Trust and the grounds of Alva House are now the Ochil Hills Woodland Park. A footpath leads from the park to the Silver Glen. Little do walkers on this path suspect, as they cross the stream, that just a few meters under their feet once lay the richest bonanza of native silver ever found in Britain.

ACKNOWLEDGMENTS

The author is greatly indebted to the following without whom this article would not have been possible: The Forestry Commission and the Woodland Trust, former and current owners respectively of the mine site, for permission to collect samples; staff at the National Library of Scotland, Edinburgh, and the Scottish Records Office and Public Records Office, in Edinburgh and Kew respectively, for assistance with historical research; Mike Rothwell, Unilever Research, for energy dispersive analyses; A. Livingstone, Royal Museum of Scotland, Peder Aspen, University of Edinburgh, and Amanda Edwards, Manchester University for mineralogical identifications; George Ryback, Sittingbourne for help with the map; Dave Green, Manchester Museum and Ken MacKay, Cambusbarron, for photography; and Dave Green for helpful comments during the preparation of the manuscript.

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[Abbreviations: f. = folio; MSS = Manuscripts; NLS = National Library of Scotland; PRO = Public Records Office, Kew; SRO = Scottish Records Office.]

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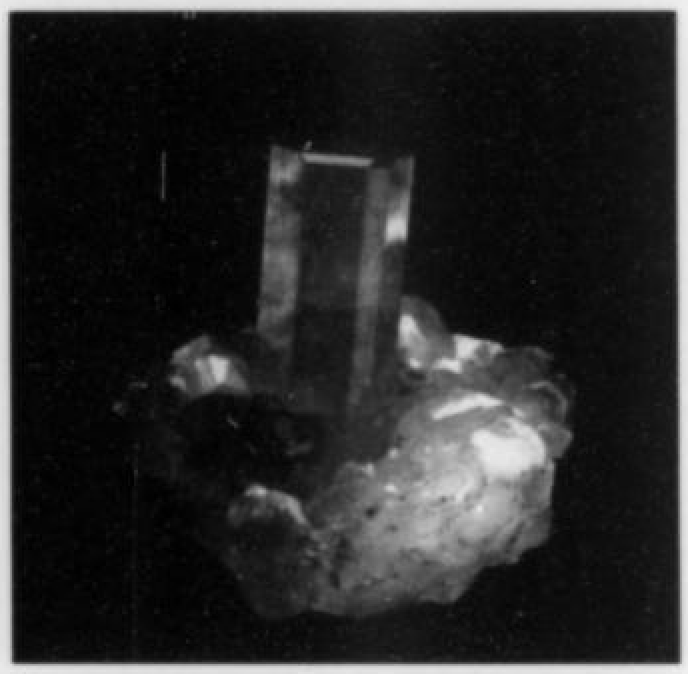

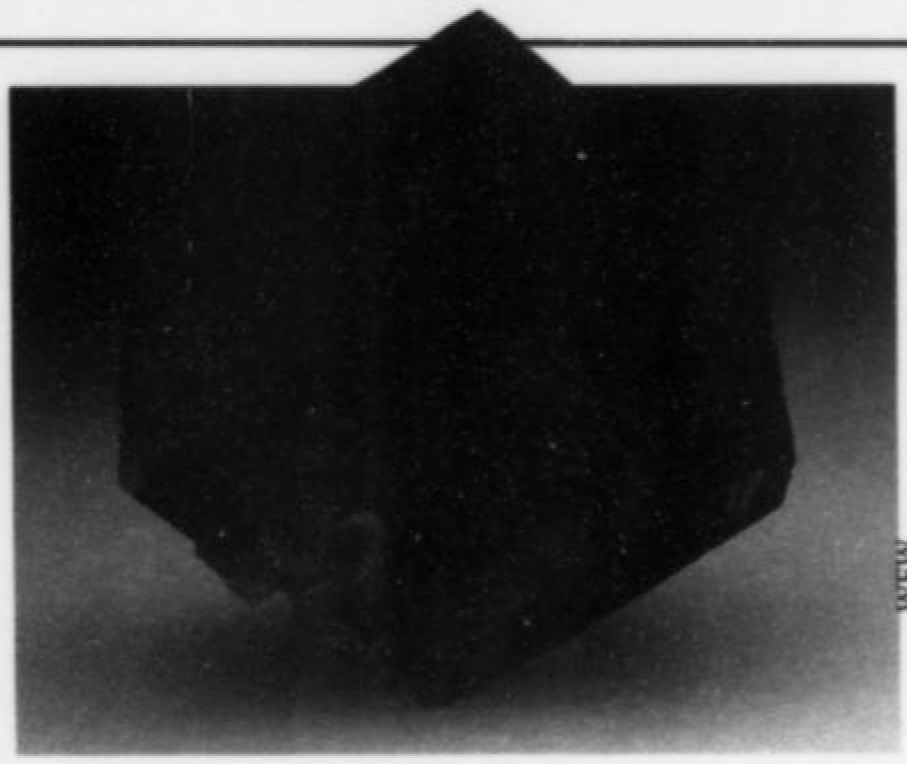

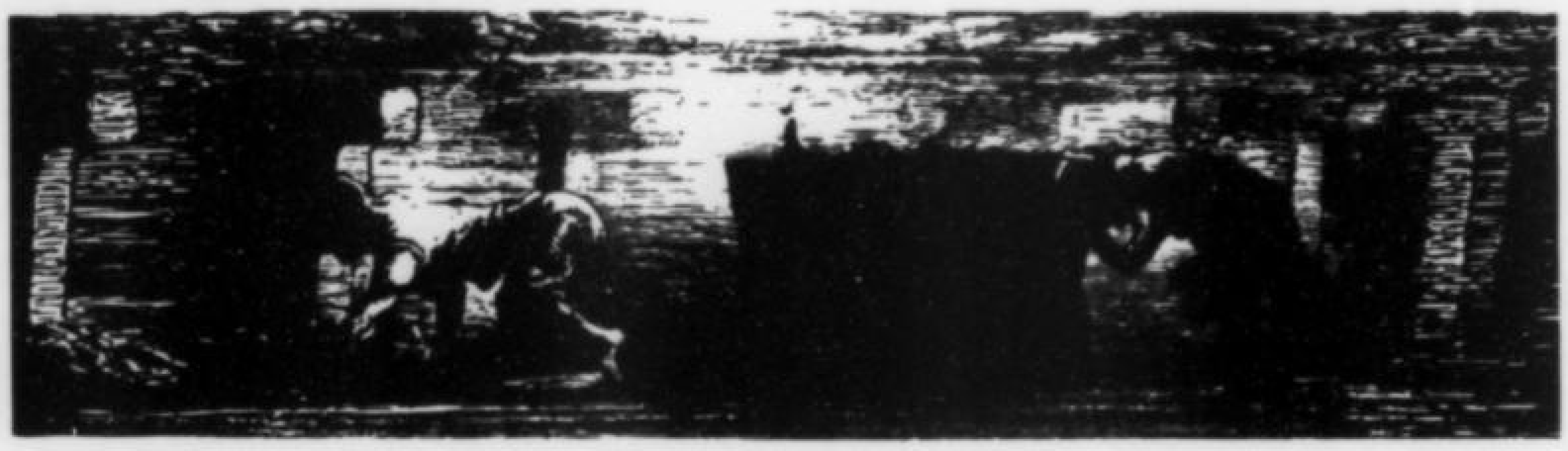

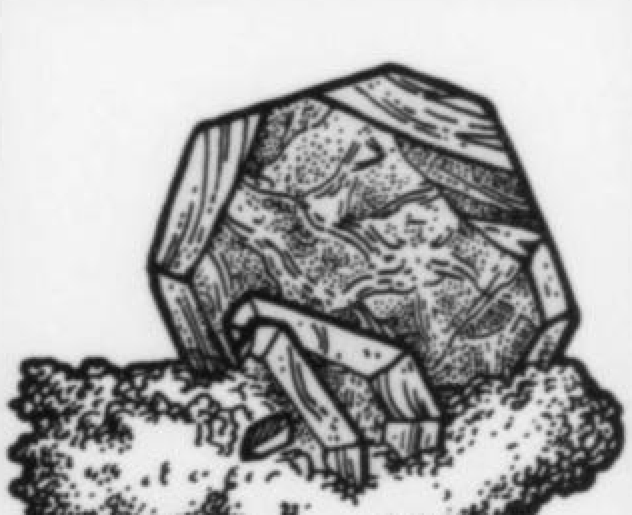

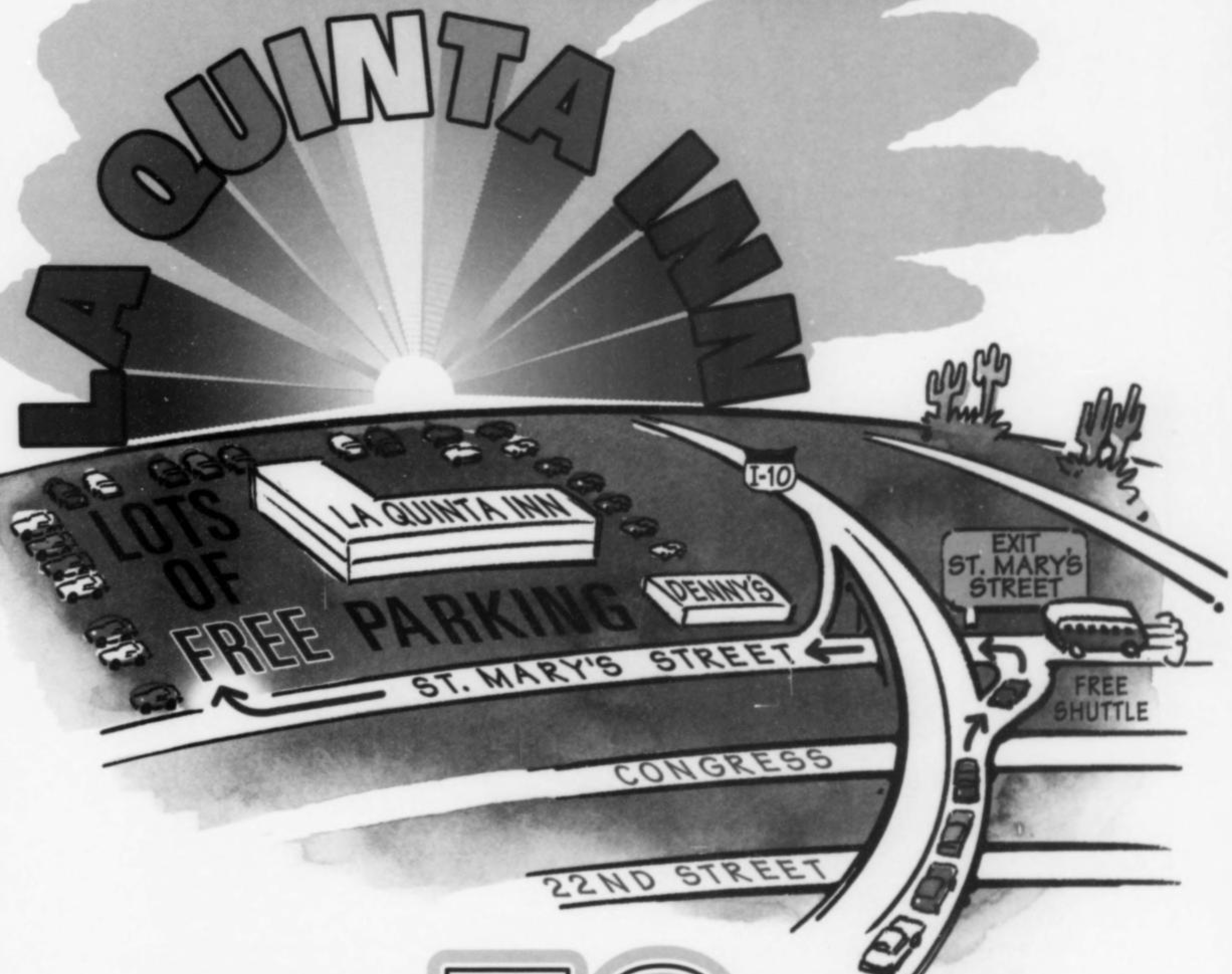
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THE KRUISRIVIER COBALT MINE

●

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Roodepoort 1709, South Africa

There are several small cobalt deposits in South Africa, but only one, Kruisrivier, has been worked commercially and solely for its cobalt content. The mine has produced some excellent specimens of erythrite and heterogenite, and also the first arsenolite and picropharmacolite reported from South Africa.

INTRODUCTION

The little-known Kruisrivier mine was thought to have been discovered around 1868, but research for this article has shown that much of the published history is inaccurate. In compiling the history a number of conflicting dates in the published literature were encountered, as well as new evidence (from the State Archives) on the discovery of the mine.

Several people have written papers on the geology of the Kruisrivier area, and some have mentioned the mineral content of the vein. However, nothing appears to have been written describing all of the known minerals from the mine, or the mine itself, or its history. To remedy this situation, I have compiled data from a variety of published and unpublished sources, and have combined the information with my own knowledge of the mine and its minerals.

The mine is named Kruis River in a number of the references, however, for the purposes of uniformity with modern references, it will be referred to here as Kruisrivier.

LOCATION

The mine is located about 180 km northwest of Johannesburg, on the Kruisrivier farm (farm no. 74 JS), from which the mine takes its name. It is situated high on the northern slope of a hill overlooking the Selons River Valley near Loskop Dam. Access is via a road from Dennilton near Groblersdal to just below the dam wall. A dirt road is then followed for about 6 km until reaching a farm gate; it is then a case of driving through thick bush country on a rough track for a further 3 km to reach the mine and its dumps.

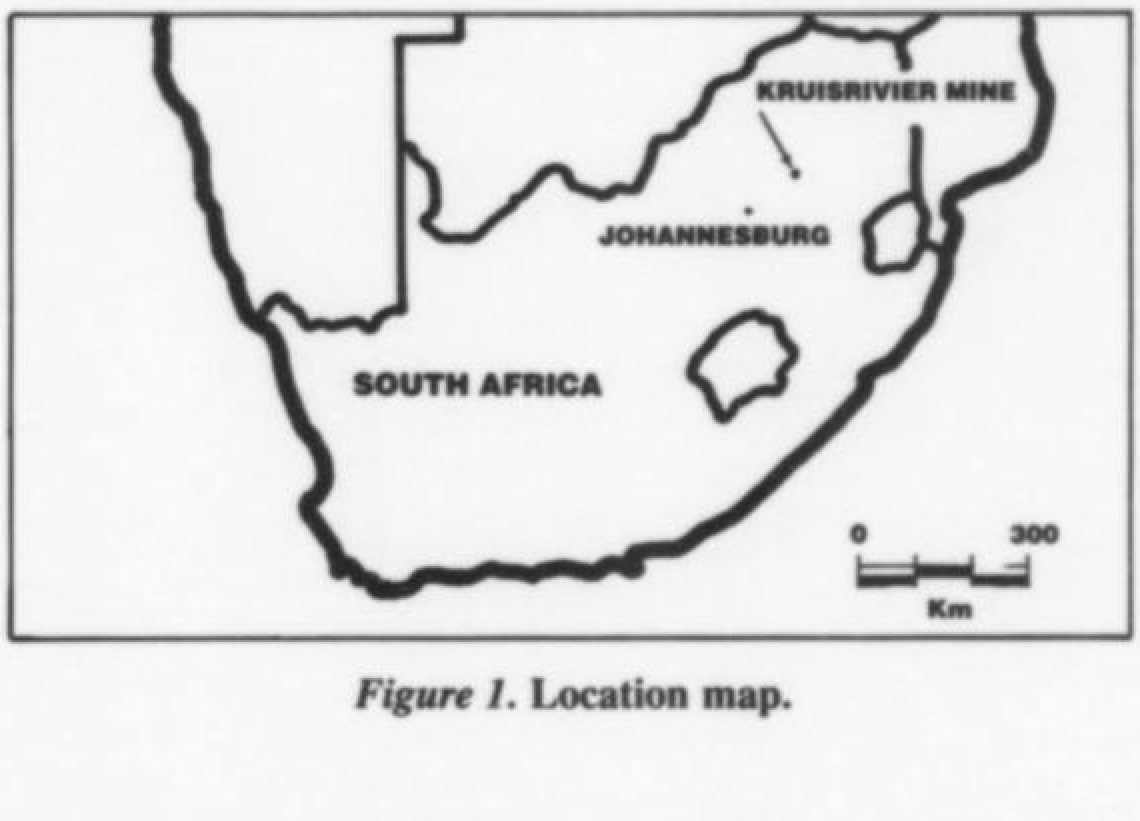

Figure 1. **Location map.**

Figure 2. **General view of the Selons and Kruis River Valleys. Graham Reeks photo.**

HISTORY

Cobalt was one of the first metals to be mined in the Transvaal, although never in substantial quantities. Since 1931 no mine has been worked primarily for cobalt ores. The relatively small quantities of cobalt concentrates produced from South Africa since 1931 have been as a by-product of gold production from certain mines on the Witwatersrand.

The dates of discovery of the Kruisrivier deposit, when mining started, and when it ceased are difficult to ascertain with any certainty. For the purpose of providing as accurate a history as possible, the sources that differ will be quoted and the probability of their accuracy evaluated.

Many of the references to Kruisrivier state that the discovery of cobalt minerals may have been made, or at least confirmed, by a German schoolmaster named Karl Gottlieb Mauch. Mauch, who had a passion for exploration and geology, arrived in South Africa in January of 1865 and started his explorations in 1866. For four years he traveled through the Transvaal. He made four extensive tours during his time in Southern Africa. From 1869 to 1872 he traveled around the Transvaal and up into present day Zimbabwe, his route certainly taking him to the Kruisrivier area. His journal entry for the 17th to the 20th of May 1871 mentions a number of "mines." The description of these mines correlates with known deposits, and one of them matches Kruisrivier. Quoting from the journal:

> At C. Vermaak's farm—(waiting for the arrival of a wagon)
>
> I undertook some small excursions which, because of the short days, were short too. During these I noticed that the mountain range between the Salon and Malco's river is a very interesting one and rich in ore. To begin with I visited an abandoned copper mine in these mountains, that is, one on the southern slope about 4 miles to the East [of Vermaak's farm]. High trees with dark green leaves in the caved-in hollow point it out from afar. It is situated about 200 feet above the bottom of the valley and has been worked in a WNW direction. [This mine is known to have been worked by ancient copper miners, probably during the 13th to 15th century. Mauch continues:] In climbing the mountain one has to scramble over diorite rock up to two-thirds of its height, from where one meets a white quartzitic sandstone which is disturbed in its lie by the former and which, after striking from East to West, turns considerably, towards North. [This agrees with the modern geological map of the area.] About a mile WNW of Vermaak's there is another mine in the same range, and the lovely rash on the rocks shows cobalt bloom, and an attempt with the hammer produces cobaltite. This shallow shaft was started about 150 ft. above the bottom of the valley. Several parallel, clearly visible layers of quartz run at a short distance from one another in an ENE direction between the otherwise hardly visible rock, the quartzite I was sorry to be unable to retrieve some of the rock containing ore from any depth, as I suspect the presence of silver here. I would have been content with only a few specimens.

What this account appears to tell us is that he discovered another "ancient miner digging" which is now referred to as the Kruisrivier cobalt mine and that for some reason he was not able to obtain samples from depth. He was the first to produce a map of the geology of part of the Transvaal.

In an extract of his report on Kruisrivier, Dudgeon (1929) states:

> Apparently the first discovery of cobalt minerals was made by a German, Carl von Maunch, about the year 1875–76, who opened up the mine on "Kruis River" farm, and who mined, collected and sent away hand picked ore by wagon to Durban, a distance of approximately 600 miles. He is said to have thus dispatched about 158 tons which realised £25,010. This hand picked ore is said (Struben) to have averaged 15.34% metallic cobalt. The mine was then closed on account of the Secocoeni wars, and was never reopened.

The problem with this account is that Mauch had left South Africa by the end of 1872 and died in Germany on April 4, 1875 (Bulpin, 1989). Mauch wrote a book (*Reisen im Inneren von Süd Afrika 1865–72*) on his travels in Southern Africa which was published in Germany in 1874. No mention of Kruisrivier or cobalt ores is made in this book. His journals were published in 1969 and they quite clearly state that he did not mine any ores in the Kruisrivier area.

Dunn in 1877 wrote in reference to Kruisrivier that "More than 100 tons of ore have been sent to London." In the Geological Survey of South Africa's publication, *Mineral Resources,* all editions mention that "In 1886, 158 tons of hand picked ore, averaging 15.34 metallic cobalt and 68 grammes of gold to the ton was exported." De Villiers (1959) quotes almost the same statement word for word. In none of the other references does it mention the shipment of ore, quantity, or when it was shipped. Despite extensive research on the literature I have found no original source for the "1886" quote.

Dudgeon's statement clashes with Dunn's statement above, which was written about 1876–1877. Dudgeon's is the earliest reference found that mentions the tonnage and grade of ore shipped, and it seems quite likely that it was the source for the Geological Survey and de Villiers. Dudgeon's source appears to have been a report by Struben dated 1894, no trace of which has been found. Assuming that the tonnage shipped is correct, to mine that quantity of pure solid ore including the development work, would have taken a number of years. Shipment by ox wagon would also have required many months or years if one assumes that the capacity of the ox wagon was probably only 2–3 tons per wagon.

That the mine was eventually closed down due to the Sekhukhune tribal wars seems very reasonable, considering that the mine was located close to the boundaries of Chief Sekhukhune's domain. The war was a fairly protracted one, lasting from approximately April 1876 to November 1879. The mine is shown on a map produced by Merensky in 1875 which, in turn, had been adapted from a map produced by Fred Jeppe in 1868. Jeppe's map does not make reference to Kruisrivier or a cobalt mine, although it does show other mines (e.g. copper and lead).

Oehmichen (1899) states that: "a company was formed at the end of the 1870's, to mine the ore body, but due to the Anglo-Boer war (1880–81) it only had a life span of a few years." Praagh (1906) mentions that a Mr. Percy Whitehead carried on mining operations in 1885 and for several years subsequently, exporting a considerable quantity of cobalt, until the market was glutted.

In a search for information on Percy Whitehead at The State Archives in Pretoria, letters from him to the State President of the then Zuid Afrikaansche Republiek were discovered, along with some replies from the office of the State Secretary. One letter is of significant importance, however, as it appears to discredit the previous theory that Mauch discovered the mine or that he even visited it as a working mine. The letter is dated December 8, 1873, and requests Government permission to prospect and mine for precious and non-precious minerals on the Kruisrivier farm. The letter included deeds of ownership of the farm by the South African Republic Mining Company Ltd. of whom Percy Whitehead was the general manager. Attached to the original letter was a report on an analysis carried out in England of the ores found on the farm, and the Articles of Incorporation of the mining company in England.

In another letter by Whitehead, also dated December 1874, he asks for special rights and privileges to be granted to him as the discoverer of the mineral deposit on the Kruisrivier farm. The subsequent replies gave Whitehead permission to mine, and his discoverer's rights on the property. Further correspondence in 1875 asks for his company to be registered in the Republic, and this was completed in the same year.

It is my belief that the mine was not in existence when Mauch traveled through the area in 1871, and that the orebody was in fact discovered by Whitehead around 1872–1873. The mine was almost certainly operational until it was closed in the mid-1870's due to the Sehkukhune wars. It is believed that Dunn's reference to the "More than 100 tons of ore being shipped to London" refers to this period of mining. Oehmichen (1899) mentions that it was opened again in the late 1870's, but due to the Anglo-Boer war [the first war of 1880–1881], it only had a life span of a few years. If it was re-opened it most probably would have been around 1879 when the Sehkukhune war was drawing to a close.

The reference to the carrying on of mining operations in 1885 by Percy Whitehead for several years ties in with the statement used by the Survey that ore was shipped in 1886. In conclusion, it is my opinion that there were two periods of ore shipment in the nineteenth century: namely in the early 1870's and around 1886.

In 1897 a German mining engineer, D. Dorffel, started further prospecting and discovered another gold-bearing cobalt vein on the adjoining Laargersdrift farm. He also "resuscitated" the old Kruisrivier workings, but no records exist suggesting that he actually produced any ore at that time.

Although reopening was strongly advised by H. Struben in 1894, by Dorffel in 1897 and again by G. A. Troye in 1905, it remained closed until 1929. After several surveys, the most notable being that of W. F. H. Dudgeon in 1929, a small private company, *Cobalt (Pty.) Ltd.*, was formed in the beginning of 1929 to reopen the mine. They erected a small plant and produced three tons of ore averaging 16.67% metallic cobalt; 1 ton of sorted ore averaged 20% metallic cobalt. When the operation closed down is not clear, but it must have been around 1930. Although Dudgeon mentions the advice to open the mine by the three above, all attempts to trace any of the reports including Dudgeon's has proven unsuccessful.

In 1931 the annual general meeting of Henderson's Transvaal Estates Ltd. Refers to prospecting operations being carried out by a subsidiary concern, Mineral Holdings, Ltd., upon the Kruisrivier cobalt mine. The report states:

> A borehole has been sunk which has proved the continuation of the deposit at a vertical depth of 281 feet. In consequence of this the old incline shaft has been cleaned out and driving has been resumed at those points of the deepest level where operations were discontinued many years ago. All the new work done is said to have exposed ore of varying values. During the last two months before the meeting some 50 tons of development ore was brought to the surface, which was estimated to contain 2% cobalt per ton, besides which gold values had not been ascertained.

Once again the date of closing is not known, but it seems that the new operation was short-lived because the final prospecting results showed insufficient reserves of ore to cover mining costs.

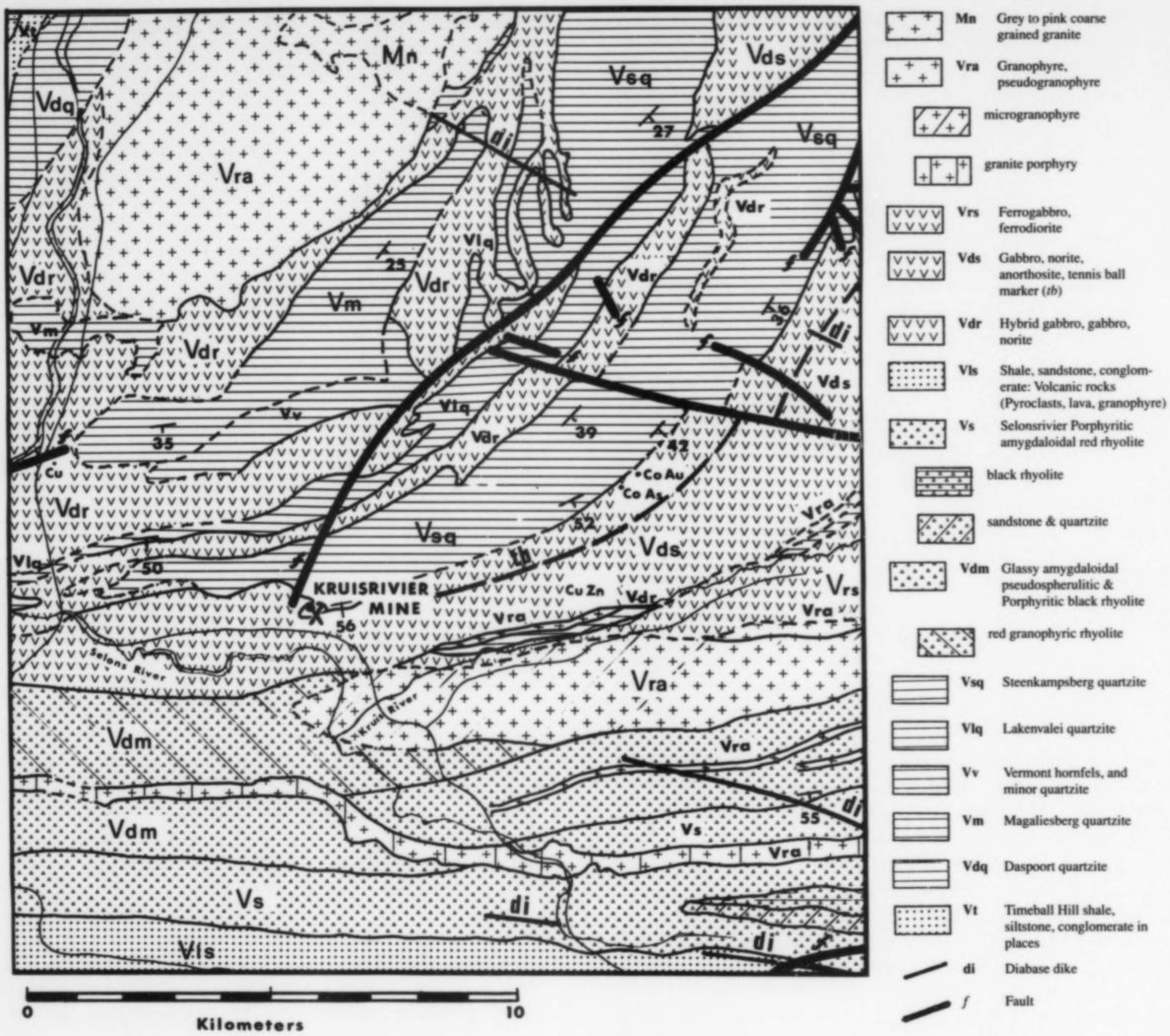

Figure 3. **Geological map of the area around the Kruisrivier cobalt mine (after South African Geological Survey, von Gruenewalt and Schwellnus).**

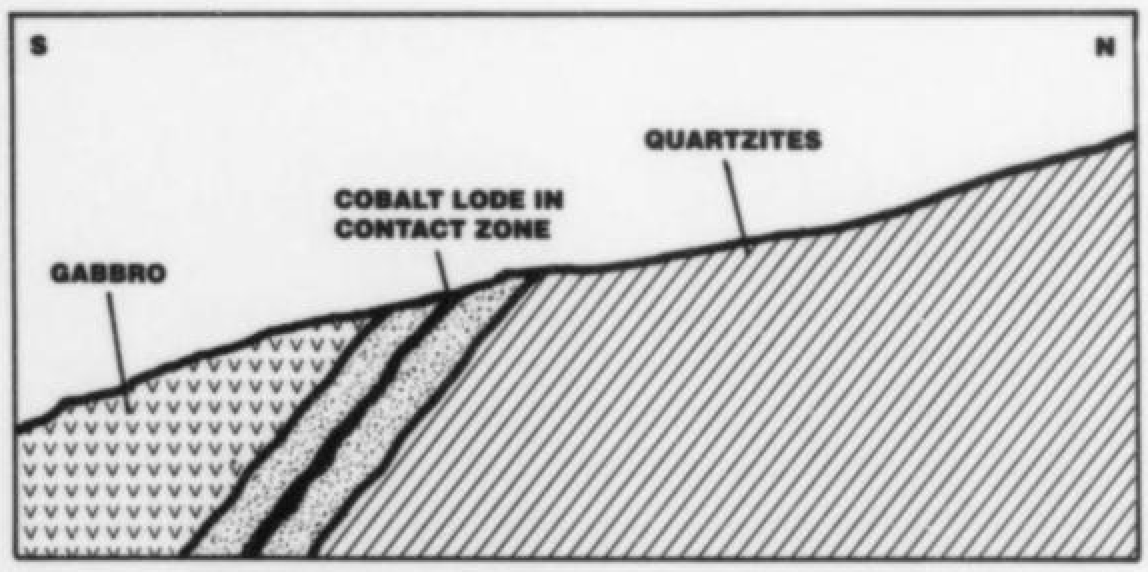

Figure 4. **Section across the Kruisrivier cobalt lode (after Mellor 1906).**

In a footnote in Molengraaff's book on Transvaal geology (1904) he states that information was given to him by Mr. Dorffel, engineer to Henderson's Transvaal Estates, Ltd., a company owning all of the deposits of cobalt discovered up to that time in the Transvaal. So far all attempts to gain more information on Henderson's Transvaal Estates and their connection with Kruisrivier have proved fruitless.

In 1938, D. L. Sholtz reinvestigated the possibilities of the area, and his results seemed encouraging. In 1940, the South African Geological Survey did more work on cobalt occurrences, especially that of Kruisrivier. However, geophysical and geological surveying followed by surface trenching and tunneling failed to reveal any further economic deposits of ore.

GEOLOGY

The geology of the mine and adjoining area has been described by Oehmichen (1899), Beck (1907), Mellor (1906 and 1907), Lombaard (1931), and briefly by Dunn in 1877. The area includes a portion of a small norite protuberance on the eastern rim of the Bushveld Complex. Several xenolithic bodies of Pretoria group quartzite and shale occur; the largest and most southerly of these masses dips at an angle of 50° to 60° towards the south.

Much discussion has taken place in the past as to just what the country rock is. Dunn (1877) described the rock in which the cobalt ores occur as a very fine-grained felsite. Beck (1907) described the country rock not as a quartzite, but as a quartz-feldspar rock with the feldspars largely altered to sericitic mica, however he was not against it being called an aplite. Mellor (1906) described the cobalt lode in great detail, stating that the country rock is an altered felspathic sandstone or quartzite and that it was altered and partially recrystallized by contact with the extensive basic igneous body overlying it (see Fig. 4).

To the north of the Kruis River and Selons River Valleys is a high ridge rising some 151 meters. The ridge consists of mostly yellowish or pinkish white medium-grained quartzites dipping 50° to the south. They are the uppermost of a series of quartzites that are at least 60 meters thick. Several such parallel ridges of quartzite occur, with intervening valleys almost completely occupied by extensive intrusions of diabasic rocks. The floor of the valley of the two rivers is formed by the lower portion of a very large intrusion of basic igneous rock which overlies the upper quartzites. Where the igneous rock is exposed its texture is very coarse and it is composed of pale gray plagioclase feldspar, greenish black augite and a small amount of magnetite. Mellor describes this rock as a gabbro. Close to the contact with the quartzites the igneous rock becomes much finer in texture and also has a darker gray color. Mellor describes this as a dolerite.

The vein of cobalt ore is positioned approximately 60 cm from the junction plane, and parallel to it and to the bedding planes of the quartzite. On either side of the vein for 4 to 6 cm the quartzite is very fine-grained with a reduction in the number of quartz grains and an increase in the quantity of felspathic material, which shows good crystalline outlines closest to the vein. Smaltite is seen as single cuboctahedral crystals growing in this fine-grained rock to either side of the vein, with a gradation of largest to smallest crystals, and the quantity being largest and highest close to the vein.

Lombaard (1931) states that the ore occurs in veins at the contact of the quartzite and a diabase or a fine-grained norite. The quartzite he refers to is one of several bands lying in the norite, and has been described by some authors as an aplite, which only emphasizes the intensity of the metamorphism to which these rocks have been subjected.

The vein is well-defined at about 50 cm from the junction plane; it consists of solid cobalt arsenide ore about 1 cm thick. The survey carried out in 1940 proved that the orebody has no appreciable depth or lateral extent. Hydrothermal solutions originating in the gabbro were responsible for the mineralization at Kruisrivier and adjoining localities. In discussions with Dr. Hammerbeck of the South African Geological Survey, he suggested that it would be more correct to define the contact rock as a fine-grained gabbro.

THE MINE WORKINGS

I have only found one reference describing the actual workings, namely that of Dudgeon (1929). The reef has a general northeasterly strike and dips at an angle of 60°. The outcropping ore of erythrite and heterogenite was apparently stoped out over a length of approximately 120 meters to an average width of 1.1 meters, although in places up to 4 meters was taken out. In Dudgeon's report he refers to Dorffel's report of 1894,* stating that the reef can be traced on the surface for up to 182 meters.

At the southwest end of the outcrop, an inclined shaft was sunk on a dip of the reef, i.e. at 60°, but at the same time pitching northeastwards and diagonally downwards at an angle of 35°. A drive at about 9 meters down represents the southern end of the first level, which as it traverses northeastwards, owing to the surface contour, gains considerably in depth at the extreme north end of the drive and is probably at 18–20 meters. A surface shaft which is now collapsed originally connected with the northern end of the drive. About 11 meters below the first level, a second level was driven for about 136 meters. The section between the two levels was largely stoped out, with the exception of a few supporting pillars. Apart from a small vertical shaft on the second level, nothing was apparently done below the second level. A vertical shaft was sunk to a depth of approximately 36 meters (Dorffel, 1897)* from the surface and a crosscut put in to connect with the second level. Both the shaft and crosscut have now caved and are inaccessible.

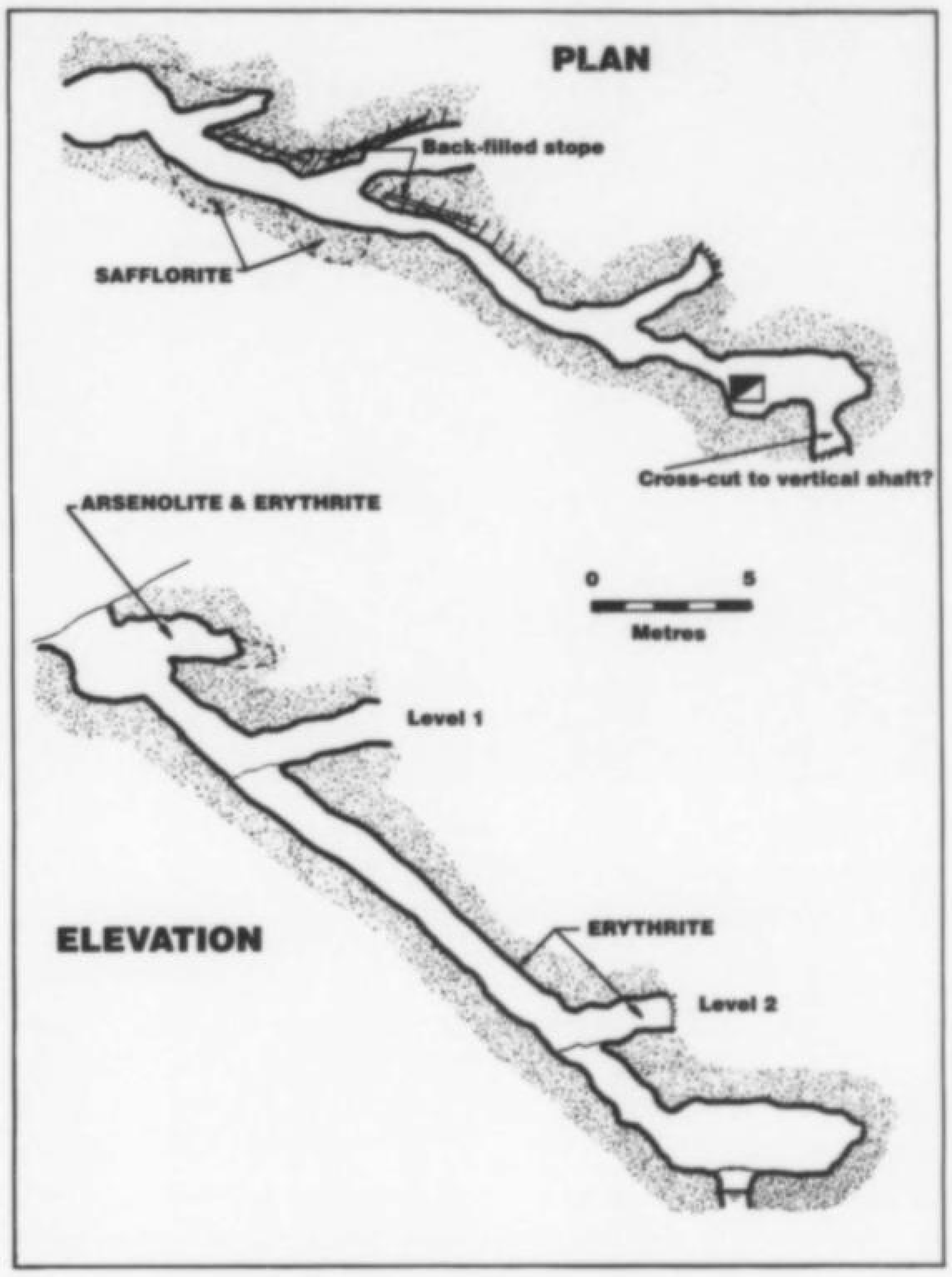

***Figure 5.* Sketch plan of the underground workings as they are accessible today.**

The sketch plans (Figs. 4 and 5) show the mine as it exists now. The first level can be entered for about 7 meters and it can be seen extending for about 5 meters further. The condition of timbering and pit props holding in back-filled stopes leaves much to be desired, and is extremely dangerous, so the full extent of level 1 is unknown.

The second level is usually under water. However, on a visit made in late 1979, the water level had dropped to such an extent that it was possible to fully explore the level. It is not extensive due to two rock falls, one blocking the main drive and the other blocking what is presumably the crosscut. A flooded vertical shaft exists but its depth is unknown.

On the surface, the dumps contain very little in the way of ore material, although some massive erythrite may be found. Many

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*Neither of the two reports by D. Dorffel (1894 and 1897) have been found; the only reference to them is made in Dudgeon's report of 1929.

Figure 6. **The main area of dumps on which one can find cobaltite and smaltite crystals as well as massive erythrite. Graham Reeks photo.**

small trial pits and a long surface trench can be seen on the hillside above the inclined shaft. A trial adit has been driven into the hillside for about 18 meters, but no mineralization can be seen. A large, rectangular hole 2 x 3 meters and about 6 meters deep can be seen on the surface. Based on its position relative to the inclined shaft, it is quite possible that this is the vertical shaft mentioned above that intersected with the second level.

No records have been found mentioning surface buildings. But close to the dumps several old concrete and brick foundations can be seen, and it is presumed that these were offices or houses of the mine.

The dumps, though large, consist mainly of gabbro and quartzite. In order to obtain good specimens of the minerals one has to go down the inclined shaft.

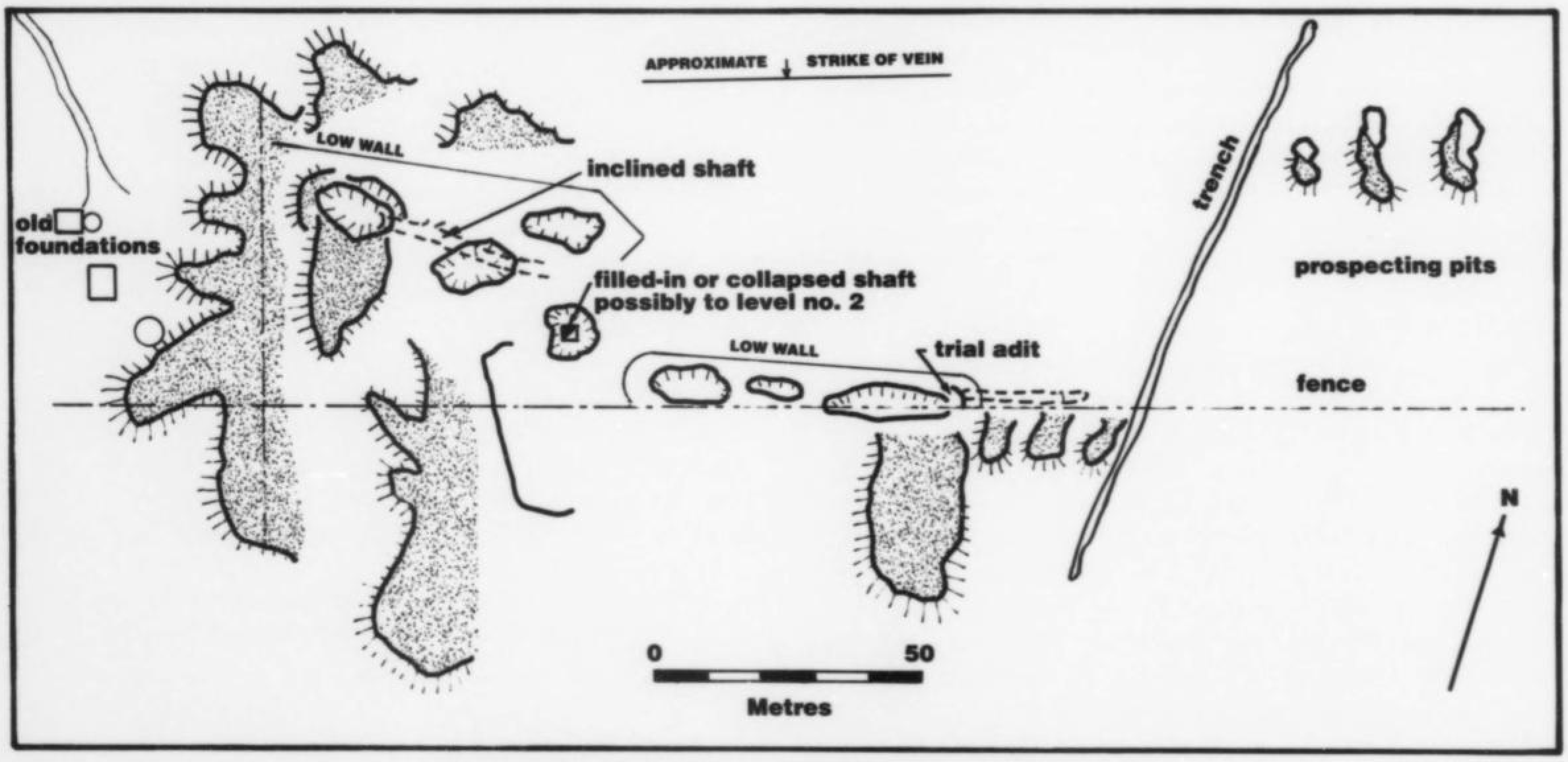


Figure 7. **Sketch plan of the surface workings of the mine.**

Figure 8. **Looking down the inclined shaft; note the fallen timbers and back-filled stope on the left. Graham Reeks photo.**

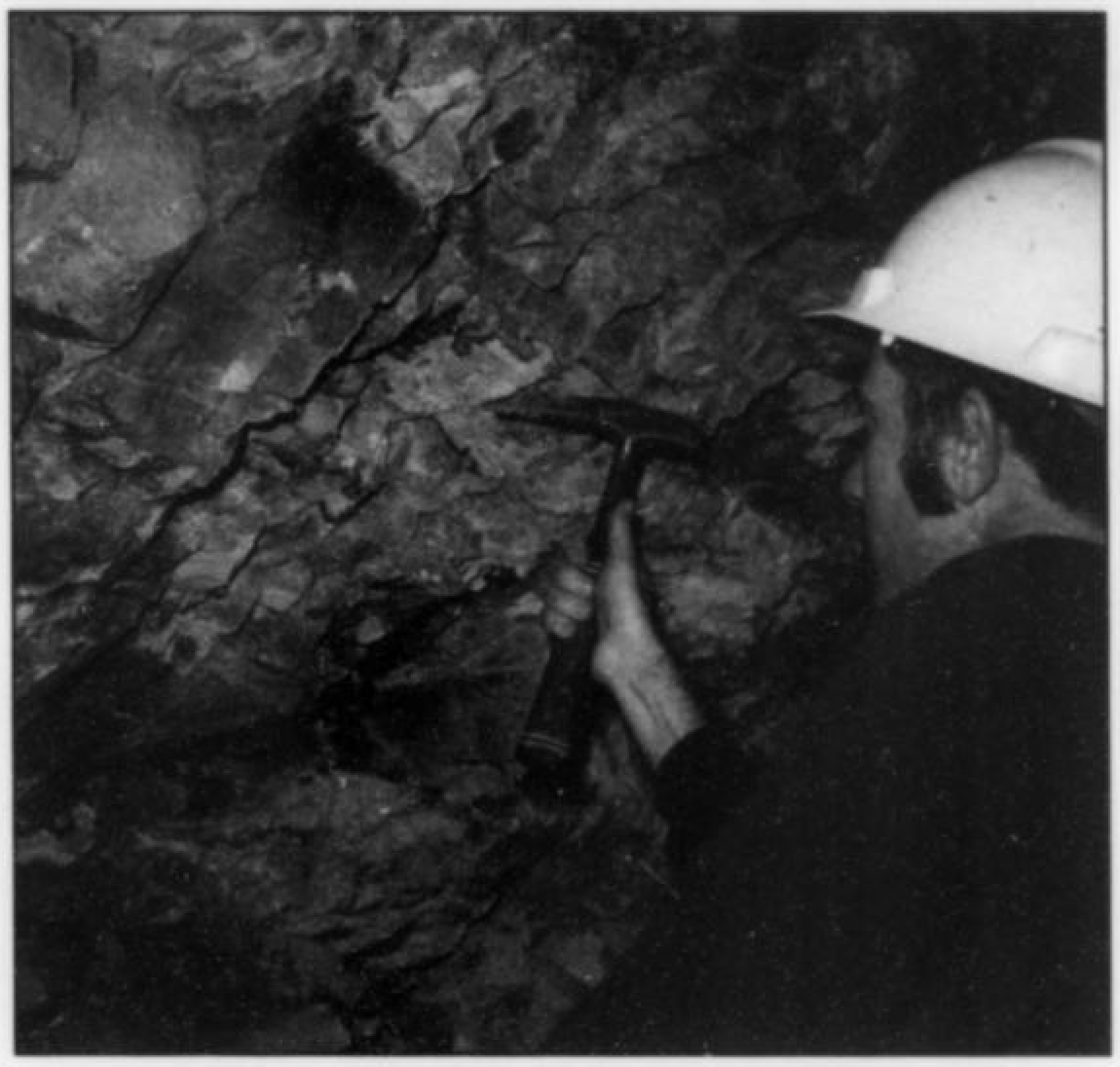


Figure 9. **Erythrite patches on the hanging wall of the inclined shaft. Graham Reeks photo.**

MINERALOGY

Minerals have been prospected or trials made on a small scale at a number of places around the Kruisrivier farm. There are sites where cobalt, gold, nickel, copper, chromium, zinc, lead, platinum, silver and arsenic have all been reported, with the first four being the most important. However, none of the occurrences except Kruisrivier has been judged economical to mine.

The inclined shaft follows the vein and two small stopes, where good samples of massive safflorite can be obtained. The norite is extremely hard, and this makes the removal of good specimens very difficult. Traces of erythrite can be seen everywhere, but pockets of good crystals are hard to find and even harder to remove intact. Most of the best specimens obtained have come from the hanging wall of the inclined shaft, where patches of sulfide were left during the mining operation. The stopes that were flooded were explored, and the best specimens of erythrite were removed from cracks or vugs between the norite and remnants of the sulfide ore veins. The largest specimen is a 15 x 25-cm slab covered with "puffball" erythrite. The mine is now sadly in an extremely dangerous condition for collecting specimens underground.

Figure 10. **Crystal drawing of arsenolite showing the commonly observed octahedron.**

Arsenolite As_2O_3

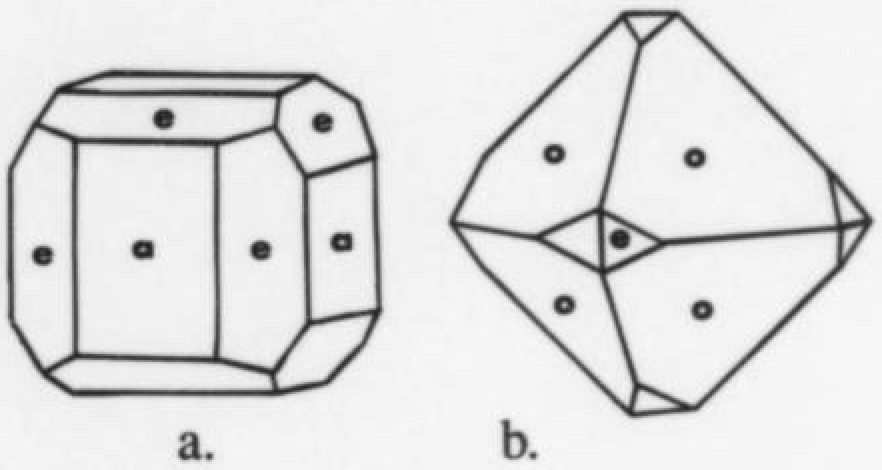
Some specimens of erythrite found close to the mouth of the inclined shaft, when viewed under the microscope at 70x magnification, were found to have very small, clear, colorless octahedra growing in and on the blades of erythrite. X-ray diffraction analyses have confirmed this to be the arsenic trioxide, arsenolite. To date only about 15 small specimens have been found. Figure 17 shows a crystal drawing of arsenolite in the typical form found at Kruisrivier.

Beryl $Be_3Al_2Si_6O_{18}$

Beryl was reported from the eastern end of the deposit by Dunn (1877). I have not, however, been able to confirm Dunn's finding.

Chalcopyrite $CuFeS_2$

Chalcopyrite is found sparingly in the contact zone, as patches within the norite and sometimes in the sulfide vein as well. No crystals have been found at Kruisrivier.



a. b.

Figure 11. **Crystal drawings of cobaltite. The cube *a*{001}, modified by the pyritohedron *e*{102} is generally more common in a very distorted habit. The octahedron *o*{111} modified by the pyritohedron *e*{102} is found as very clean microcrystals in the finely disseminated part of the vein.**

Cobaltite CoAsS

Cobaltite has been identified in close association with safflorite. Generally it is found as small grains or euhedral crystals at or very near the safflorite/norite interface. No crystals larger than 1 mm have been observed in any of the specimens. Figure 11 shows two crystal drawings of the forms found at Kruisrivier. Habit *a* is more typical in distorted interconnected granular masses, where occasionally a clean, undistorted crystal can be seen. Habit *b* is found rarely in the disseminated grains in the norite, and then usually as perfect, shiny crystals.

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

Erythrite is the main attraction at the mine, for mineral collectors. It occurs as lustrous, deep pink to purple bladed crystals growing along joint planes and in cracks and vugs close to the sulfide ore vein. It has also been found in cracks and vugs within the solid ore; generally the deeper purple crystals are found in such specimens. The crystals are terminated blades up to 6 mm long, although the average size is closer to 2 or 3 mm. Most crystals are oriented flat or parallel to the face of the matrix. Several different termination habits have been observed (see Fig. 12). The most common habits are *a* and *b*; habits *c* to *h* are rare. Habit *d* exhibits pyramidal modification by {111}. One specimen shows the habit *e*; such a habit has only the {101} and {$\bar{1}01$} faces on the termination. Habits *f* and *g* show the development of the {$\bar{1}20$} face. Habit *h* consists of the {001}, {100} and {110} forms modified by {130} faces—only two crystals of this habit have been found so far.

By far the most plentiful variety of erythrite is the so-called "cobalt bloom," which is actually a mass of velvety, pale pink

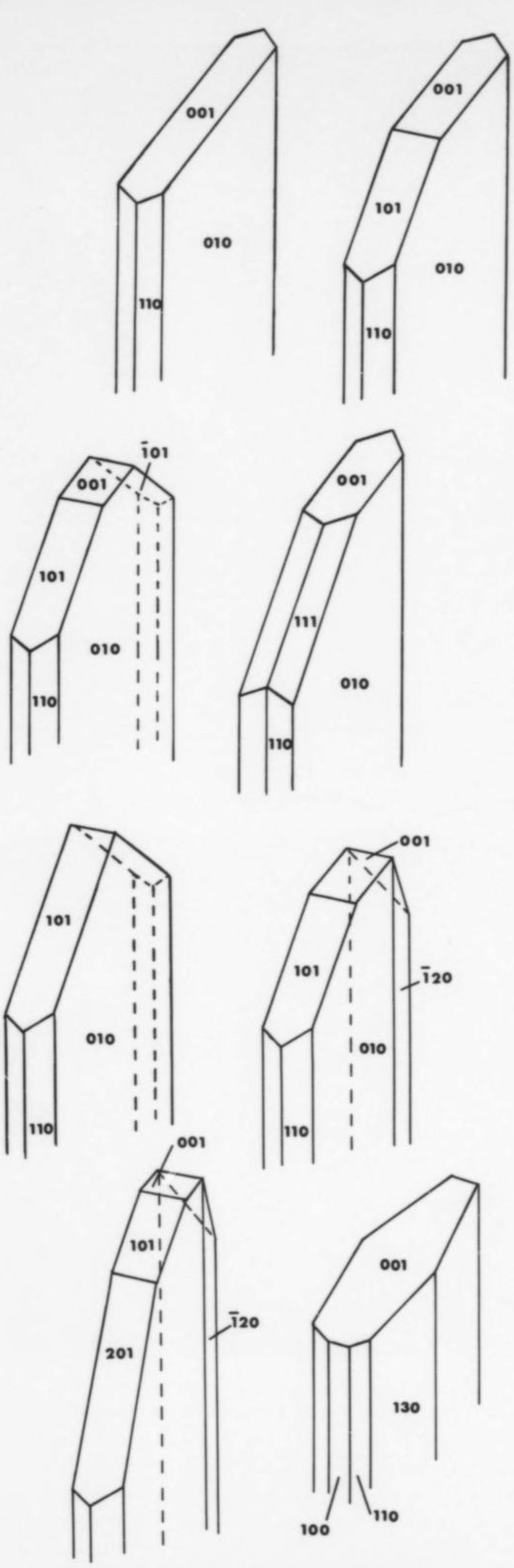


Figure 12. **Crystal drawings of erythrite; habits a and b are the most common, while habits c to h are rarely found, the latter being the rarest.**

microcrystals growing perpendicular to the matrix surface, or in some cases as puffballs. These specimens are often the most visually pleasing, but are also the most difficult to extract without damage. Erythrite in massive form is visible as staining on much of the dump material, and it was probably such staining on the surface of the country rock that led to the discovery of the orebody. Some of the erythrite has been found to have an orange to brown color due to traces of iron.

The best specimens have been recovered from an area between the two levels in the inclined shaft, and from just inside the mouth of the inclined shaft.

Fluorite CaF_2

Fluorite is found as massive vein fillings around the sulfide vein. A few microcrystals have been found in some of the material. The color ranges from cream-white to purple. Fluorite is a common mineral in the quartzites and granophyres of the Bushveld Complex.

Gold Au

The Kruisrivier cobalt ores are associated with a notable quantity of gold. Beck (1905), in his book on the nature of ore deposits, placed Kruisrivier in a class of its own, calling it a *cobaltiferous gold quartz vein deposit.* He gave the gold content as 60 to 150 grams per ton of ore. Selected specimens examined by the Geological Survey gave 56 grams per ton in the case of a specimen weighing 113 grams, rich in smaltite, and 30 grams per ton in the case of an ore sample weighing 20 grams and composed almost entirely of heterogenite. Some microtraces of visible gold have been found on a heterogenite specimen.

Table 1. **Chemical analysis of Kruisrivier mine heterogenite.**

	%
Co_2O_3	76.07
Al_2O_3	2.50
Fe_2O_3	1.00
CuO	0.03
CaO	2.04
MgO	0.84
NiO	2.43
MnO_2	0.09
ZnO_2	0.03
As_2O_5	3.49
subtotal	88.52*

*The balance of 11.42% is assumed to be water. The above figures were recalculated to exclude admixed quartz (SiO_2) which amounted to approximately 21%. The samples tested were found to contain gold at 28 grams per ton. The following elements were also detected in very low percentage levels: titanium, tin, vanadium, lead, molybdenum and chromium.

Heterogenite $Co^{3+}O(OH)$

Around the turn of the century a new hydrated oxide of cobalt was found and described from the Kruisrivier mine. It was named "transvaalite" after the then-Republic of the Transvaal. The name "transvaalite" is now discredited, and the mineral is known as heterogenite. It occurs as an oxidation product of the cobalt arsenide ores, and is found as a dull black amorphous mineral filling fissures in the quartzites, and in contact with the sulfide vein. In places cavities are found within a vein of the heterogenite, where the surface takes on a glossy botryoidal appearance.

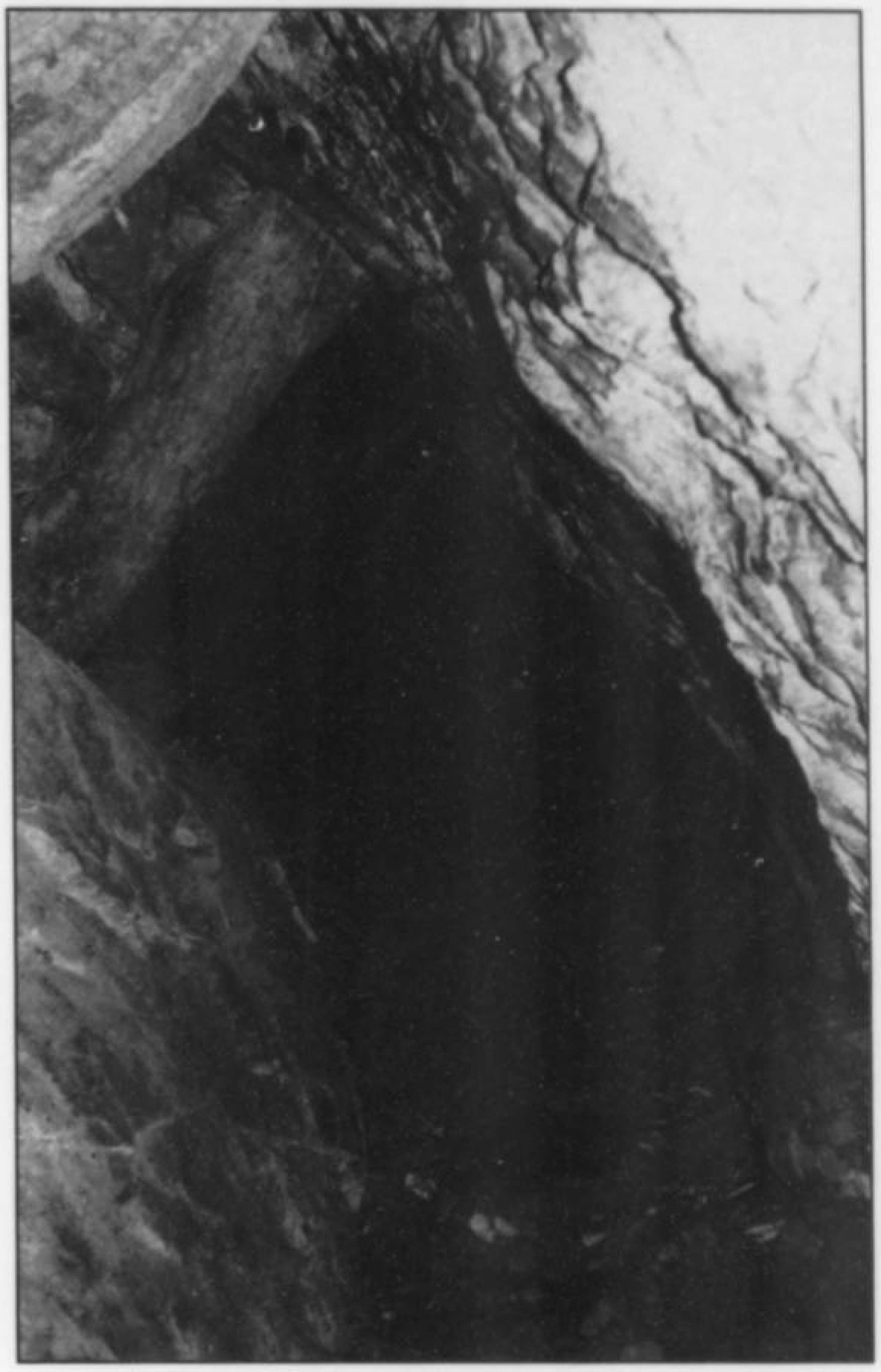


Figure 13. **Number 2 level and entrance to stopes.**

Malachite $Cu_2^{2+}(CO_3)(OH)_2$

Green coatings and vein fillings have been found to be the copper carbonate malachite.

Millerite NiS

Millerite has been identified as a minor constituent of the sulfide vein and the norite contact zone.

Nickeline NiAs

In some of the ore samples nickeline has been detected as a minor constituent.

Picropharmacolite $H_2Ca_4Mg(AsO_4)_4 \cdot 11H_2O$

Some samples of heterogenite and erythrite have a white efflorescence growing on them. X-ray diffraction has shown this to be the rare magnesium arsenate, picropharmacolite. It is very rare at Kruisrivier and has only been found in two small pockets close to the entrance of the inclined shaft. It occurs as small, 1 to 4-mm rosettes growing randomly on erythrite crystals on or near heterogenite/safflorite, where the crystals of erythrite exceed 3–4 mm in length. One specimen has been found consisting of a pseudomorphic replacement of the erythrite by a "ghost" outline of picropharmacolite (Fig. 20).

Safflorite $CoAs_2$

The chief ore mineral of the vein is the cobalt arsenide, safflorite. It occurs as massive, fine-grained vein material up to 1.2

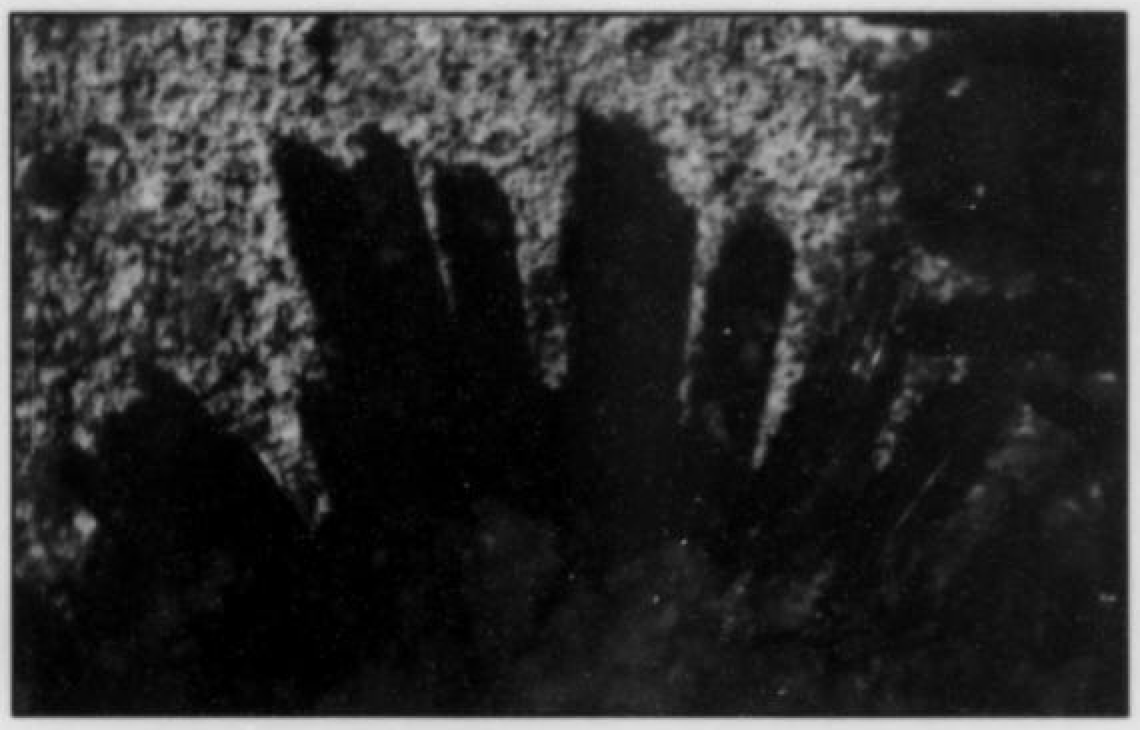


Figure 14. Photomicrograph of erythrite crystals to 4 mm with white picropharmacolite. Graham Reeks specimen and photo.

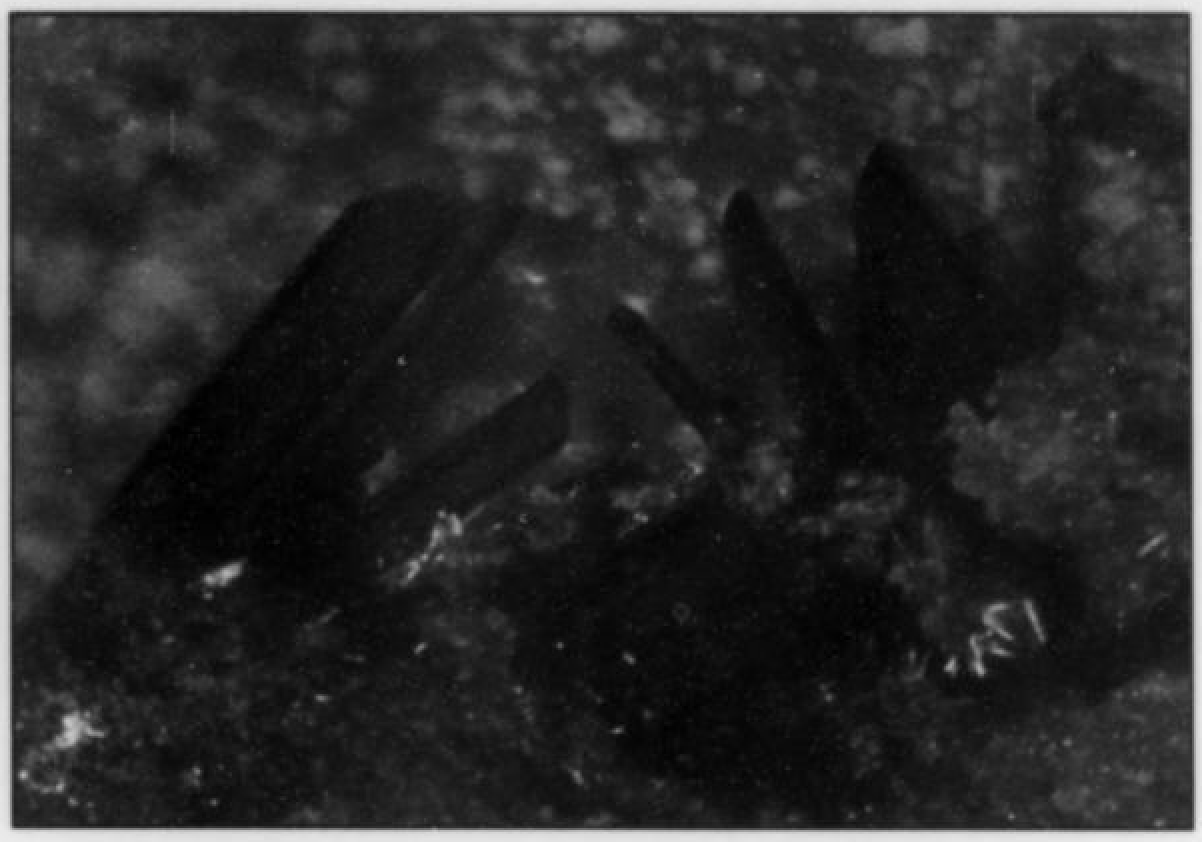


Figure 15. Photomicrograph of erythrite crystals to 3 mm with some minor picropharmacolite. Graham Reeks specimen and photo.

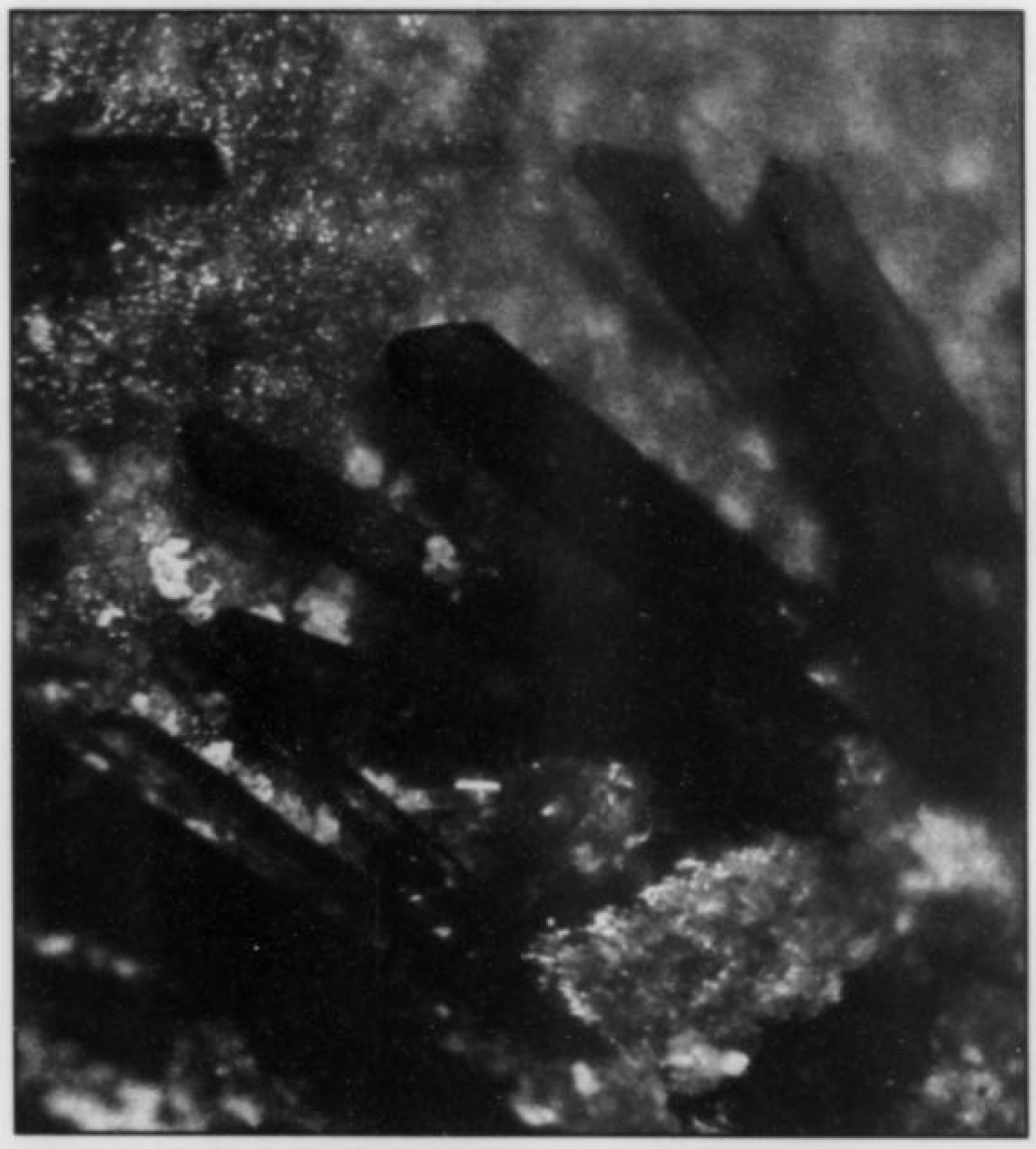


Figure 16. Erythrite crystals to 3 mm showing habit e with dominant {101} and {$\bar{1}$01} faces. Graham Reeks specimen and photo.

Figure 17. Erythrite crystal, about 0.5 mm, showing habit h. A cluster of arsenolite crystals can be seen alongside. Graham Reeks specimen and photo.

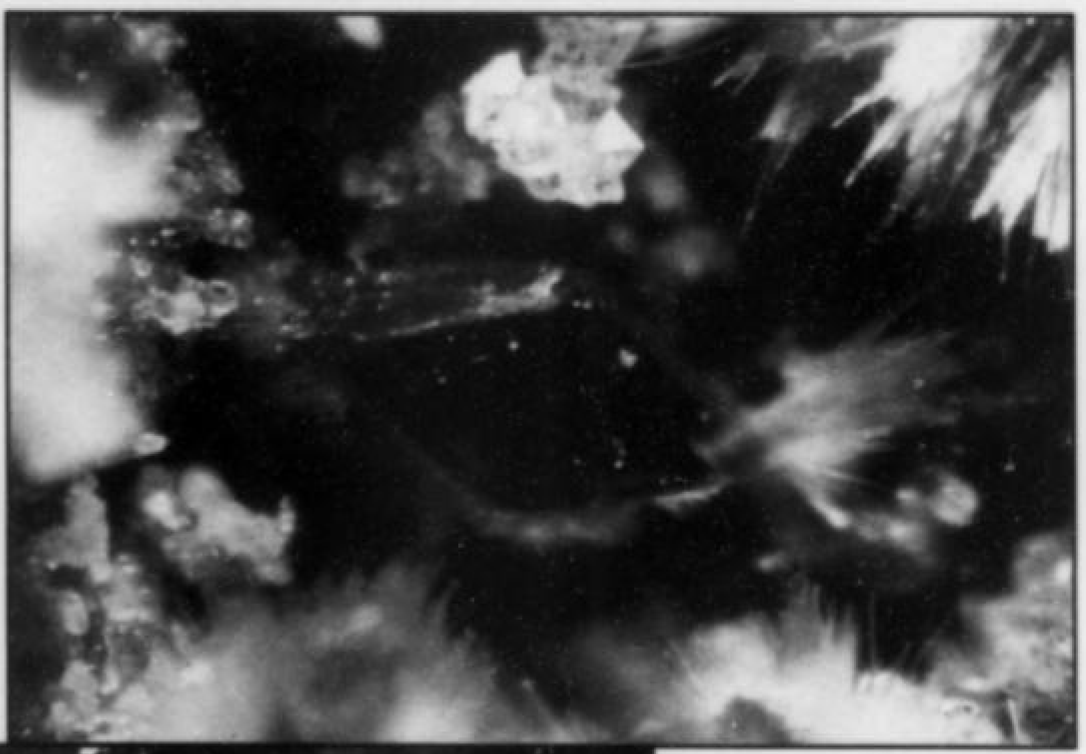


Figure 18. Photomicrograph of erythrite "puffballs" to about 3 mm. Graham Reeks specimen and photo.

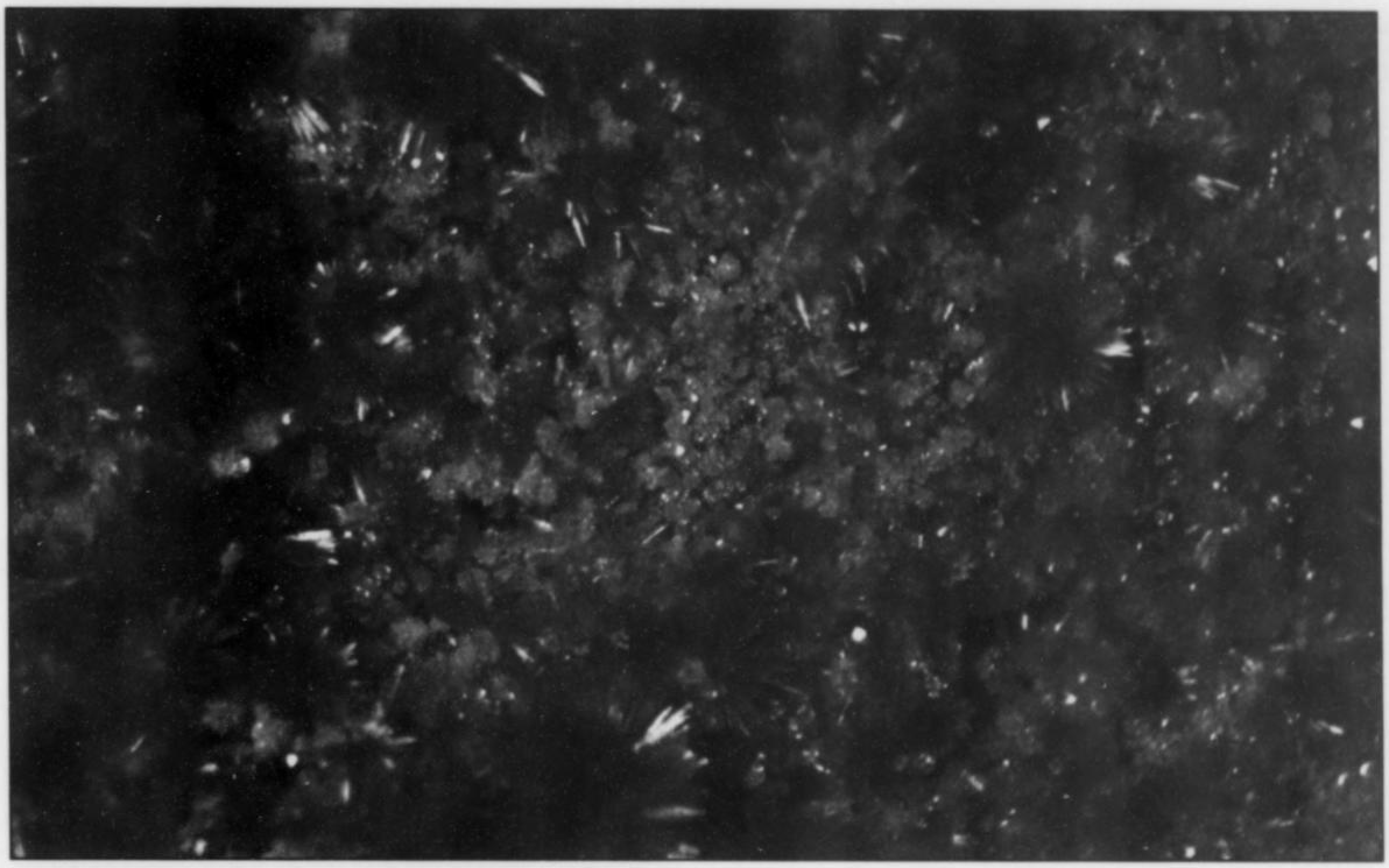


Figure 19. **Photomicrograph of clear to white arsenolite crystals to 0.5 mm on erythrite. Graham Reeks specimen and photo.**

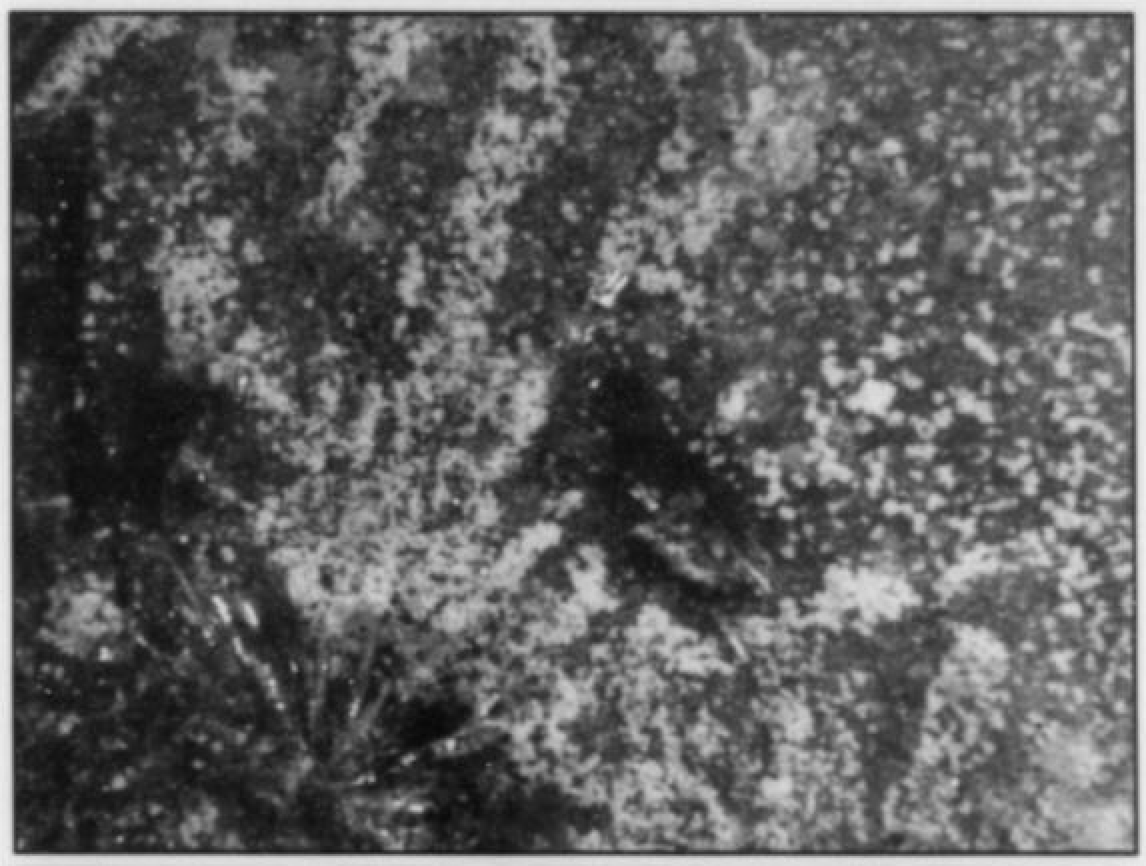


Figure 20. **Erythrite crystals replaced in "ghost" outline by picropharmacolite. The length of the photographed area is about 6 mm. Photo by R. Dixon; Graham Reeks specimen.**

cm thick and as fine stringers running along joint planes. Its color is gray to dark dirty gray, and it emits a very strong arsenical odor when hit with a hammer. Some of the best erythrite specimens have been found growing on or in the safflorite. No macroscopic crystals of safflorite have ever been found at the Kruisrivier mine, although crystals can be seen in thin section.

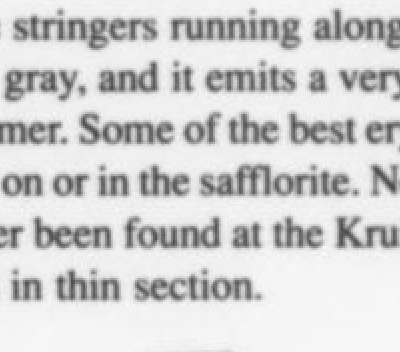


Figure 22. **Crystal drawing of typical Kruisrivier smaltite in the cuboctahedral habit.**

Skutterudite $CoAs_2$

The coarsely crystalline and disseminated part of the vein tends to consist of skutterudite. In solid patches of white quartz associated with the norite and sulfide vein some very nice 0.5 to 1-mm microcrystals of cuboctahedral skutterudite have been found. The skutterudite has a very lustrous tin-white color, and the crystal faces are highly reflective. Most of the disseminated skutterudite, however, is in the form of rounded euhedral grains. Figure 22 shows a crystal drawing of the skutterudite. In most cases the crystals are distorted or rounded.

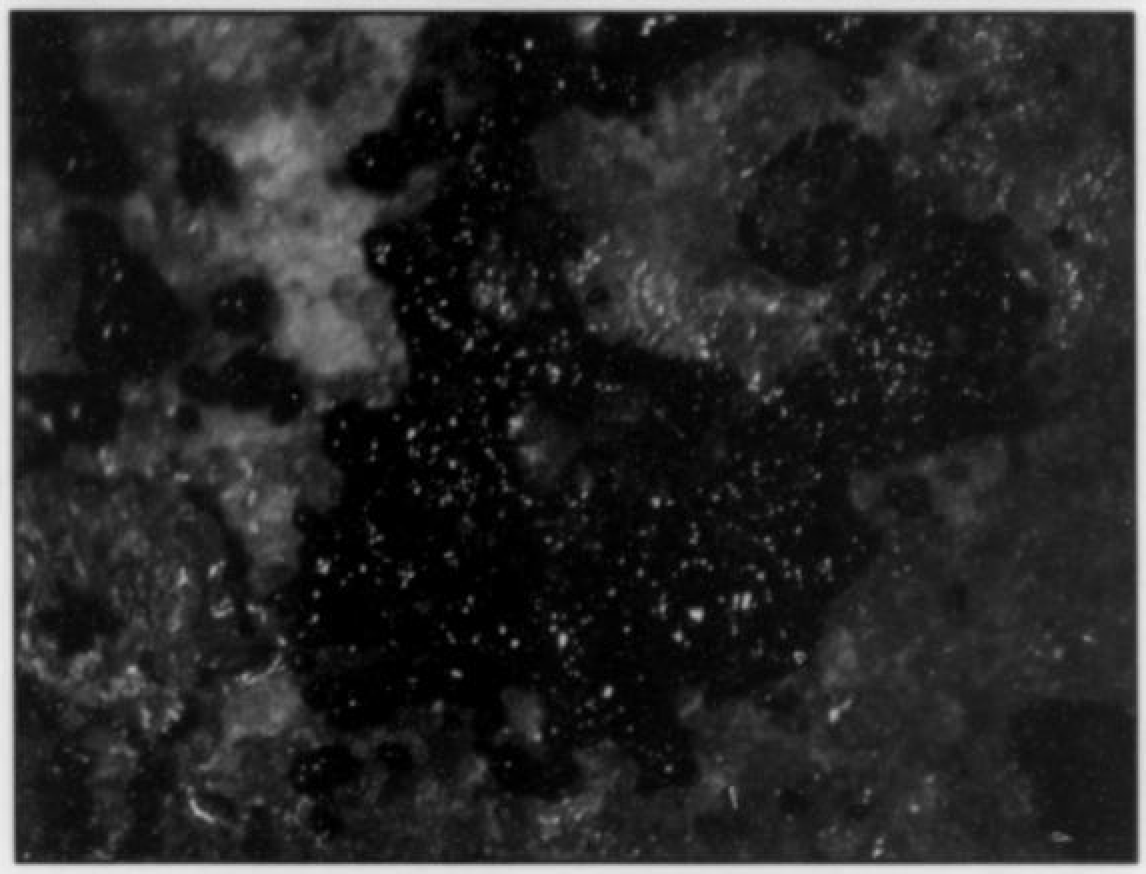


Figure 21. **Photomicrograph of heterogenite on matrix, 1 cm across. Graham Reeks specimen and photo.**

ACKNOWLEDGMENTS

I would like to express my gratitude to the following people: Andre de Ruijter for the analysis of the heterogenite specimens; Prof. P. Bariand for the identification of the picropharmacolite; Roger Dixon for the erythrite photograph (Fig. 20); the staff at the Johannesburg Public Reference Library, the Harold Strange Library of African Studies in Johannesburg, The State Library and the State Archives in Pretoria; Mrs. M. Fraser at Barlows Archives in Johannesburg, for access to the information on the Sekhukhune wars; Horst Windisch for research on Henderson's Transvaal Estates Ltd.; and the Registrar of Companies in Pretoria, for assisting in searches of references, and for translating Oehmichen's paper; the Chief Director of the South African Geological Survey for permission to publish the geological map, which has been redrawn and adapted from the Survey's 1:250,000 series maps; and Dr. E. C. I. Hammerbeck and Mr. D. J. Winterbach of the South African Geological Survey for discussions and information on the geology of the area. Finally a special word of thanks to Denise Holahan for reviewing the manuscript and making suggestions for its improvement.

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A WORLD-CLASS GOLD FROM THE COLORADO QUARTZ MINE

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Famous since the 1970's for beautifully crystallized gold, the Colorado Quartz mine near Mariposa, California, has recently yielded what may well be the finest specimen ever found at the mine, and certainly one of the finest gold specimens in the world.

INTRODUCTION

California has produced a huge number of crystallized gold specimens over the last quarter-century. One of the most important localities during that time has been the Colorado Quartz mine in west-central Mariposa County, about 5 miles north of the town of Mariposa, at the site of the old mining camp of Colorado. Hundreds of superb miniature and thumbnail specimens, as well as some incredible cabinet pieces have been collected there, some with quartz crystals and matrix still attached.

The Colorado Quartz mine has produced only intermittently over the years, with long dry spells between discoveries. Until recently the best specimen from the mine was considered to be the one currently in the Natural History Museum of Los Angeles County, containing about 7 ounces of crystallized gold. It was found in the late 1970's and sold then to a private buyer for about $100,000. A specimen found early this year, however, has surpassed it.

HISTORY

The Colorado Quartz mine is situated with others along a structure called the Colorado dike or vein. The vein was probably discovered in the 1860's; the Colorado Quartz mine itself was patented in 1875 by John A. Bataille. He sold the property in 1885 to three men from Mariposa (P. W. Judkins, C. H. Weston and I. L. Dearborn); it remained in the hands of their families until 1974. At that time the mine was purchased by David A. Grimes, who recovered some gold which he sold as bullion rather than as specimens. In 1975 Grimes sold the mine to Unlimited Minerals of Detroit.

A sizeable strike apparently took place in April 1976, when miners are said to have encountered a "bonanza" of crystallized gold. According to Kampf and Keller (1982), much of this material reached the specimen market in Europe, priced at only a little above bullion value. Eidahl (1977) reported purchasing a fine miniature-size specimen at the California Federation Show in San Francisco in July of 1976, and states that other important pieces from the find were sold there as well.

Because Unlimited Minerals failed to pay Grimes a percentage of the gold as promised, Grimes sued successfully to regain possession of the mine in 1977, and soon thereafter found another pocket of crystallized gold. Drifting into the dike at a depth of 86 feet, more pockets were found. In June of 1979 Grimes sold the mine to Colorado Gold Inc. of Fallbrook, California, who continued to develop the deposit. During the 1980's hundreds of fine gold specimens were recovered (Bancroft, 1987), but by 1987 the property had been shut down and was being offered for sale (Leicht, 1987).

In 1989 the Colorado Quartz mine was taken over by the Colorado Quartz Gold Corporation of Midpines, California, under

Figure 1. **The gold specimen found in January 1996 at the Colorado Quartz mine; the area of gold coverage measures 26 cm (over 10 inches) across. Photo by Jeff Scovil.**

Figure 2. **Close-up showing part of the gold specimen. Photo by Bernie Kowalski.**

Figure 3. **Close-up of the gold specimen. Photo by Jeff Scovil.**

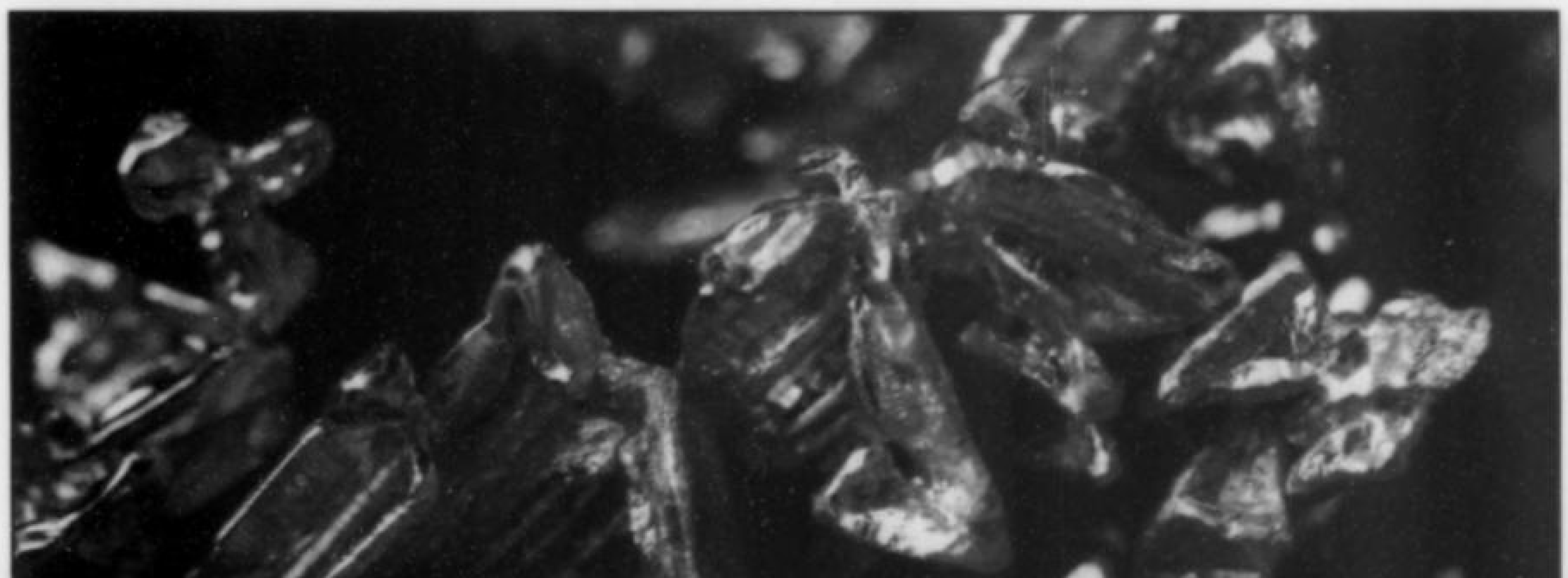

Figure 4. **Close-up showing part of the gold specimen. Photo by Bernie Kowalski.**

***Figure 5.* Location map of the Colorado Quartz mine.**

president Larry Lehto. He and a group of investors put together a specimen-mining project which continued without much success until 1995. Over that time, five or six palm-size pockets of gold were found which kept the operation going. But the work was plagued with difficulties: cash-flow problems, a collapsed shaft, and a blasting accident that severely injured two miners. By the end of 1995 their operating capital was approaching zero, and they were preparing to shut down the mine.

THE SPECIMEN

In January of 1996 Lehto decided to drive a short off-shoot from the main 140-foot-level cross-cut into an area he felt was promising. It was there that all the hard work finally paid off, with the discovery of a superb pocket of crystallized gold. Traditional methods of specimen removal would have dismembered the pocket into a dozen miniatures and small cabinet pieces. However, they could see that everything was more or less connected in the football-size (26 cm) clay-filled vug, and they decided to attempt to remove it in one piece.

Using methods pioneered by Bryan Lees at the Sweet Home mine in Colorado, they went to work with power saws to cut a 125-pound block of matrix from the vein. It came loose in perfect shape, with all of the gold still in place, and large quartz crystals penetrating it here and there.

The specimen was then turned over to Bryan Lees for preparation. The gold had all grown in an open pocket and was not encased in milky quartz as at many other California localities. However, the pocket was filled with a hard, compact gray-green clay which was too dense to wash off with water alone. Bryan's preparators went to work with small sticks of sharpened bamboo, and loosened the clay a tiny bit at a time, then washed it off bit by bit, all with excruciating patience and care.

Preparation ultimately required over 200 hours of work. As the clay slowly came off they began to realize what a remarkable specimen they had. Approximately 40 ounces of gold were uncovered, ranging from flat dendritic fans to arborescent groups to small, parallel octahedron clusters, to elongated bar-shaped crystals (probably twins), and finally to enormous hopper-faced octahedrons measuring up to 2 cm! And virtually all of the gold shows a brilliant, almost adamantine luster, with a great deal of sparkle because of the many tiny faces comprising the complex individuals. The specimen is shown on the cover of this issue, and in the photos here.

Lees has thus far not cut down the 125-pound block of rock containing the pocket. It is well suited as it stands for installation into a museum. But if the ultimate buyer wants it reduced, Lees is prepared to cut it down as much as necessary.

How does this specimen rank among all the world's great gold specimens, or even among other California golds? That is a difficult question, because habit, size and sculptural quality are so varied among the world's top examples of the species. Nevertheless, it is clearly "in the running" for best known specimen. Perhaps some day the world's luckiest museums and private collectors will bring their best golds together in one place. Then we could all judge for ourselves which was "the best." And even if we couldn't agree—which is likely—what an experience it would be! [NOTE: Gold will be the featured mineral at the 1997 Denver Show!]

ACKNOWLEDGMENTS

My thanks to Bryan Lees for showing this specimen to me when I visited him recently; the unveiling will remain one of my most memorable aesthetic experiences in mineralogy. Thanks also to Jeff Scovil and Bernie Kowalski for the fine photography.

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MINERALS OF THE SILVANA MINE,

SANDON, BRITISH COLUMBIA

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The Silvana mine has produced an array of very fine to spectacular micromineral and thumbnail specimens including rare, fiery-orange pyrostilpnite, lustrous cubanite, pyrargyrite and stephanite as well as showy, irridescent pyrrhotite.

INTRODUCTION

The Silvana mine is an amalgamation of many mines in the heart of the Slocan mining camp of British Columbia. It lies at the head of the east fork of Tributary Creek just south of the town of Sandon. Sandon is about 13 km (8 miles) east of New Denver on Highway 31A. National Topographic Series Map Sheet 82 F/14 covers this area.

HISTORY

The story of mining in the Slocan camp began when native peoples extracted lead from the rich galena veins to manufacture bullets in the mid to late 1800's. As prices for silver soared in the early 1890's, prospectors and miners rushed into the area. By 1892, 750 claims were recorded (Cairnes, 1934).

The first boom in the Slocan area began in 1891 with the discovery of the Payne claim. Prospectors Eli Carpenter and Jack Seaton were not having much luck that season. Finding the way back to Ainsworth Hot Springs through the dense bush in this steep, rugged terrain was proving to be difficult. They climbed Payne Ridge for a better view to orient themselves. At 2,100 meters (6,890 feet), the two came across a rusty ledge a few meters wide. Sampling uncovered rich veins of shiny galena.

After quickly staking the "Payne Claim," they hurried back to Ainsworth. Once there, Carpenter headed off to the assay office, Seaton was off to sate a thirst. Carpenter, a cunning, tight-lipped man, had admonished Seaton, a boisterous, care-free man, to keep the discovery quiet so they could return to look over the property more carefully. However, whiskey flowed in through Jack's lips and words flowed out. Before the end of the night the whole town had heard of the Payne discovery.

Carpenter returned from the assay office with a report showing silver values of 175 ounces per ton and 75% lead but told his partner loudly, "Our assay reads silver twenty-five ounces and not much lead either!" (May, 1986).

Carpenter then left, hooked up with a new partner, to sneak back

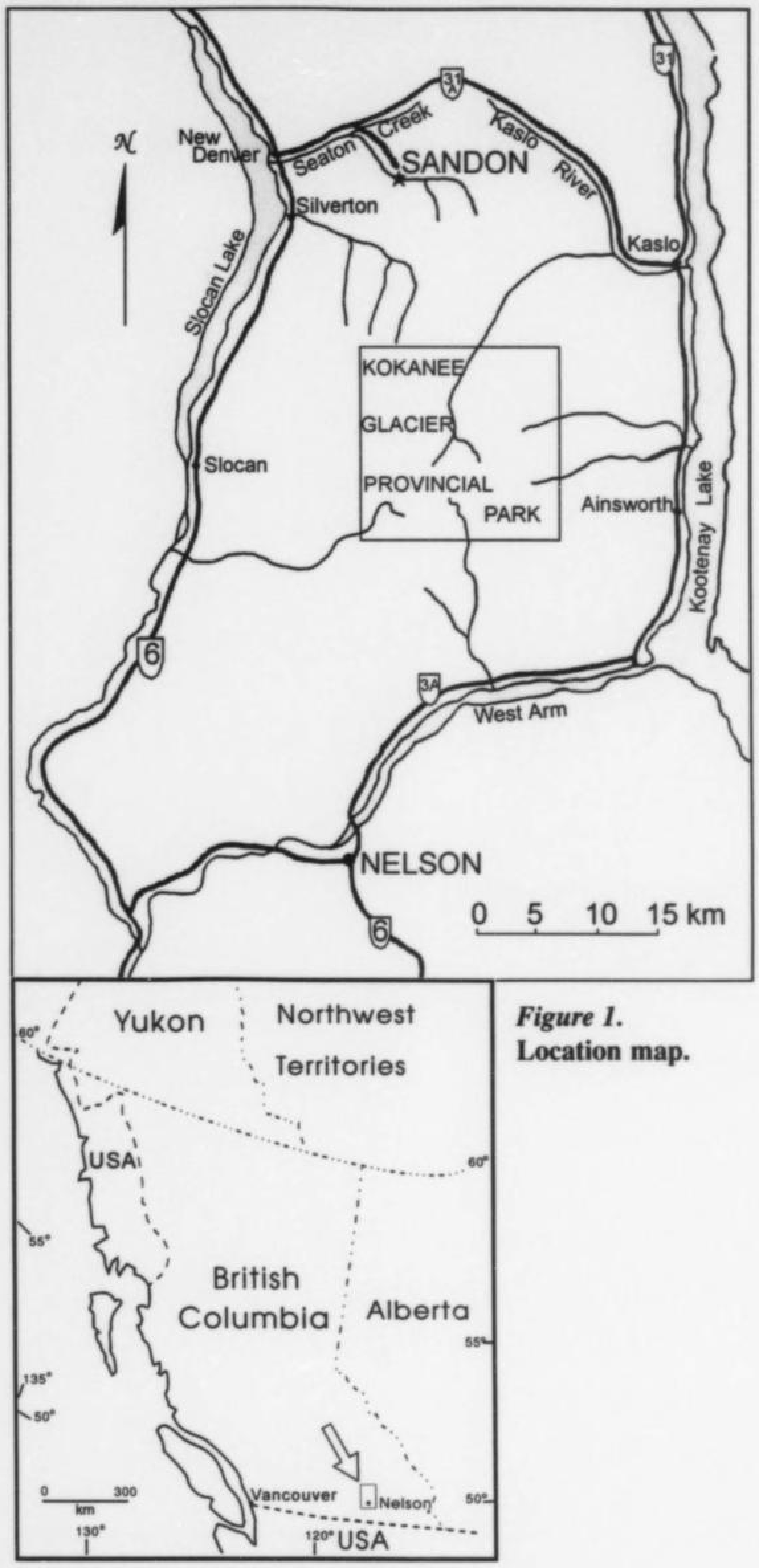

***Figure 1.* Location map.**

to the property. Seaton learned of his plan and with four others struck out to beat Carpenter to the claim. This group, known as the "Noble Five," reached Payne Ridge first. They scouted around and staked another 21 claims, all of which became producing mines.

The first boom lasted until 1899. A major labor dispute in that year slowed production; it did not recover until the world war in 1914 when the demand for base metals increased.

This renewed prosperity continued until 1920, having reached its peak in 1918, when a combination of more strike action and declining market values for metals brought production to a halt. Hungry workers either left the area or trickled back to work. Production never reached prior levels and continued to fluctuate until 1929. As the economy bottomed out on Wall Street, so did mining in the Slocan area.

During the late 1940's, the Kelowna Exploration Company undertook a program of exploration and mapping that lasted until 1951. Silver Standard Mines continued exploration of the properties after acquiring an option on 59 claims in the vicinity in 1961. This exploration company and others formed the Silmonac Syndicate in 1962. A year later the Syndicate incorporated and became Silmonac Mines Limited. Exploration continued off and on until 1970, when it was determined that enough reserves existed to warrant commencement of production. Silmonac Mines had its name changed to Silvana Mines Incorporated in 1977 after a reorganization of the company. Dickenson Mines acquired the properties and operated the Silvana mine until 1989, when Treminco Resources Limited bought the property. The mine was closed in July of 1991 due to low base metal prices and low ore reserves.

GEOLOGY

The first geological map work was done in 1894 and 1895 by R. G. McConnell. Cairnes (1934) and Hedley (1952) wrote the two most significant general geological reports on the area. There are also several minor reports and papers dealing with this region that are not cited in this article. However, to provide a comprehensive list of references, they are mentioned in the reference section.

The Slocan mining camp lies within the Kootenay Arc, an arcuate zone of highly deformed Proterozoic to mid-Jurassic metasedimentary and metavolcanic rocks. It lies on the eastern edge of the Omenica Crystalline Belt and contains the suture zone between the amalgamated, allochthonous terranes and the ancient western margin of the North American craton (Price *et al.*, 1981).

The orebodies of the Silvana mine lie within the Triassic Slocan Group, a thick succession of north-northwest-trending argillites, quartzites and limestones that appear to be folded about a large, recumbent syncline (Hedley, 1952). Apophyses thought to be related to the underlying Upper Cretaceous Nelson Batholith have intruded the Slocan Group. The ore occurs as lenses less than 2 meters thick with down-dip and strike lengths up to tens of meters within the Main Lode. The Main Lode is a south to southeasterly dipping zone of faulting and brecciation up to 50 meters (164 feet) wide and interpreted over 11 km (6.8 miles) between Silverton Creek and Sandon.

Sphalerite with gangue siderite and minor galena with variable silver values characterize the first phase of at least two stages in the main lead/zinc sulfide mineralization. Argentiferous galena characterizes the later mineralization phase. Later shearing is responsible for the extensive "graphitic" slickensiding throughout the Silvana portion of the Main Lode.

Remobilization of silver and other elements during this shearing produced the sulfide and sulfosalt minerals that occur in tension gashes along the slickensiding and cavities in the ore veins. Other minerals of interest to the collector occur in the calcite veins associated with the intrusives.

MINRALS

Acanthite AgS

Tiny (> 0.5 mm) black blades of acanthite associated with minor native silver in massive quartz were found on some specimens from the 4560 stope. However, these are suspected to be "cabinet growth" on samples left in storage for some time before being unwrapped and examined. Bladed acanthite was also found coating cubanite needles (D. K. Joyce, personal communication).

Anatase TiO_2

Anatase occurs as pale blue, brown or silver-gray crystals in quartz-lined fractures in the intrusive dikes on the 4270 level. The crystals are less than 1 mm long. The calcite-infilled fractures must be etched to expose the anatase.

Antimony Sb

Gwillam (1896) notes the occurrence of antimony in galena at the Alamo mine, which neighbors the present Silvana properties.

Figure 2. The Silvana mine, 4625 level loading ramp. Mark Mauthner photo.

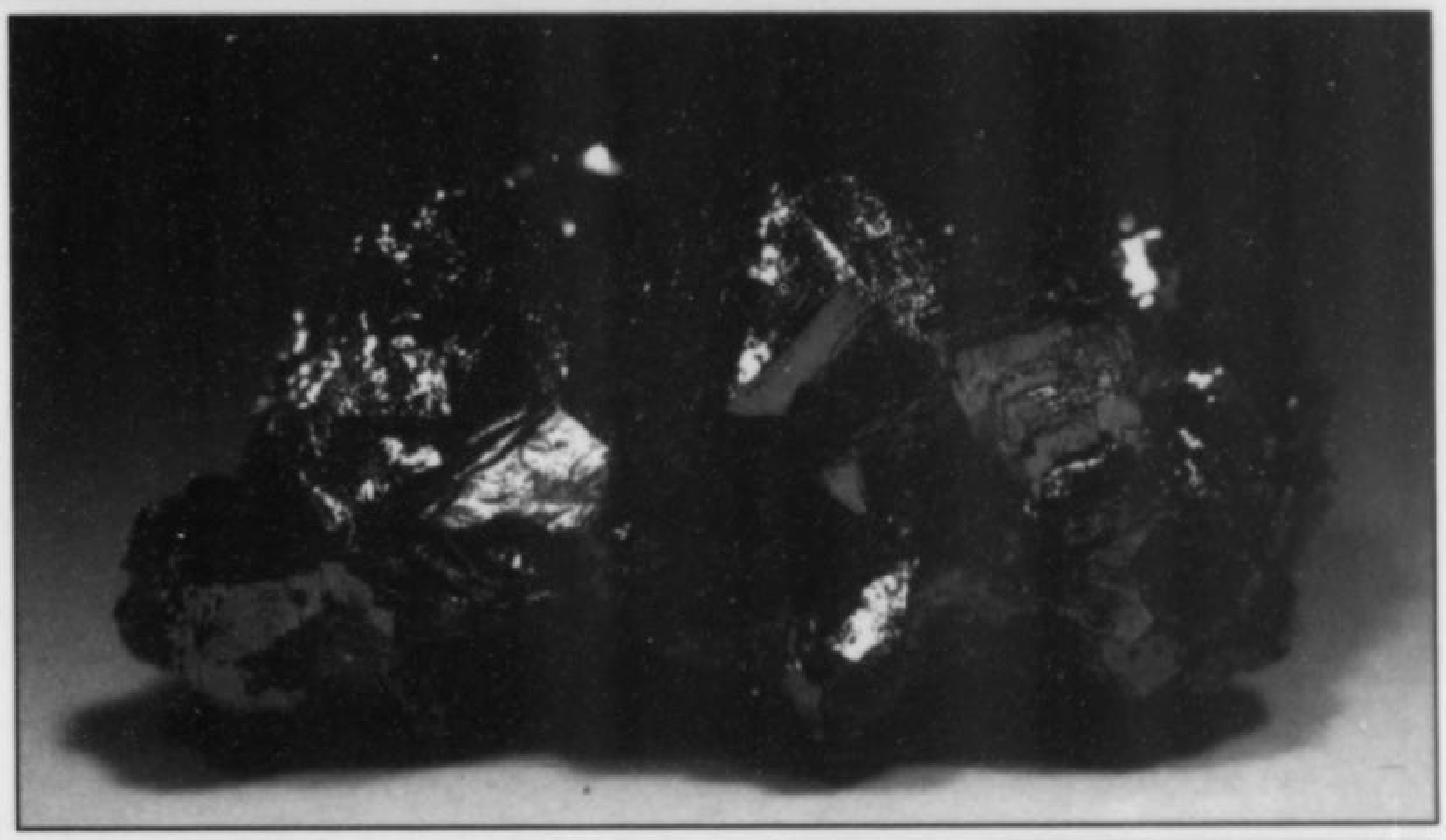

Figure 3. Pyrite crystal group, 3.5 cm, from shear zone fractures in the 45-13-7 stope. Mark Mauthner collection and photo.

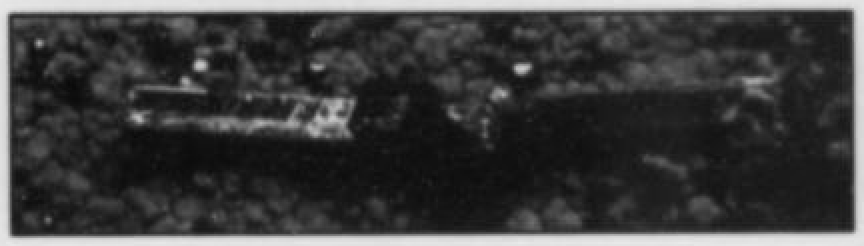

Figure 4. Pyrostilpnite crystals, 0.6 mm, with pyrargyrite. Mark Mauthner collection; Robert Brewster photo.

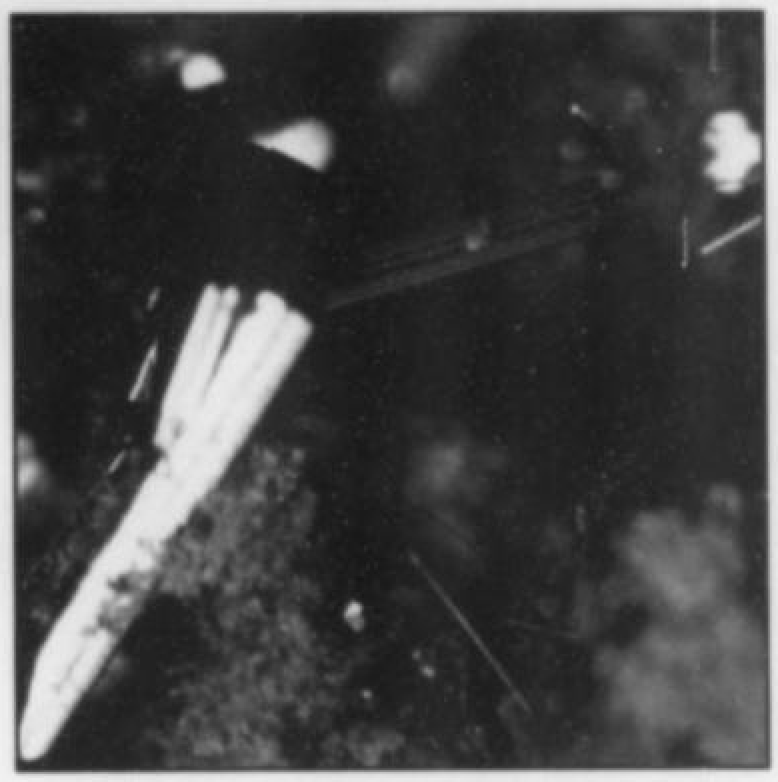

Figure 5. Cubanite crystals to 0.7 mm, with galena, pyrrhotite and pyrargyrite. Mark Mauthner collection and photo.

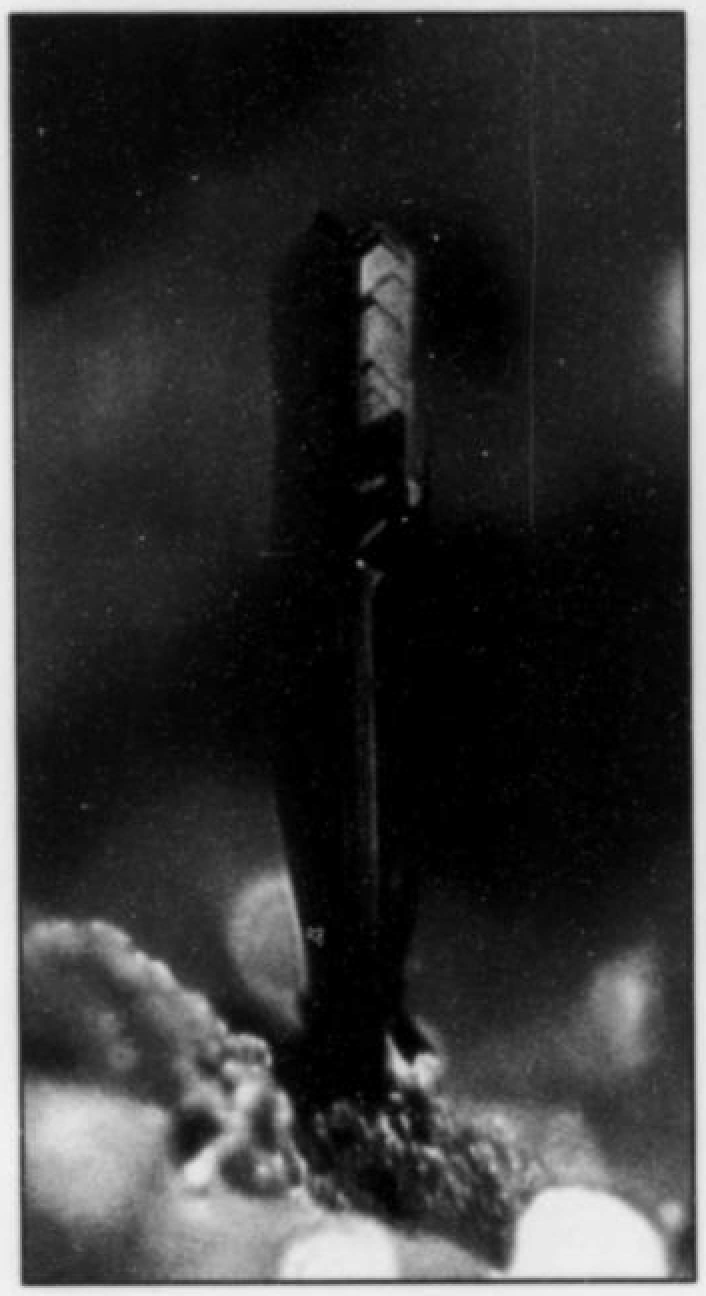

Figure 6. Pyrostilpnite crystal, 0.6 mm. Robert Brewster specimen and photo.

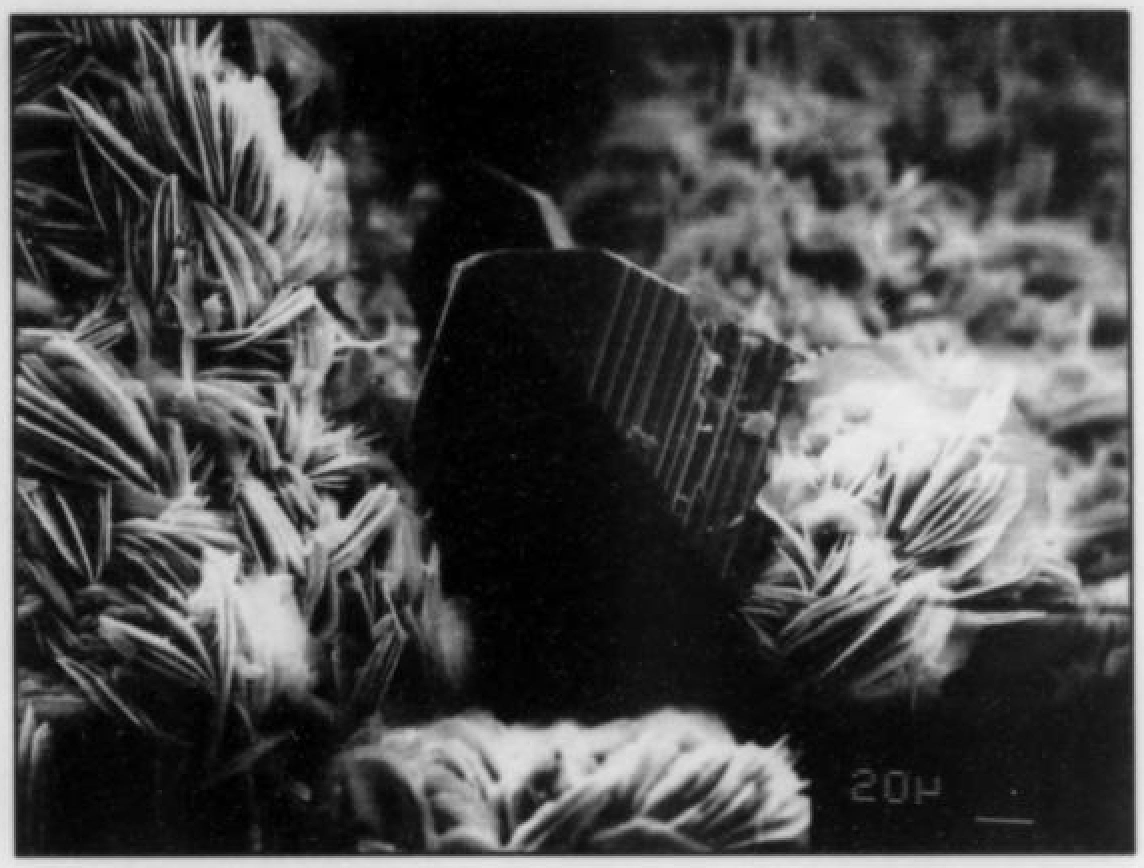

Figure 7. **Anatase crystal, about 170 µm, on chlorite from the 4270 level. U.B.C. collection; Mark Mauthner photo.**

Native antimony was found as tiny (< 0.1 mm) blebs with boulangerite, freibergite and meneghinite in a polished section of the massive, sheared galena.

Aragonite $CaCO_3$

Aragonite occurs as acicular white tufts, up to 2 or 3 mm in width, associated with gypsum, sulfosalts and pyrrhotite. Aragonite also occurs as an efflorescence on the walls in the mine.

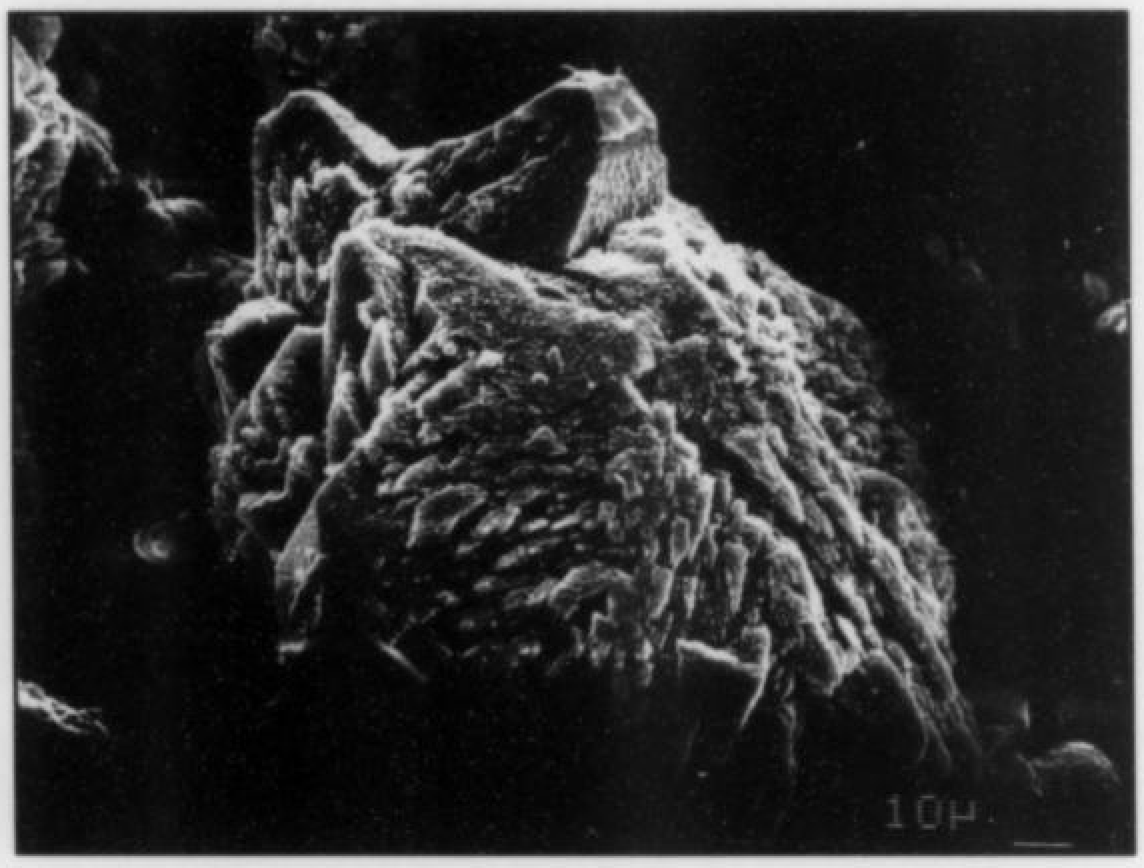

Figure 8. **Argentopyrite crystal group, about 180 µm. Mark Mauthner collection and photo.**

Argentopyrite $AgFe_2S_3$

This rare sulfide occurs as tiny prismatic pseudohexagonal crystals associated with polybasite, cubanite, pyrargyrite, pyrrhotite, calcite and aragonite in the 44-11-8 and 4560 stopes. Some elongate prisms show a star-shaped cross-section.

Needle-like crystals of a silver-iron sulfide suspected to be argentopyrite were discovered on a sample from the Silvana mine. Associated with these crystals are cubanite needles, some with silver-rich zones. Research is presently being conducted to determine whether or not argentopyrite and cubanite form a series.

Arsenopyrite FeAsS

Stope 40-13-1 produced some massive to subhedral arsenopyrite. This is noteworthy only because it shows the presence of arsenic in the system.

Barite $BaSO_4$

Barite occurs as cream-white, tabular crystals up to 1 mm on an edge in the chlorite-coated extension fractures within the heavily slickensided shear zones. It is most often associated with pyrrhotite and quartz.

Boulangerite $Pb_5Sb_4S_{11}$

Boulangerite occurs as hairlike tufts in vugs and as fibrous masses up to 1.5 cm long in the massive, sheared galena. Additional associated minerals include meneghinite, antimony, freibergite, sphalerite, siderite and quartz.

Calcite $CaCO_3$

Calcite occurs as euhedral crystals of various habits throughout the mine. Typical habits include trigonal bipyramids, tabular, six-sided plates and hexagonal prisms with rhombohedral terminations. Crystals up to 4 cm in width have been found.

Chalcopyrite $CuFeS_2$

Stope 45-13-0 produced lustrous disphenoids (< 1 mm) intimately associated with sphalerite on gemmy clear quartz crystals. Clusters of lustrous disphenoids occur with pyrostilpnite, pyrargyrite, cubanite and quartz on specimens from the 42-12-1 stope. Chalcopyrite usually occurs as small (5–10 mm), massive blebs in sphalerite. These are uncommon except in the 43-13-2 and 43-13-3 stopes.

Cubanite $CuFe_2S_3$

Lustrous cubanite crystals with an elongate, striated prismatic habit, originally thought to be a strange habit of chalcopyrite, occur associated with pyrrhotite, pyrargyrite, galena and pyrostilpnite in several stopes. Cubanite also occurs as single or small tufts of very fine, elastic needles up to 5 mm in length. As mentioned under **Argentopyrite,** some cubanite needles found on one sample contain silver-rich zones.

Dravite $NaMg_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$

Dravite occurs as greenish black needles in calcite-filled veinlets associated with intrusive dikes. The crystals are usually no more than 1 mm thick and up to 4 mm long.

Epsomite $MgSO_4 \cdot 7H_2O$

Epsomite occurs as white balls in fractures within the slickensided shear zones. These tight aggregates of bladed crystals occur with aragonite and are up to 2 mm wide. It is possible, since this mineral has been found only in older, mined out stopes, that the epsomite formed after mining activity.

Freibergite $(Ag,Cu,Fe)_{12}(Sb,As)_4S_{13}$

Cairnes (1934) uses the term "gray copper" to describe occurrences of freibergite and tetrahedrite. This, he states, occurs as masses within the galena in several Sandon area mines. The report by Dubord also indicates the presence of tetrahedrite in polished sections of the massive ore. Freibergite was found as crystals in vugs and as blebs in massive, sheared galena specimens found in the millsite ore bin. All of the euhedral specimens originally labeled as tetrahedrite in the authors' collections, for which the source stopes were known, have been shown to be galena with an odd habit.

Galena PbS

Massive argentiferous galena comprises the main ore vein material. This vein material exhibits some interesting deformation textures. Of interest to the micromounter though, are the highly lustrous, euhedral crystals found in stopes 42-13-0, 42-13-1 and 42-13-8. Most of these crystals show cubic forms modified by octahedrons and occur up to 7 mm in size, though most are in the 0.5 to 2 mm range.

***Figure 9.* Galena crystal, about 60 μm, with chlorite, from the 43-13-8 stope. U.B.C. collection; Mark Mauthner photo.**

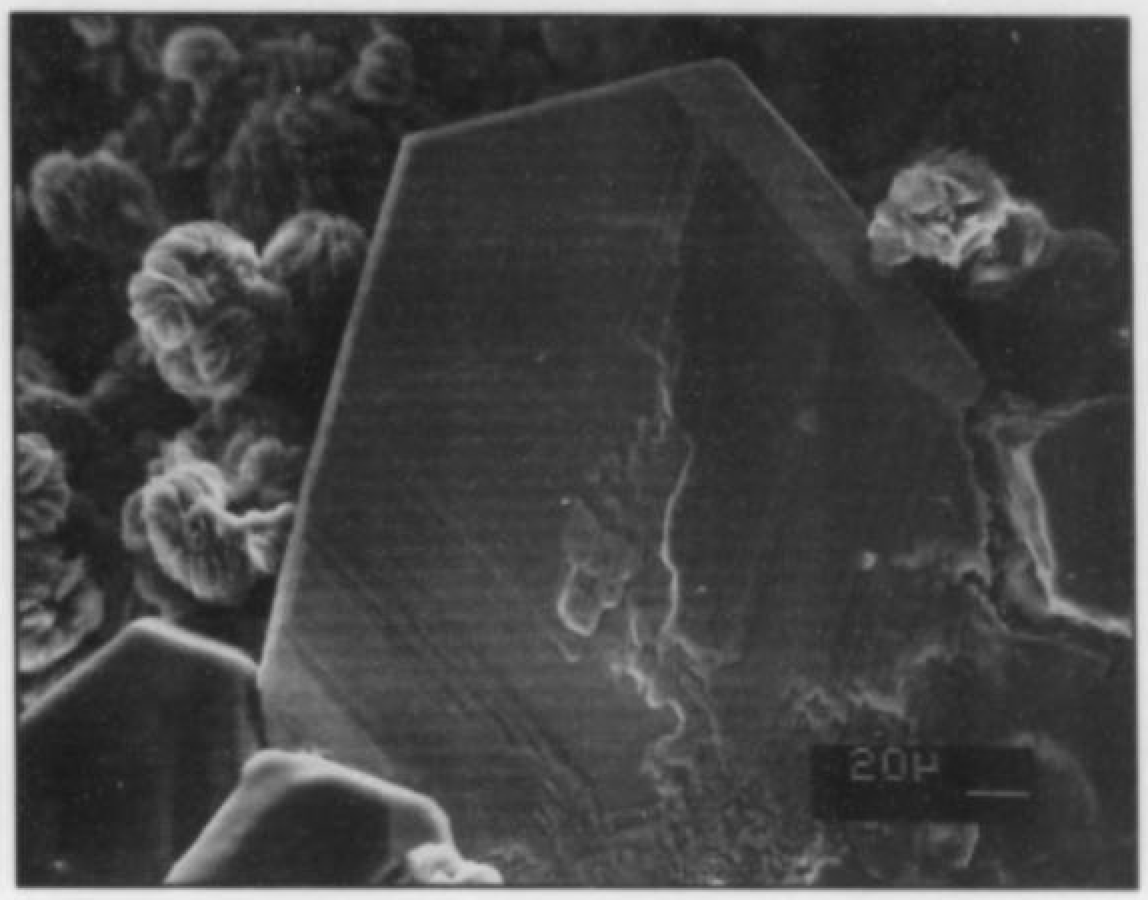

***Figure 10.* Polybasite crystal, about 150 μm, from the 14-11-8 stope. U.B.C. collection; Mark Mauthner photo.**

Gypsum $CaSO_4$

Gypsum occurs as clear blades (1–2 mm) most often associated with aragonite on limonite-coated fracture surfaces in the 44-11-8 and 43-11-8 stopes. Stephanite and polybasite are also common associates. As with the aragonite, it is possible that some gypsum formed after mining activity in the stope.

Heulandite $(Ca,Na_2)Al_2Si_7O_{18}\cdot 6H_2O$

Water-clear crystals of heulandite occur in a shear zone within the intrusions in the 4000 level, #4 West lateral drift. The crystals measure up to 1.5 mm in length and are associated with stilbite.

Laumontite $CaAl_2Si_4O_{12}\cdot 4H_2O$

When freshly exposed, laumontite occurs as clear, colorless prisms up to 3 mm in length. These, however, quickly alter and are usually milky white by the time the collector reaches the mine portal. After that, the laumontite is fairly stable. It occurs in a wide "graphitic" shear zone in the 44-11-1 stope.

Meneghinite $Pb_{13}CuSb_7S_{24}$

Some specimens of massive, sheared galena, picked up from the ore bin at the millsite, were found to have vugs lined with meneghinite crystals up to 2 mm in length. These are associated with crystals of galena, sphalerite, freibergite, boulangerite, quartz and siderite. They are elongate, heavily striated, sometimes curved prisms with sphenoidal terminations.

Orthoclase $KAlSi_3O_8$

Gemmy, colorless crystals of orthoclase line calcite-filled veinlets in a porphyry on the 4755 level East. The crystals exhibit a prismatic habit with wedge-shaped terminations. Lustrous cubes of pyrite are often sprinkled on the orthoclase.

Polybasite $(Ag,Cu)_{16}Sb_2S_{11}$

Stopes 44-11-8 and 43-11-8 have produced some lustrous, black, hexagonal plates of polybasite. It is usually associated with stephanite, pyrargyrite, gypsum and aragonite and occasionally with pyrrhotite. This assemblage is always found on a limonitic crust with a border around it that is reminiscent of molten plastic. It is an interesting alteration feature that needs to be studied further.

Pyrargyrite Ag_3SbS_3

Probably the most common sulfosalt, pyrargyrite occurs as deep red, hexagonal prisms up to 1 cm throughout the mine. Most crystals range from 0.5 to 2 mm in length. It occurs on shear surfaces within the massive galena where the crystals appear to be "frozen" in the fine-grained galena matrix. Pyrargyrite also occurs in the quartz-lined cavities with other sulfosalts and sulfides. The pyrargyrite crystals tarnish after long exposure to light.

Pyrite FeS_2

Pyrite occurs throughout the mine in a variety of habits. Vugs in the calcite vein in the intrusions along the 4270 drift contain crusts of irridescent cubes and elongated cubes on calcite crystals. Within the calcite veins of an altered porphyry are filiform pyrite crystals.

Large, lustrous groups of cubes, up to 1.5 cm on an edge, occur in fractures in the graphitic shearing zone of the 45-13-7 Stope. These occur associated with floater pyrrhotite rosettes in black, spongy wad.

Other locations in the mine produce cubes and octahedrons, or combinations of both, in chlorite-coated vugs, on quartz or on orthoclase.

Pyrostilpnite Ag_3SbS_3

Pyrostilpnite is not common but occurs in small quantities in several stopes of the Silvana mine. It occurs as superb, thin, bladed orange-red crystals in fractures along with chlorite or pyrargyrite, cubanite, pyrrhotite, galena and quartz in silica-rich zones. More often than not, pyrostilpnite is intimately associated with pyrargyrite. The crystals are quite small; the largest seen are about 1 mm. Some specimens exhibit a thin, long and curved threadlike habit.

Quartz SiO_2

Beautifully gemmy quartz crystals line the fracture cavities, making a dazzling background for the more desirable mineral species found in the same cavities. However, some unusual quartz habits that warrant attention occur in the 45-13-8 and 45-13-9 stopes. One of these is a pseudocubic quartz that is associated with another of bipyramidal habit. There are also some interestingly sceptred quartzes exhibiting a bipyramidal habit overgrowing a chlorite-coated prism. Doubly terminated quartz crystals up to 1.5 cm occur on chlorite-coated cavities in the siderite lenses.

Rutile TiO_2

Dark red-brown rutile crystals frozen in quartzite and in calcite-filled fractures occur in rocks associated with the intrusives on the 4460 East level. This material was found during an exploratory drilling program and has not yet been found in any area actually being mined. Anatase is usually found as the titanium oxide constituent in the intrusive dikes.

Silver Ag

Native silver occurs as small platelets up to several millimeters across in massive quartz from the 4560 Stope.

Sphalerite (Zn,Fe)S

Although sphalerite is one of the main ore minerals in the mine, good crystals of it are uncommon in comparison to other crystallized sulfides and sulfosalts. However, tiny (0.5 mm), gemmy red tetrahedrons of sphalerite occur in the veinlets within the intrusive dikes. Larger (up to 1 mm) brown crystals occur in the 44-13-0 Stope. The latter are intimately associated with chalcopyrite. Both the chalcopyrite and the sphalerite exhibit a stepped habit on the octahedral faces.

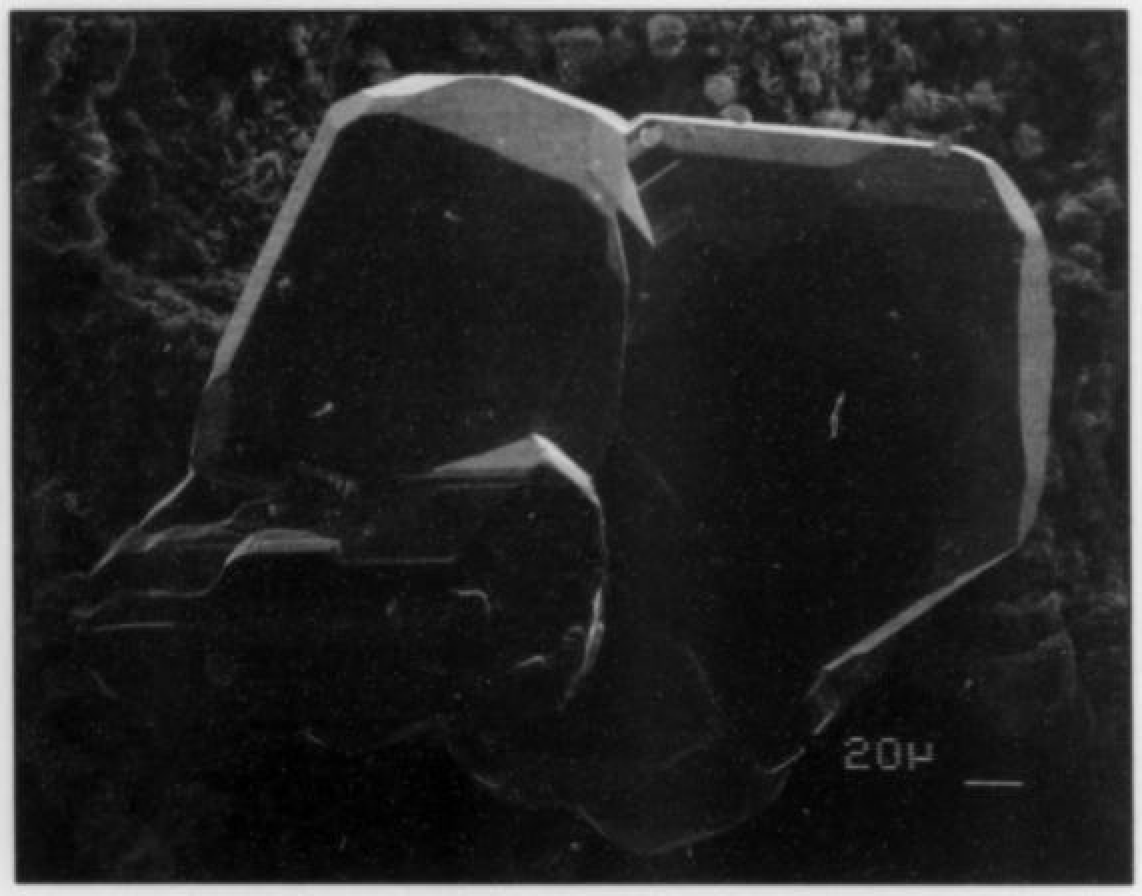

Figure 11. **Stephanite crystals, 300 µm across, perched on a smaller, striated pyrargyrite crystal. U.B.C. collection; Mark Mauthner photo.**

Stephanite Ag_5SbS_4

Stephanite occurs as lustrous hexagonal prisms and groups associated with quartz, pyrrhotite, cubanite and polybasite. Some crystals reach a length of 2 mm.

Stilbite $NaCa_2Al_5Si_{13}O_{36} \cdot 16H_2O$

Clear to white crystals of stilbite occur on heulandite in a shear zone within the intrusive rocks in the 4000 level, #4 West lateral drift. The crystals measure up to 1.5 mm in length.

Titanite $CaTiSiO_5$

Titanite occurs as honey-colored crystals frozen in a hypabyssal porphyrytic quartz diorite intrusive in the 4555 East Drift. Titanite crystallized out of the original intruding melt. The rutile and anatase are found in veinlets thought to be related to subsequent deformation activity. These minerals could be the result of titanium remobilized from titanite during these events.

COLLECTING

Collecting at the Silvana mine is for the time virtually impossible. The mine is shut and most of the collectable stopes have been slashed, making the ground unsafe. A substantial amount of material was collected by Bob Attridge over the past 15 years and much of this material still needs to be unwrapped and checked for worthwhile specimens.

ACKNOWLEDGMENTS

We thank Treminco Mines for permission to collect in the mine and for the use of geological data gathered by the company. Many thanks go to Joe Nagel and Jim Mortenson for their valuable input and to Lloyd Twaites for providing specimens not represented in the authors' collections for analysis.

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MONAZITE-(CE) FROM THE BUCKWHEAT DOLOMITE AT FRANKLIN, NEW JERSEY

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INTRODUCTION

A variety of minerals that are found in the vuggy "Buckwheat dolomite" at Franklin, Sussex County, New Jersey, have been described in detail by Peters *et al.* (1983). The dolomite is found on the dump which holds material excavated from the Buckwheat open pit located at the southern end of the Franklin ore deposit. Over the years 41 species have been reported from this occurrence. Peters *et al.* (1983) report 22 validated species from the dump, most of which occur as microcrystals in the 10's to 100's of µm. A few, such as fluorite and sphalerite, range up to 5 mm in crystal size.

Commencing in 1988, one of us (GTB) gradually purchased the bulk of the mineral collection of Steven Kiss of Garfield, New Jersey. Among the micromounts acquired early was a specimen labeled "humite (?)" from the Buckwheat dump at Franklin. This specimen consists of a vug in massive dolomite which is lined with dolomite and quartz crystals and which also contains two transparent, deep yellow crystals with vitreous luster and some rutile needles. Although the associations placed the tentative identification of humite in question, no further work was done due to paucity of material. However, by 1993, when most of the Kiss collection had been acquired, more specimens of similar appearance and association were found, this time labeled "humite or chondrodite (?)." Qualitative testing indicated that the yellow mineral is not a humite-group mineral, because it possesses a high specific gravity, is insoluble in 1:1 HCl, and shows at least one good cleavage. At this point quantitative examination was undertaken by one of us (LCP) and the yellow mineral was determined to be ***monazite-(Ce)***, believed to be a first occurrence of the monazite group reported from Franklin. The investigation and results are reported below.

Investigation determined that the monazite-containing material had been collected in August of 1963. The Buckwheat dump has been reworked many times in the intervening 31 years, and dolomite masses are now rare at the dump surface. Significant effort would be required to find dolomite by digging, and additional work would be needed to search for the rare vug that might contain monazite.

GEOLOGY

The Franklin ore deposit was probably formed from stratiform sedimentary deposits through deformation and recrystallization by regional sillimanite-facies metamorphism associated with the Grenville Orogeny, at about 950 million years ago (Frondel and Baum, 1974). This initial event is estimated to have occurred at temperatures of 557 to 827°C and pressures of 700 to 1,300 atm. Small granitic and pegmatitic intrusions of late Precambrian age are present in the Franklin marble and associated gneisses. These probably relate to post-metamorphic granitic intrusions of the same age. There was intrusion of basic igneous dikes probably in Lower Silurian time. Veins in the deposit are probably associated with hydrothermal activity of a later time and at a lower grade than the Precambrian initial event, and are possibly related to the Appalachian Orogeny.

The location and setting of the Buckwheat pit area in the Franklin ore deposit are described by Frondel and Baum (1974). They place the area at the southernmost extremity of the ore deposit, bounded by two mica diabase (camptonite) dikes with chilled margins to the north and south, by the Franklin orebody and the Cork Hill gneiss to the west, and by the recurving orebody and the Median gneiss to the east. Palache (1935) described a vein-like mass of cavity-containing gray dolomite in the west wall of the Buckwheat open pit; this places the dolomite close to the Cork Hill gneiss. There was also a pegmatite several hundred feet in length within about 300 feet of the northern end of the Buckwheat pit area; this pegmatite was described by Frondel and Baum (1974) as containing thorite and abundant allanite.

MINERALOGY

Palache (1935) described the cavities in the Buckwheat dolomite as being lined with drusy rhombohedral crystals of dolomite, on top of which may be crystals of calcite, quartz, albite, sphalerite, pyrite, millerite, hematite and goethite, mostly well crystallized. A more recent description of the minerals of the Buckwheat dolomite by Peters *et al.* (1983) includes a list of 22 known species. No rare-earth element (REE)-bearing species are included in this list. Hydrozincite found in association with albite, brookite, calcite,

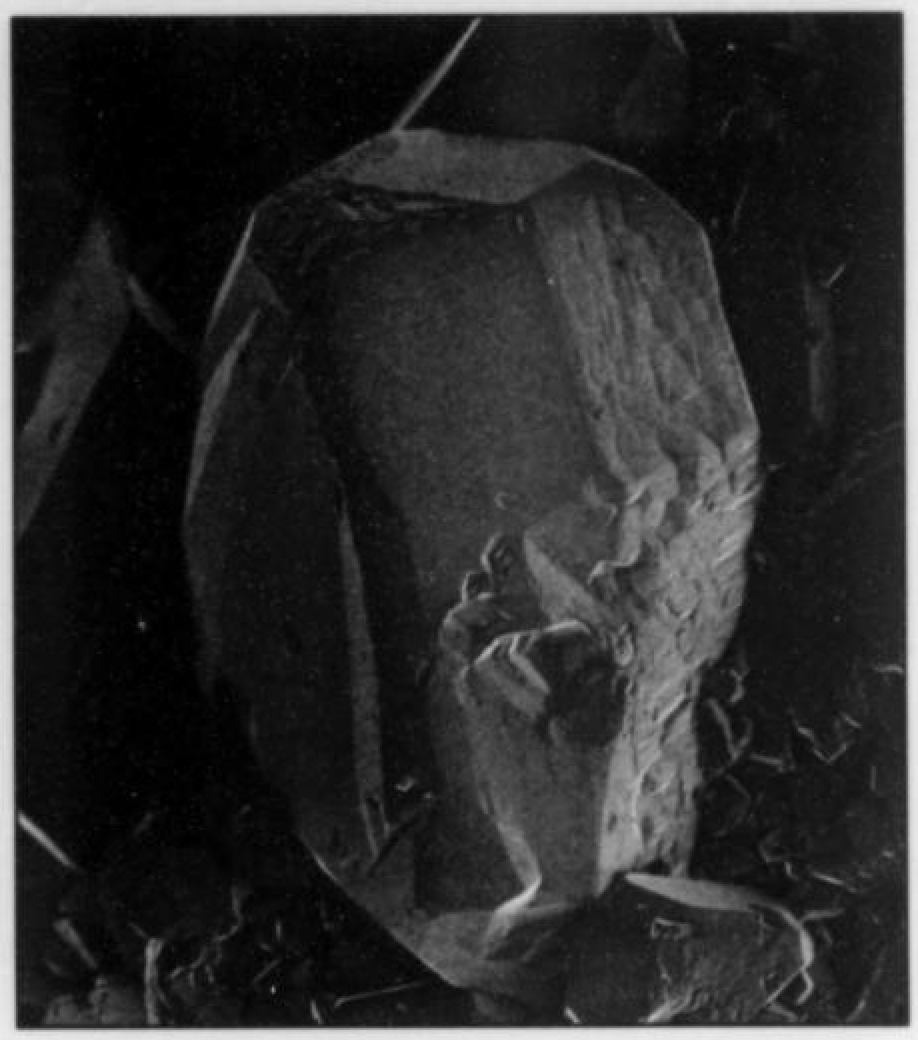

Figure 1. **Scanning electron microscope photograph of a 200-micron monazite-(Ce) crystal on dolomite and quartz from Franklin, New Jersey.**

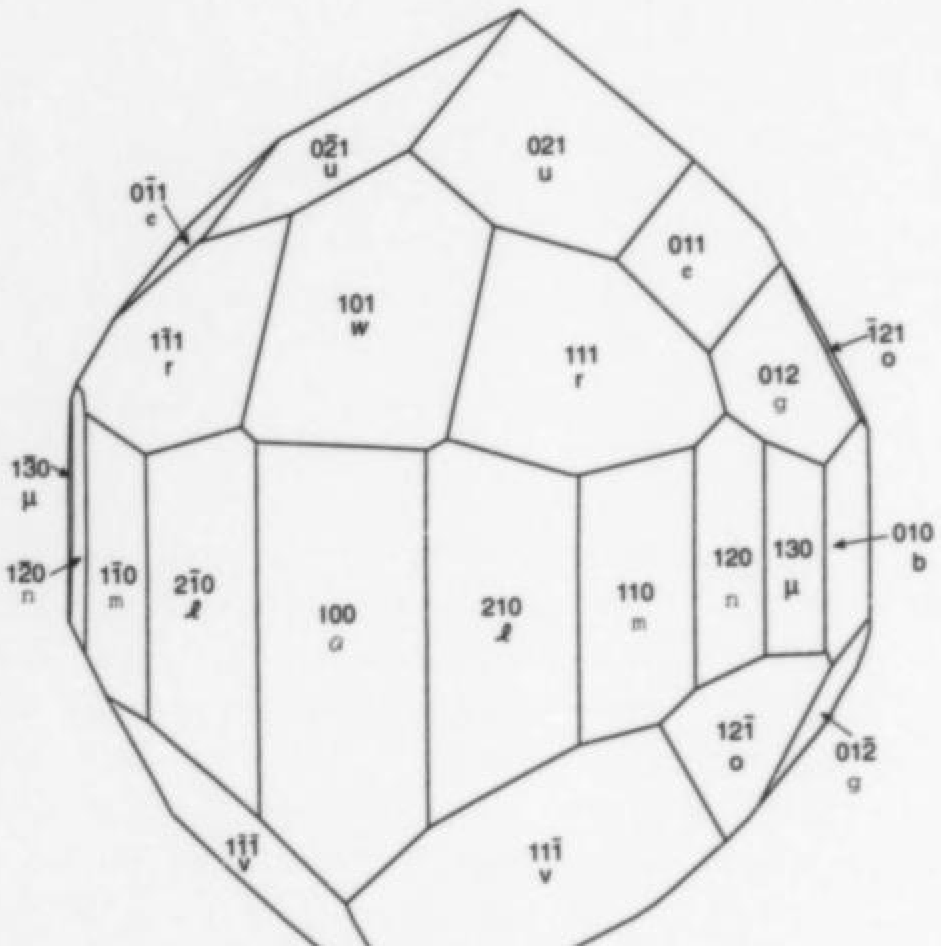

Figure 2. **Idealized crystal drawing of monazite-(Ce) from Franklin, New Jersey.**

celestine, dolomite, fluorapatite, goethite, microcline, pyrite, quartz, rutile, smithsonite and sphalerite was added to the list by Wilk (1989).

Cummings (1988) proposed a new paragenetic sequence based on field observation and examination of specimens from adjacent locations. His model postulates that the Buckwheat dolomite cavity occurrences are essentially a hybrid of Alpine cleft type and Mississippi Valley–type hydrothermal mineralization. This model suggests deposition of cleft-type minerals at 200 to 500°C from fluids whose chemistry is dominated by local rocks, and of deposition of Mississippi Valley–type minerals at 80 to 200°C from fluids whose chemistry is dominated by distant source rocks. It is suggested that the mineralizing agent for the Buckwheat region was fluid migrating out of the Paleozoic meta-sediments, with fluid domination early but changing to rock domination as deposition reduced fluid flow. A second fluid-dominated episode may have occurred subsequently after refracturing of the formation. This sequence would lead to the deposition of dolomite early, silicates and oxides second, and finally sphalerite and calcite.

The studied specimens have been deposited in the Harvard Mineralogical Museum under catalog number 133486.

FRANKLIN MONAZITE

Five small specimens (typically 5 x 5 x 10 mm) each containing monazite were examined in the course of this study. All contain dolomite rhombs and minute (<50 µm) grains of pyrite. Three contain small euhedral quartz crystals. One specimen has quartz, dolomite, pyrite and rutile needles. The monazite, always as transparent, deep yellow, euhedral crystals, occurs in some cases on quartz, more commonly on dolomite, and in some specimens on both. The largest monazite crystal found is 0.7 mm. One specimen, H133486, was selected for study. This possesses two monazite crystals, dolomite, quartz, pyrite and rutile needles. A portion of one monazite crystal was removed initially for the qualitative tests mentioned above. The remainder, called hereafter crystal 1, was used for X-ray and electron microprobe analysis. The other crystal, located about 1 mm from the first and called crystal 2, was used for optical and morphological studies. A scanning electron microscope photograph of a monazite crystal with associated dolomite and quartz is shown in Figure 1.

CHEMISTRY

Crystal 1 was embedded in epoxy and polished for electron microprobe analysis. A Cameca MBX instrument was used with an operating voltage of 15 kV and a current of 30 nA. The analyses are given in Table 1. The standards used were: for Na, albite; Si and Mg, enstatite; Al, kyanite; Ca, wollastonite; Mn, tephroite; Fe, fayalite; Th, ThO_2; and U, UO_2. USNM standards used for P and REE (Jarosewich and Boatner, 1991) were: P and Ce, $CePO_4$ (168484); La, $LaPO_4$ (168490); Pr, $PrPO_4$, Nd, $NdPO_4$ (168492); and Y, YPO_4 (168499). The formula, based on four oxygens, is:

$$(Ce_{0.44}La_{0.35}Nd_{0.17}Pr_{0.05})_{1.01}P_{0.99}O_4$$

Table 1. **Chemical composition of some monazites.**

Oxide	*1*	*2*	*3*	*4*
CaO	0.05	0.04	0.34	0.40
MgO	—	—	0.22	n.d.
MnO	0.02	0.01	—	0.045
FeO	0.01	0.01	—	n.d.
SiO_2	0.05	0.11	0.27	0.18
ThO_2	0.02	0.51	nil	n.d.
Y_2O_3	0.01	n.d.	5.08	1.14
La_2O_3	22.99	25.40	33.19	13.29
Ce_2O_3	30.29	30.23	31.41	34.34
Pr_2O_3	3.45	3.13	(a)	3.73
Nd_2O_3	13.20	10.99	(a)	14.85
P_2O_5	29.61	29.83	29.29	29.87
Total	99.71	100.26	99.80	97.90

1. Spot 1 on sample 93.127 (H133486), Franklin, New Jersey
2. Spot 2 on sample 93.127 (H133486)
3. Analysis 11 for monazite from Llallagua, Bolivia (Palache *et al.*, 1957).
4. Average of 5 spots from H133626, Llallagua, Bolivia

(a) Quoted as $(La,Nd)_2O_3$

The clear dominance of cerium over the other REE establishes this species as monazite-(Ce). The values are close to those given by Palache *et al.* (1951) for a thorium-free sample from Llallagua, Bolivia, also included in Table 1. A sample of Llallagua monazite studied earlier by S. Gordon is still resident in the Harvard collection (H110663). To acquire data on another essentially actinide-free monazite a sample of this material was also analyzed by electron microprobe and the results, presented in Table 1, are in reasonable agreement with the earlier analysis. There appear to be few data in the literature on non-metamict monazites.

X-RAY DIFFRACTION

Crystal 1, measuring 0.3 x 0.5 x 0.6 mm, was studied using a 114.6-mm Gandolfi camera with Ni-filtered Cu Kα radiation. The results are in excellent agreement with those of Carron *et al.* (1958) for pure monazite-(Ce) prepared hydrothermally at 300°C and 90 atm.

MORPHOLOGY

Crystal 2, measuring 0.1 x 0.2 x 0.3 mm, was examined with a Goldschmidt two-circle goniometer and showed the presence of 16 faces representing 13 forms. One rare form, {130}, is present; the rest are typical (Palache *et al.*, 1951). An indexed idealized crystal drawing is shown in Figure 2.

OPTICAL PROPERTIES

Crystal 2, euhedral and optically homogeneous, was studied on the spindle stage, using a wavelength of 589 nm from a Leitz monochromator. The results are: biaxial positive, $2V$ meas. = 24(4)°, $\alpha = 1.790$, $\beta = 1.795$, and $\gamma = 1.847$, all ± 0.005. A sample of monazite from Llallagua, Bolivia (H110663) was also examined on the spindle stage and yielded a $2V$ of 25(2)° with indices of refraction equal to those reported in Palache *et al.* (1951) for material from the same location which was originally published by S. Gordon.

There appears to be an effect of nuclear radiation on the optical properties of monazite. The Franklin and Llallagua non-metamict material both have $2V$ values near 25°. Thorium-containing monazites reported in the literature show $2V$ values ranging from 5° to 15° (Fleischer, 1984; Palache *et al.*, 1951). Index of refraction does not seem to vary in any systematic manner with the actinide content.

DISCUSSION

The occurrence of monazite-(Ce) in the Buckwheat dolomite at Franklin provides the first example of a species from there that contains essential REE. The sources of the REE and phosphorus required can be traced to the local environment with some confidence. The pegmatite south of the Trotter shaft was described by Frondel and Baum (1974) as containing green microcline containing zircon, thorite, titanite and abundant allanite. This pegmatite is within about 300 feet of the northern limit of the Buckwheat pit. Frondel (1964) analyzed allanite associated with green feldspar (microcline) from Franklin as part of an X-ray fluorescence (XRF) study of allanites. Synthetic allanite XRF standards prepared for that study were for the analysis of Y, La, Ce and Nd only. During the course of this study, an electron microprobe analysis was made of the borax glass material used for Frondel's (1964) original XRF analysis. Y, La, Ce, Pr and Nd impurities were found. The quantities are in reasonable agreement with the original analysis if Ce and Pr are combined. Th was not reported by Frondel (1964), but 0.6 weight % ThO_2 was determined by microprobe on the borax glass. Given the association with green feldspar, it is quite probable that the material analyzed by Frondel (1964) is in fact from the pegmatite described by Frondel and Baum (1974). This places an REE source within a few hundred feet of the Buckwheat dolomite.

Phosphorus was reported by Frondel and Baum (1974) to occur almost exclusively in the form of the apatite-svabite series, and was present both in the orebody and the calcsilicate units found in the Franklin marble. Palache (1935) and Peters *et al.* (1983) both report fluorapatite in the Buckwheat dolomite. Thus the phosphorus source was also very near at hand. Following the model of Cummings (1988), one may postulate the reaction of REE-containing fluid with indigenous phosphate to form monazite. The REE, Th and Y seen in the allanite are also found in the monazite, with no other REE present in the latter. Chondrite-normalized distributions for both minerals, prepared to facilitate comparison with the literature and given as Figure 3, show relative enrichment in La and Nd and depletion in Pr for monazite-(Ce) relative to allanite. Both distributions fall within their respective fields for REE in allanite and in monazite in metamorphic rocks as displayed by Grauch (1989). Carron *et al.* (1954) showed that synthesis of monazite was not possible below 300°C at 90 atm, with rhabdophane forming at lower temperatures. One may add the constraint of a minimum temperature of deposition of about 300°C, dependent on the effect of pressure on the rhabdophane-monazite transition observed by Carron *et al.* (1958). This would place the formation of the monazite-(Ce) in the latter part of the first fluid-dominated phase of the Cummings model and as an Alpine cleft-type of deposit. The foregoing constitutes a likely paragenesis for the monazite-(Ce), but other sources of REE could be invoked, from either the transecting mica-diabase dikes or from the Cork Hill gneiss.

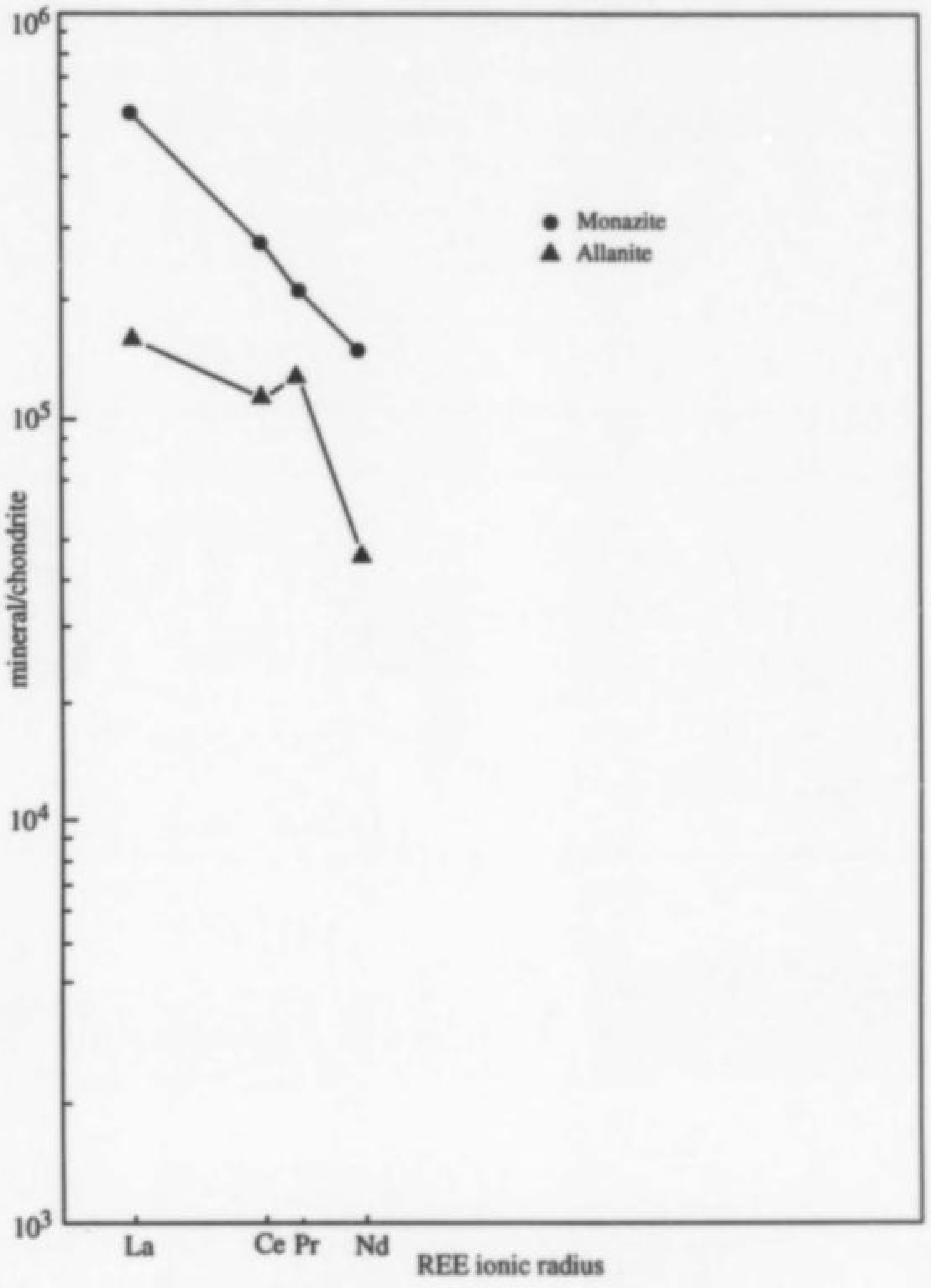

***Figure 3.* Chondrite-normalized ratio for monazite-(Ce) and allanite from Franklin, New Jersey.**

However, the chemical similarities suggest the pegmatite as the likely REE source.

ACKNOWLEDGMENTS

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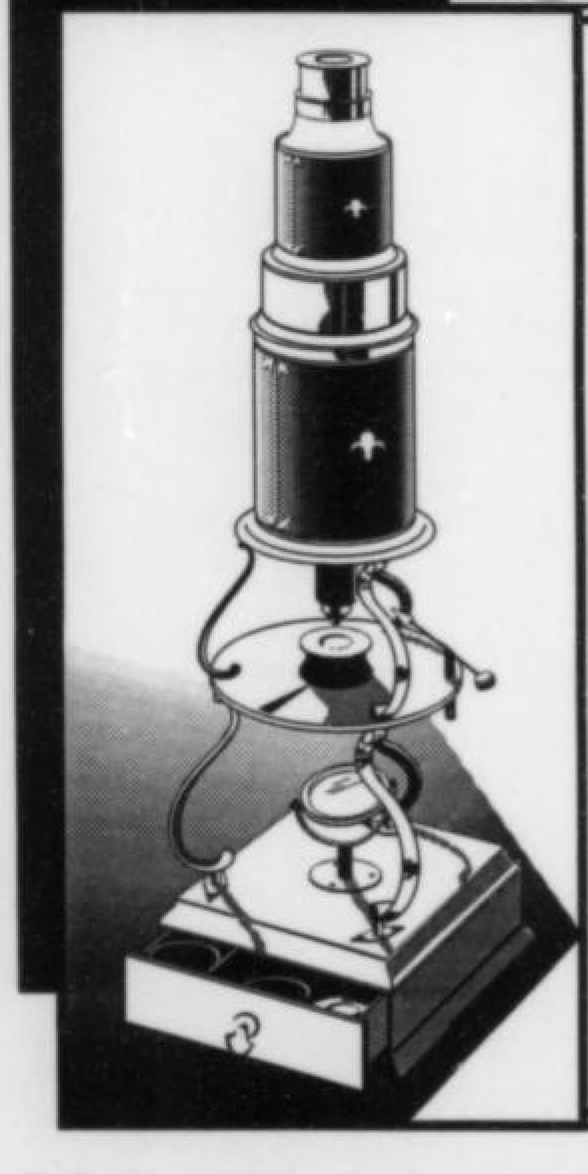

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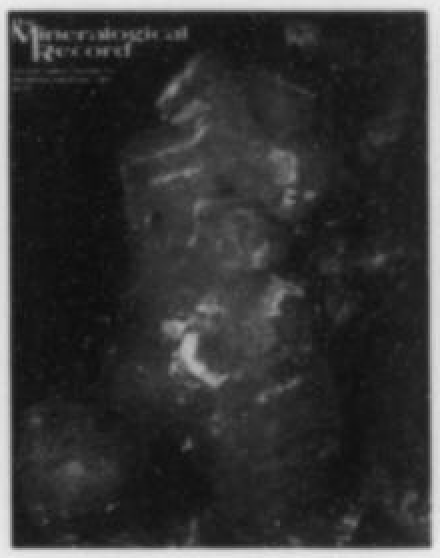

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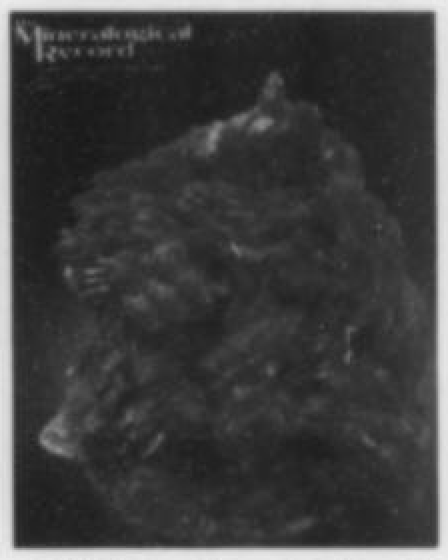

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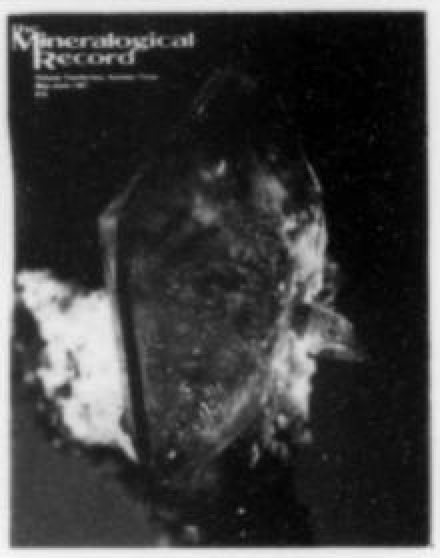

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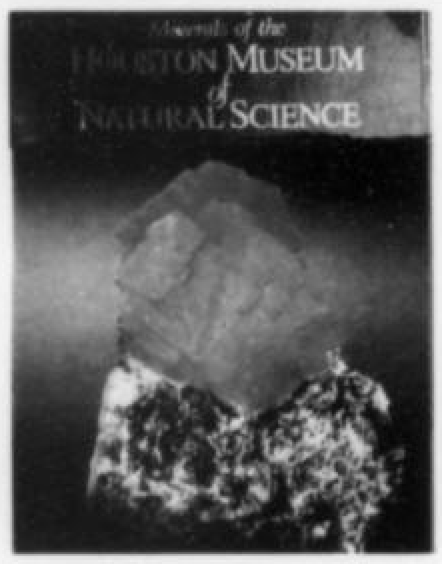

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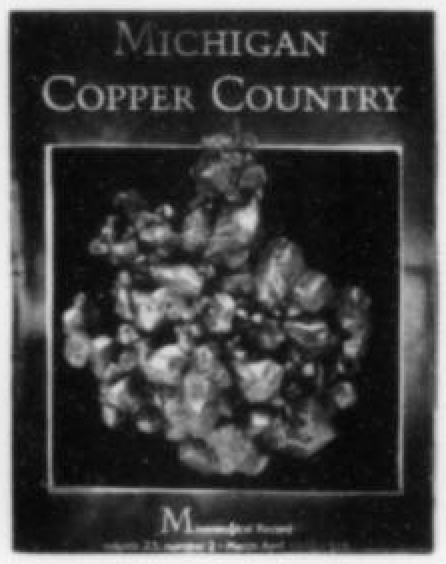

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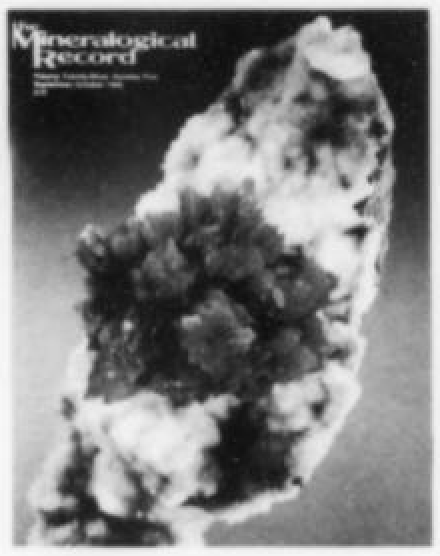

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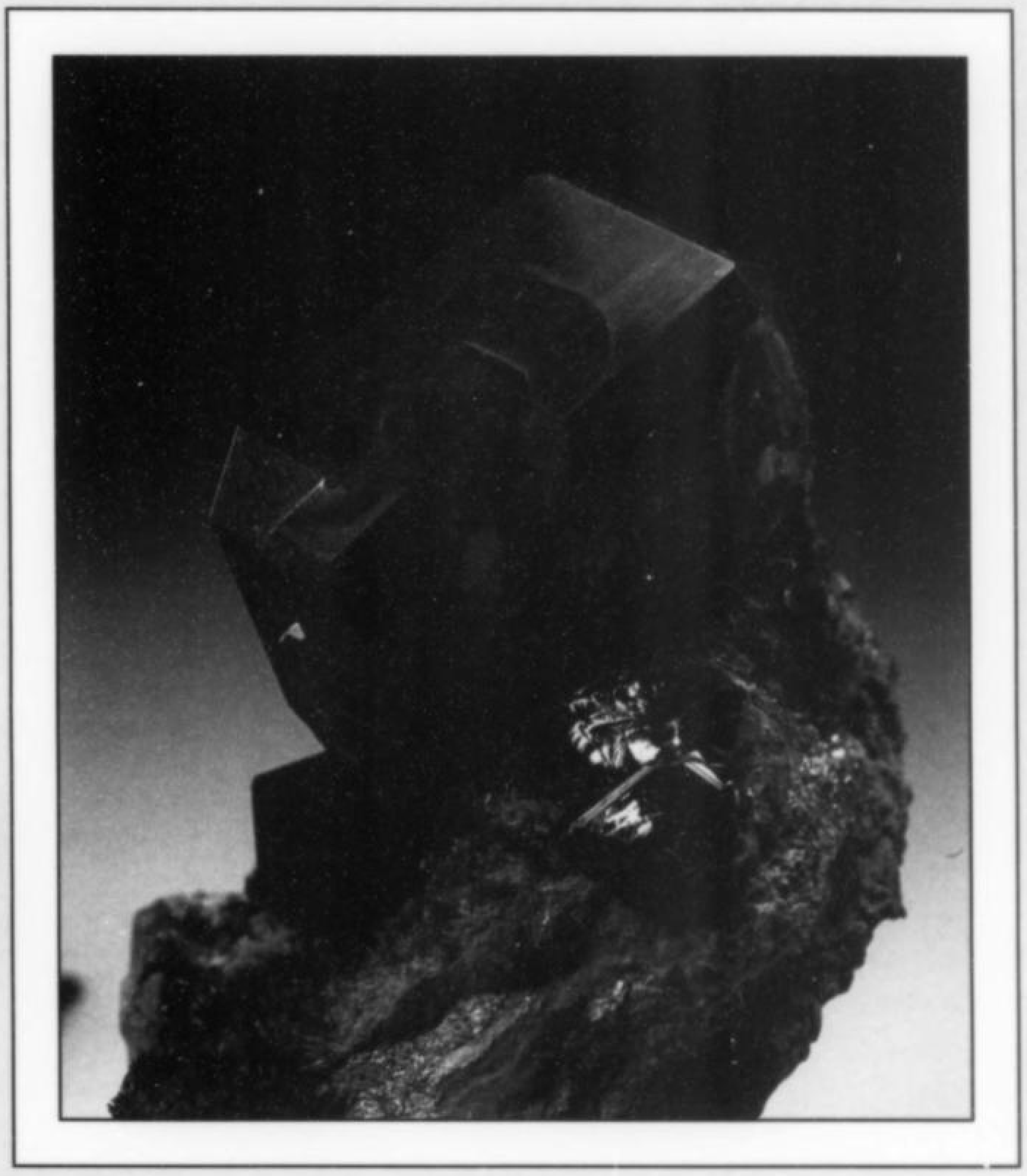

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What's New

in Minerals

Bologna Show 1996

by Renato Pagano

Bologna, a lovely Italian city located about 100 km north of Florence, at the base of the Apennines, has been a center of art and culture since Roman times. Its famous university, founded in the 11th century, is certainly one of the oldest in Europe. In more recent times, Bologna has been the center of a large community of mineral collectors, and a mineral show has been organized there annually for 26 consecutive years. The requests for space in recent years had substantially outgrown the area available in the usual building at the Bologna fairgrounds; finally this year the organizers expanded the show into the adjacent *Palazzo dei Congressi.*

The 27th edition of the Bologna Show was organized in style: about 250 exhibitors shared 800 meters of table space. The foreign dealers were present in significant number (over 25% of the total), mainly from France, Spain, Germany, various Eastern European countries and even India and Morocco. The average quality of the specimens was high. The show featured a special exhibition of Elba minerals, set up in cooperation with various institutions (the University of Florence, the Regional Museums of Natural History of Pisa and Torino, the University of Rome, the Museum of Leghorn) and numerous private collectors. Several cases included the very best Elba specimens from the pegmatite veins of the San Piero in Campo area, from the iron mines of Rio Marina and Capo Calamita and from other localities on this mineral-rich island.

Next year the show will take place on March 14–16, under the patronage of the Department of Mineralogical Sciences of the University of Bologna. The exhibition theme will be the Carrara Marble minerals; those *Mineralogical Record* readers who have enjoyed the article by Franzini, Orlandi, Bracci and Dalena on this famous locality (vol. 18, p. 263–296), which won the Friends of Mineralogy Best Article Award for 1987, will also enjoy visiting the 28th Bologna Show and perhaps doing some sightseeing in this beautiful old-world city.

Rochester Symposium 1996

by Jeffrey A. Scovil

[April 18–21]

Most people don't think of the basalts of Virginia when **datolite** is mentioned, but *Topaz Mineral Exploration* had some that drew me up short. In December of 1995 one pocket was hit at the Virginia Traprock quarry in Leesburg that produced very attractive, tabular to prismatic, pale green crystals to 2.4 cm, loose and on matrix.

Mongort Minerals has been actively mining the pegmatite at the Emmons quarry in Greenwood, Maine, and made a large find of the rare mineral **perhamite**. The tan hemispheres up to 6 mm are associated with white cleavlandite. Specimens were available from micromount size to small cabinets. The best piece has several hemispheres nearly 1 cm across. Also found at the Emmons quarry were some fine **goyazite** microcrystals in clusters to 1.2 cm.

Larry Venezia had some interesting twins of adularian **orthoclase** from Morro Redondo, Minas Gerais, Brazil. The off-white crystals on a matrix of cleavlandite are X-shaped twins that appear to be a combination of Manebach and Baveno laws. Individual crystals up to 14 cm across were collected in the fall of 1995.

The old asbestos quarry in Eden Mills, Vermont, has been "officially" closed for some time now, but collecting there goes on. Mike Haritos of *S.T.D. Minerals* was justifiably proud as he showed me some of the finds that he and several others have made recently. The locality is known for its superb, gemmy, cinnamon-colored **grossular** garnets, which Mike had in large clusters with crystals over 1 cm across. Particularly aesthetic are the individuals perched on prisms of pale green **diopside,** in thumbnail and miniature sizes. Mike also had a nice selection of single, well-terminated **clinozoisite** crystals (reported previously) collected over the previous two years, the most recent specimens having come out September of 1995.

Danny Trinchillo (*De Trin Mineral Company*) has been delving deeper into the Chinese hinterland, in addition to his trips to Russia. From a locality near Chenzhou, Hunan, he obtained some interesting **sphalerite**. The rich orange-brown crystals to 3.7 cm across are actually complex multiple crystals on drusy quartz with dull, cuboctahedral **galena** (to 1.2 cm) and **chalcopyrite** crystals (to 5 cm) plus minor rhombohedral calcite.

From Linopolis, Minas Gerais, Brazil, *Hawthorneden* has obtained some nice twinned **wodginite** crystals to 2 cm. The material had been sold to them as "cassiterites." Frank Melanson of *Hawthorneden* also pointed out some rather nice **wardite** crystals perched on green **elbaite** from the Pirineus mine, Itinga, Minas Gerais, Brazil. The combination is quite a pleasing one, especially since many of the elbaite crystals are terminated.

Vietnam has produced a surprise again—this time the locality is Thah Hoa Province in North Vietnam. Larry Conklin had an exquisite **aquamarine** about 8 cm long from the locality. The crystal is very clean and not water-worn as some of the other Vietnamese pegmatite minerals are.

One of the many fine displays that caught my eye was that of William and Viki Hladysz. Bill and Viki have been collecting at the Eastern Rock Products quarry in Saint Johnsville, New York, for several years. This quarry is in the famous "Herkimer diamond" **quartz** region, and produces its share of the lustrous crystals. The really interesting material coming from this quarry though, is the "Herkimer diamond" scepters on black, heavily included shafts. Some of the crystals are even found on matrix with fine calcite and dolomite crystals. To make things even more interesting, some of the calcites have phantoms outlined by included pyrite crystals.

Figure 1. **Partial view of the show floor at the 1996 Bologna Show. C. Baratta photo.**

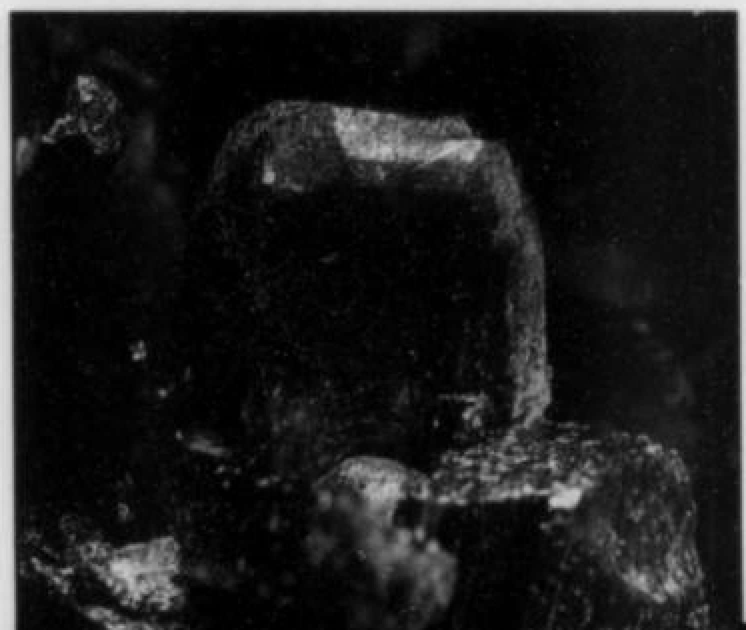


Figure 2. **Chalcostibite crystal, 1.5 cm, from Saint-Pons, Barcelonnette, Alpes de Haute Provence, France. Cristophe Dubois specimen; R. Appiani photo.**

Figure 3. **Emerald crystal, 1.5 cm, on matrix from Cosquez, Boiaca, Colombia. Ennio Prato specimen; R. Appiani photo.**

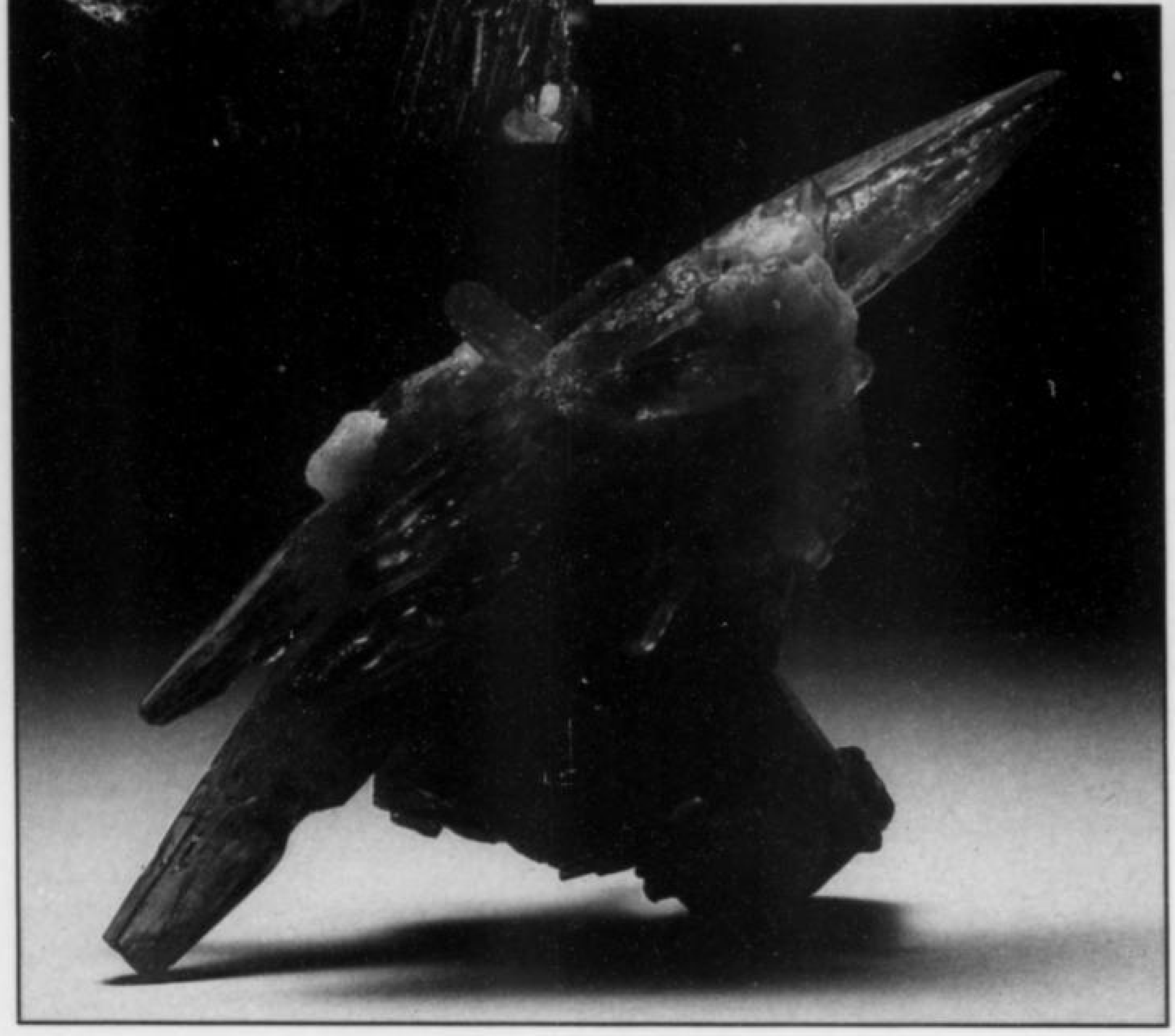


Figure 4. **Aquamarine crystal group, 7 cm, from the Mimoso do Sul mine, Espirito Santo, Brazil. Lino Caserini specimen; R. Appiani photo.**

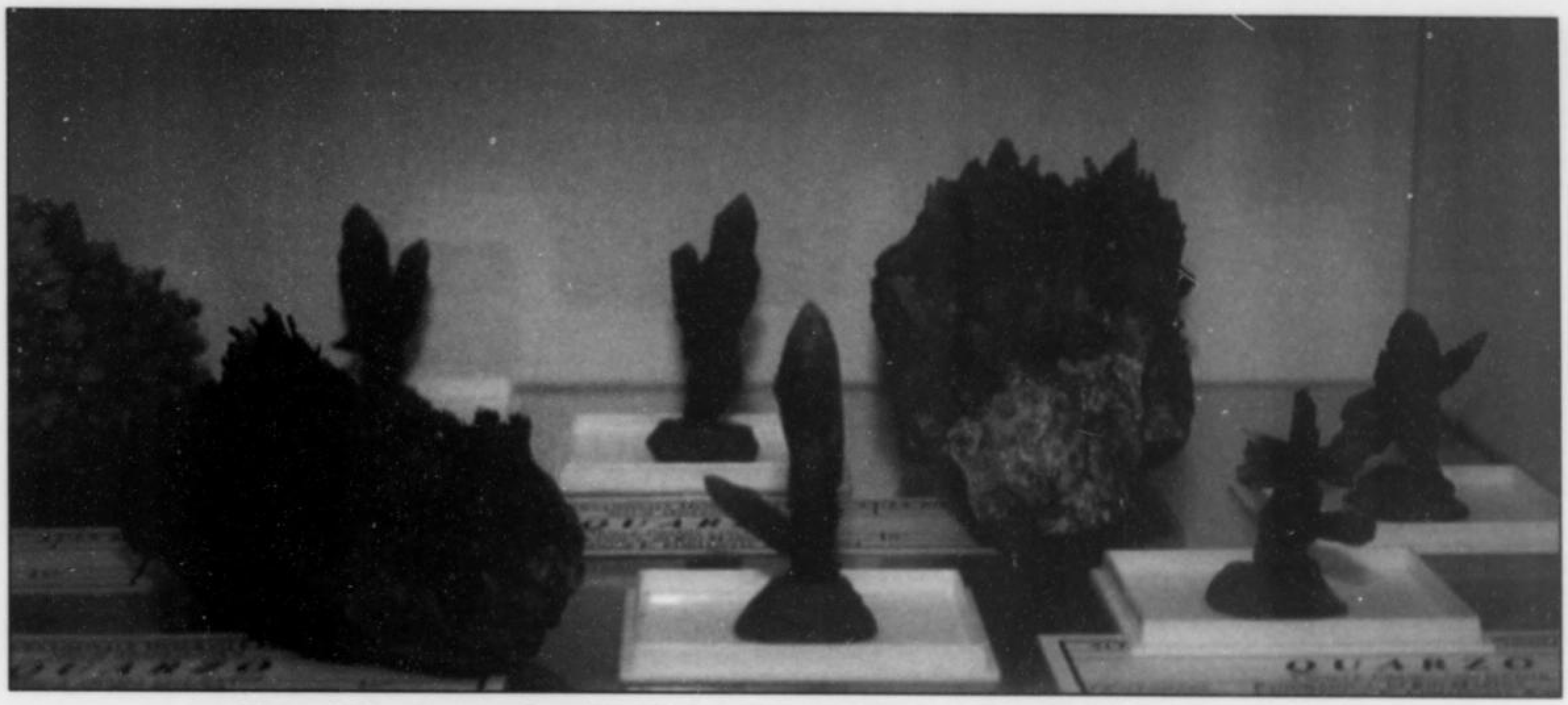


Figure 5. Green quartz from Rio Marina, Elba, exhibited by F. Fortunati. C. Baratta photo.

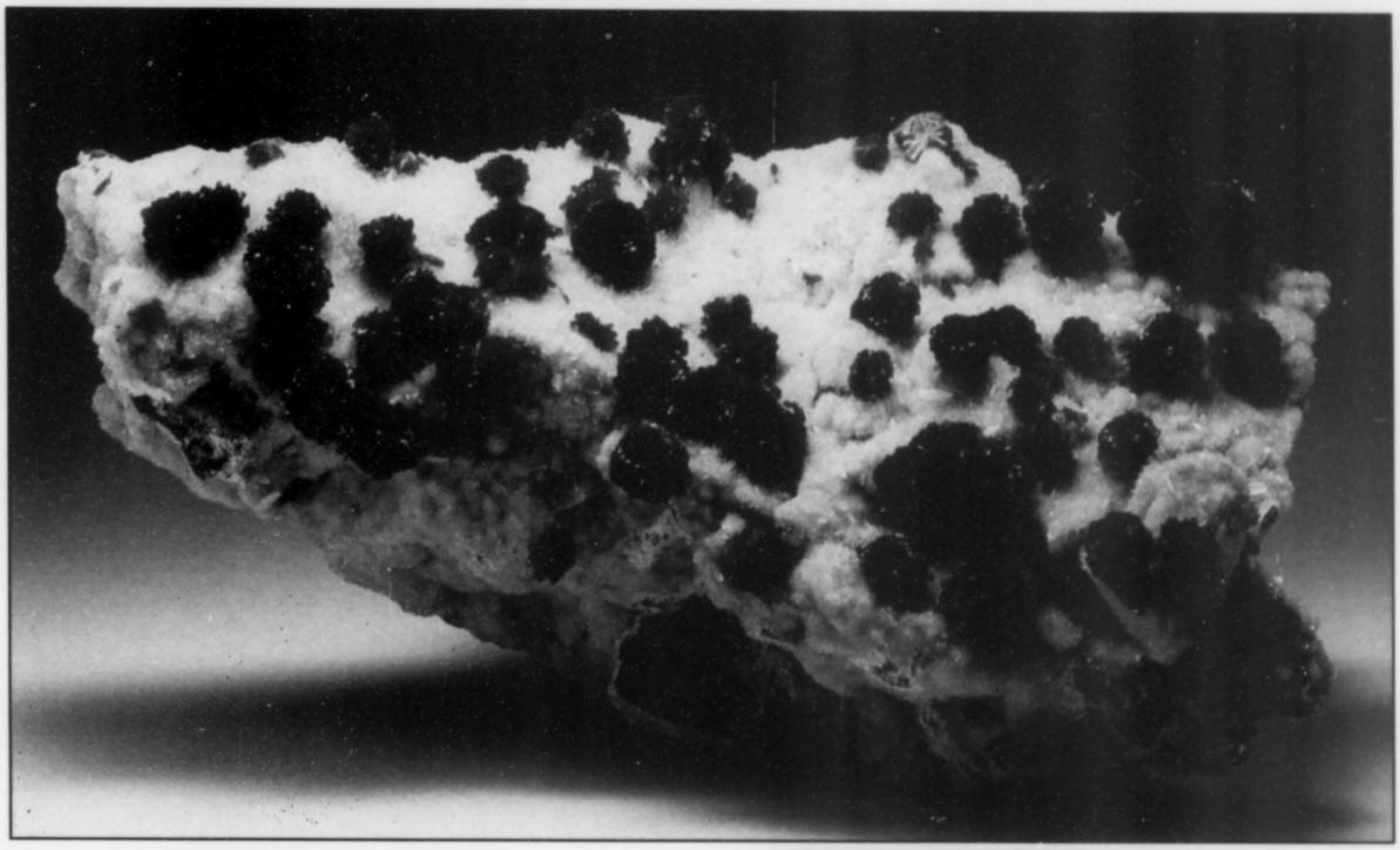


Figure 6. Cavansite crystal clusters on matrix, 18 cm, from the Wagholi quarry near Poona, India. *Ottens Mineralien* specimen; R. Appiani photo.

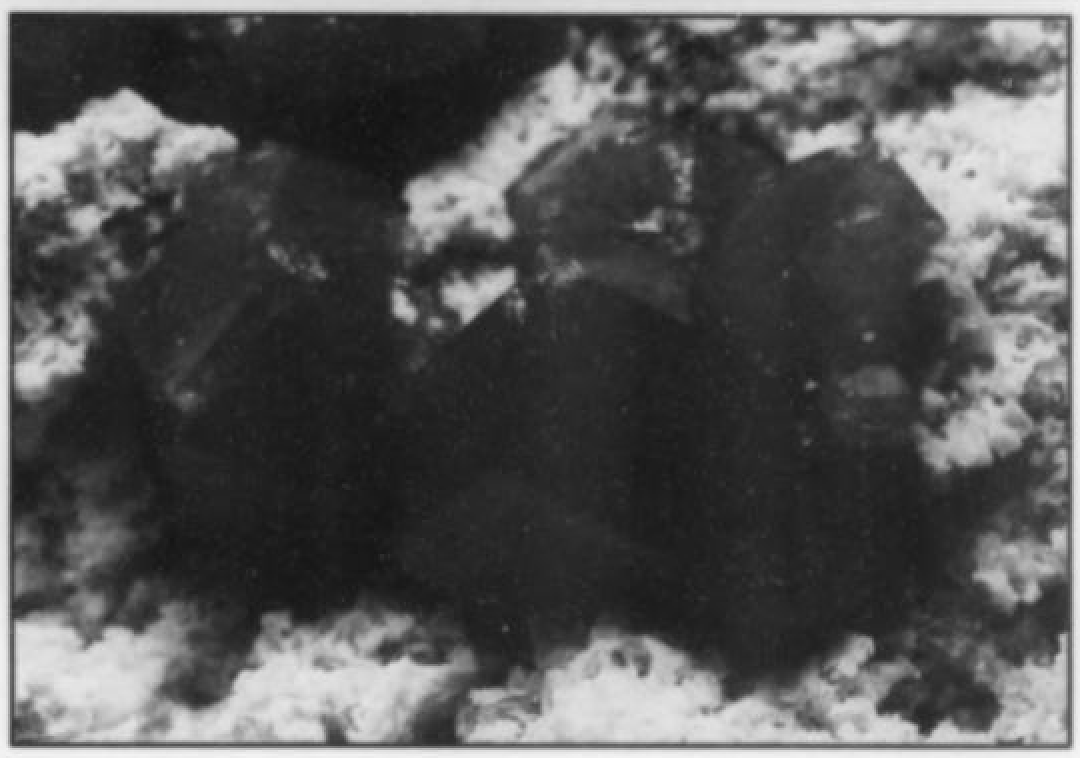


Figure 7. Grossular crystals to 1 cm from Sierra de Cruces, Coahuila, Mexico. Lino Caserini specimen; R. Appiani photo.

Cincinnati Show 1996

by Jeffrey A. Scovil

[May 3–5]

The Cincinnati Show also had several new finds this year. Mike New of *Top Gem* specializes in Mexican minerals, including some interesting material from the classic danburite locality of Charcas, San Luis Potosi: Japan-law twinned, pale **amethyst quartz** crystals. Their appearance is enhanced by a light sprinkling of pyrite microcrystals. Even more interesting are the pale blue **danburite** crystals coating larger, rather etched, prismatic **danburite** from the same locality. The small crystals are tabular and diamond-shaped. When first found, they were thought to be barite or datolite crystals. The danburite encrustation is so dense that it nearly obscures the larger danburite. The exact locality is the Rey & Reina mine, level 12. The first find was made on March 29, 1996. A total of 104 pieces were recovered and are being sold retail by *Dave Bunk Minerals* and *M. Phantom Minerals.*

Mike New also had some very nice **calcite** crystals from the San Martin mine, Zacatecas, Mexico. The crystals show a large variety of forms, but the most aesthetic are simple prisms terminated by a low rhombohedron. The colorless, gemmy crystals reach up to 5 cm long, in clusters to 15 cm across. Minor associates include pyrite, sphalerite and some included stibnite.

Costa Mesa Show 1996

by Jeffrey A. Scovil

[May 17–19]

The *West Coast Gem & Mineral Show* in Costa Mesa, California, is the most international of the spring shows, with dealers from around the world. A relatively new dealer on the scene (this was her third show) is *Debbie Meng's Minerals.* Both the dealers and show visitors were having a field day with her very reasonably priced and good quality **pyrite** concretions from Guangxi, China. Most of the specimens are flattened, discoidal forms, with a core of small crystals surrounded by a rim of more coarsely crystallized pyrite. The largest are 12 cm across. From a new tungsten mine at Xianghuapu, Hunan, Debbie had obtained some **scheelite** and **cassiterite** crystals that were not too impressive. What *is* impressive from the locality is the clusters of green **fluorite** cubes, many exhibiting phantoms. The crystals are up to 5 cm across, in clusters up to 30 cm.

What are probably the largest **boracite** crystals in the world, were being sold by Alfredo Petrov. The crystals are simple, pale blue cubes, some in matrix up to 2 cm across, from Alto Chapare, Bolivia. This is the same locality that produced the doubly terminated **danburite** crystals I reported on previously, as well as a rare member of the tourmaline group, **povondraite**. Alfredo told me that some of the crystals show an interesting color change to brownish gray under fluorescent lights. From the same locality he also had **ericaite**, which is the Fe end-member of a series with boracite. The ericaite crystals are pale pink and up to 1 cm in size.

Alfredo also had some interesting fans of **epidote** crystals on matrix from Kari Kari, Potosi, Bolivia. The dark green fans, to 3 cm long, are made up of many fine, prismatic epidote crystals.

Luis Menezes always has choice new material from Brazil, and this show was no exception. The first things to catch my eye were the brownish, champagne-colored fluorapatite crystals up to 5.4 cm long. The gemmy, mostly loose prismatic crystals are from Teofilo Otoni, Minas Gerais, and were collected from a small pocket in May of 1995; then a larger pocket was found in October of the same year. The specimens were actually being sold by Jose Barbosa of *The Gemmological Center,* who was sharing the room with Luis. The same locality produced some bright yellow microhemispheres of the rare uranium mineral **haiweeite** on calcite.

Ouro Preto is known as the source of the world's best "imperial" topaz; now it is also known for some very fine **hematite** roses. Luis had lustrous, black groups up to 12 cm across and as good as any I have seen from other Brazilian localities.

An item of interest, especially for collectors of things from Arizona, was the **dioptase** crystals from Morenci that Mike New of *Top Gem* had for sale. This is the first find of the species at Morenci. The attractive specimens are composed of druses of prismatic, bright green crystals up to 3 mm long on botryoidal, drusy quartz. The quartz formed on massive chrysocolla which ranges from very poor to top gem-grade material. Some of these specimens are being retailed by Les Presmyk of *De Natura.*

The Russian dealer *Stone Flower* had some surprises, including wonderful **magnetite** crystals. The magnetites are clean dodecahedra up to 3 cm across, on matrix associated with beautiful fans of **epidote** to 2 cm, drusy **quartz**, **hematite** platelets, **calcite** scalenohedra to 5 cm (some as butterfly twins), **chalcopyrite**, druses of small, brown **andradite** crystals, and white, prismatic **fluorapatite**. This is the same locality that produced the single fluorapatite at the Tucson Show that *The Collector's Edge* had—Daskesan, Azerbaijan. Photographs of the locality show a tremendous open pit iron mine; it has been in operation for 50 years but has recently closed. Some of the quartz is amethystine, forming bow-tie-shaped, doubly terminated clusters reminiscent of the amethyst from Guerrero, Mexico.

The biggest news of the spring had nothing to do with any mineral shows. Most people know by now that Wayne Thompson started mining the Red Cloud mine, La Paz County, Arizona, in the fall of 1995 (see the article in the previous issue). On April 1, 1996, Bob Johnson, one of the crew members, hit a pocket which may well be the largest ever found at the mine. Dave Bunk was one of the lucky dealers to get there early and had some of the material for sale at the Cincinnati and West Coast Shows. *De Trin Minerals* also bought a large quantity of material, which should be available at the East Coast Gem and Mineral Show in August. Plenty of material will be available from a number of dealers at the big Denver Show in September.

New Exhibits at the Carnegie Museum

by Sandra P. Lepri

Ongoing major renovations to the Hillman Hall of Minerals & Gems at the Carnegie Museum of Natural History in Pittsburgh will soon include permanent installations of *Pseudomorphism in Minerals* (in October 1996) and *Minerals of the Former Soviet Union* (in January 1997), the latter exhibit spurred by new acquisitions to the museum's "Russian Suite" collection. A display of *Amber* and a renovation of the *Pennsylvania Minerals & Gems* exhibit were recently completed in November 1995 and April 1996 respectively.

Since its opening in 1980, the Hillman Hall of Minerals & Gems has been highly regarded for the depth of its collections, the beauty of its specimens and its commitment to scientific explication. Ongoing acquisitions and renovations have made this possible, but also ensure that the visitor's trip to Hillman Hall is always filled with surprises. The recent phase of the renovation is a significant milestone in the hall's development.

Twenty-four specimens, representing the eight categories of pseudomorphs as defined by a modified version of Dana's 1898 classification, will be on permanent display in *Pseudomorphism in Minerals*. Of those specimens, 17 are new to the collection. The specimens have been acquired from collections and mineral dealers all over the world, and are of particularly high quality both scientifically and artistically.

Pseudomorphs, minerals that take on the shape of other minerals in the formation process, "are typically so ugly only a mother could love them," jokes Marc Wilson, collection manager and head of the Section of Minerals. The goal of *Pseudomorphism in Minerals* is to display specimens important enough to illustrate adequately the scientific aspects of the pseudomorphism processes and yet also attractive enough to interest the public.

Minerals of the Former Soviet Union will show the dramatic expansion of the Hillman Hall's "Russian Suite," examples of which were first unveiled in April of 1994. The permanent exhibit will feature 35 select specimens, 16 of which are new to the Hillman Hall, from the various republics of the former Soviet Union. The specimens are from a suite of approximately 300 minerals, two-thirds of which are exhibit quality, acquired over the last few years by the Museum. The suite represents one of the finest in the Western Hemisphere; some of the most noteworthy specimens include betekhtinite, silver and bertrandite from Kazakhstan; gem heliodor beryl from the Ukraine; and stibnite and barite from Kyrgyzstan. A host of Russian specimens includes a copper crystal cluster collected in 1848; an 18-cm cluster of emerald crystals; and superb crystals of galena, sphalerite, chalcopyrite and pyrrhotite from Dal'negorsk in the Russian Far East.

Specimens from important ore deposits in the Soviet Union were practically unobtainable after 1917 and have become available to Western museums only in the last few years. Of interest to the economic geologist and mineralogist alike, these deposits produced minerals of extreme rarity, breathtaking beauty and great scientific value. Several of the Carnegie's Russian specimens are among the finest known examples of their species from these or other localities.

In April 1996, the Bryon Brookmyer collection of Pennsylvania minerals was installed in the Hillman Hall. Currently in the *Pennsylvania Minerals* and *Pennsylvania Minerals & Gems* exhibits cases, 128 of 133 specimens are on long-term loan from Brookmyer. Included are some of the finest mineral specimens ever collected in the Commonwealth of Pennsylvania, some recently collected and some over 100 years old. Of particular note is the *Pennsylvania Minerals & Gems* exhibit case complex which presents "rough and cut" Pennsylvania gems and gem minerals with fiber optic illumination.

The Hillman Hall's new educational display of *Amber* was installed with explanatory text in November 1995 in a specially designed case. Eighteen specimens represent a wide range of amber, including succinite and retinite, and a common amber substitute, copal. Unworked amber and copal are displayed along with finished amber products such as necklaces, carvings and freeform polished specimens. A suite of seven retinite specimens from the Dominican Republic illustrate the range of color in amber. Three specimens contain easily recognizable insect inclusions. Five specimens (one carving, one worked succinite and three with insect inclusions) are backlit with fiber optic illumination to better illustrate colors, structures and inclusions.

The Carnegie Museum of Natural History is open Tuesday through Saturday from 10 am to 5 pm and Sunday from 1 to 5 pm. Admission is $5 for adults, $4 for senior citizens, $3 for children and students, and free for members. Parking is $1 per hour on weekdays and $3 flat rate on weekends and evenings in the Carnegie's garage at Forbes Avenue and South Craig Street. For information, call (412) 622-3131.

Springfield Show 1996

by Tom Moore

[August 9–11]

The East Coast Gem, Mineral and Fossil Show in West Springfield, Massachusetts, attracted, as usual, enough good mineral people and mineral features to firm up its reputation as the East's leading annual show. Accustomed to (and spoiled by) the extravaganzas at Tucson and Denver, one might still unguardedly go to this as to a merely "local" show, but a first glance from the entrance out over the sprawling peneplane of show floor corrects one's attitude: there is undoubtedly a frenzied time ahead if the visitor wants, as I did, to do justice to the event in a single day.

To the right (going in) was the familiar what's-old-in-cholesterol food concession and eating area, and hard by this were trusty Charlie and Marcelle Weber selling back issues of, and new subscriptions to, *The Mineralogical Record*. Back by popular demand, there was Marty Zinn's kid-friendly Emerald Store. And any young geophiles who weren't clustered here, buying pretty stones for a buck apiece, were probably standing in line to enter the darkened alcove which was advertised as a "Gem and Fossil Mine"; for $6 admission the kid-geophile got to keep everything he/she could find inside! This year, too, a proud Jeff Scovil was on hand to sell autographed copies of his fine new book on mineral photography, and Joe Peters and Bob Jones offered educational talks.

The three doubled-sided rows of exhibit cases seemed always to have about as many gawkers around them as did any comparable space on the selling floor—a good omen for intellectual curiosity. The general show theme this year was "birthstones"; the general emphasis, as in most years, was on New England minerals; and surely the general quality of the exhibits was as high as at just about any show anywhere. Some individual "birthstone" species got their own individual cases, but the best general array of these stones, rough and cut, and extremely pretty in overall effect, was in the case put in by the American Museum of Natural History, New York. Other cases harbored miscellanies of knockout mineral specimens (Russell Behnke, Joe Polityka, the Carnegie Museum, Harvard, the Pratt Museum of Amherst, Massachusetts); minerals of western Massachusetts (Springfield Science Museum); dramatic feldspar-group specimens from everywhere (Roy A. Smith); Al_2SiO_5 polymorphs (Yale/Peabody Museum); self-collected Connecticut minerals (Joel Sweet); and many others to whom I willingly apologize for not having the space to list them. Finally, the Houston Museum had a "new acquisitions" case which included two spectacular foot-long Afghanistan specimens, each with a terminated gem spodumene crystal in matrix (one kunzite, one hiddenite), and, from Pakistan, a most amazing gemmy, medium-green, textbook-perfect 5 x 6-cm herderite crystal on a 20-cm white feldspar matrix.

On, then, to what's new, and otherwise what's happening, among the dealers:

Dudley Blauwet of *Mountain Minerals International* had a couple of flats of yet another new find of **heulandite** from India—specifically, from a quarry about 20 km from Sangamner on the Poona-Nasik Road, Maharashtra. Here were found, last May, intergrown clusters of the distinctively slightly twisted "coffin" crystals of heulandite, in form exactly like the now familiar chlorite-including green ones but, this time, of a lovely creamy orange-white opaque color (though some have very faint green overtones), and with medium glassy luster. Individual coffins and tight stellate intergrowths can reach 4 cm, and stacked groups of lightly attached crystals, occasionally with some matrix, can reach 15 cm across; all are very appealing.

Dudley also showed me—radically to change the mineralogical subject here—one of the only three so-far-known specimens of **cubic gold** crystals in sulfide matrix from the Talaya River, Transbaikal, Chita Oblast, Siberia, Russia. According to Dudley the other two specimens are much better, but already are in private hands. The one I saw shows a sharp, 2-mm simple cube of gold sitting lightly in a cavity in a platy gray (unidentified) metallic

Figure 8. Small danburite crystals encrusting a large danburite crystal group, 10.4 cm, from the Rey & Reina mine, Charcas, San Luis Potosi, Mexico. *Top Gem* specimen; Jeff Scovil photo.

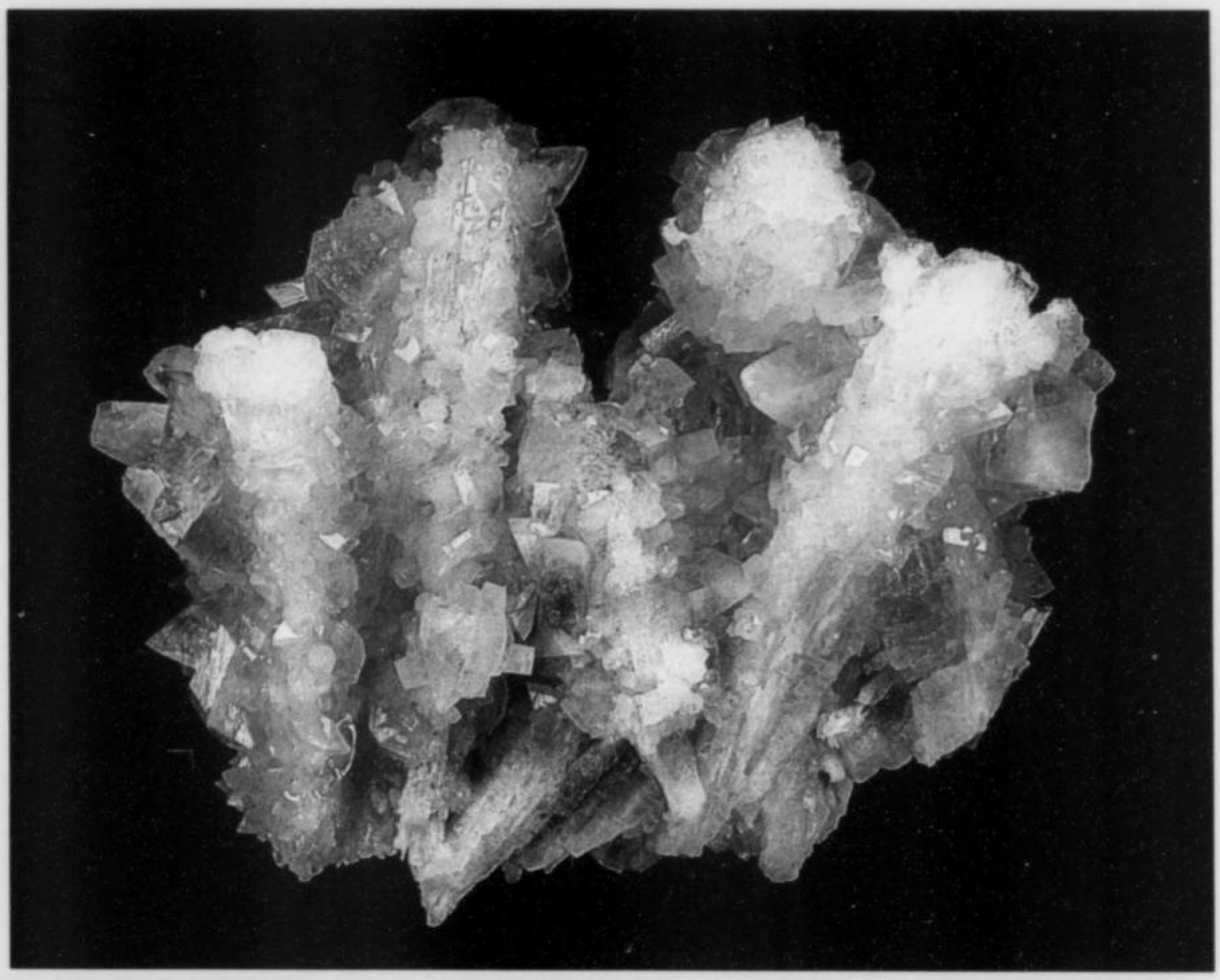


Figure 9. (below) Wodginite, 1.6 cm, from near Linopolis, Minas Gerais, Brazil. *Hawthorneden* specimen; Jeff Scovil photo.

Figure 10. Fluorapatite, 1.4 cm, with calcite and quartz from Dzhezkazgan, Azerbaijan. Dave Bunk specimen.

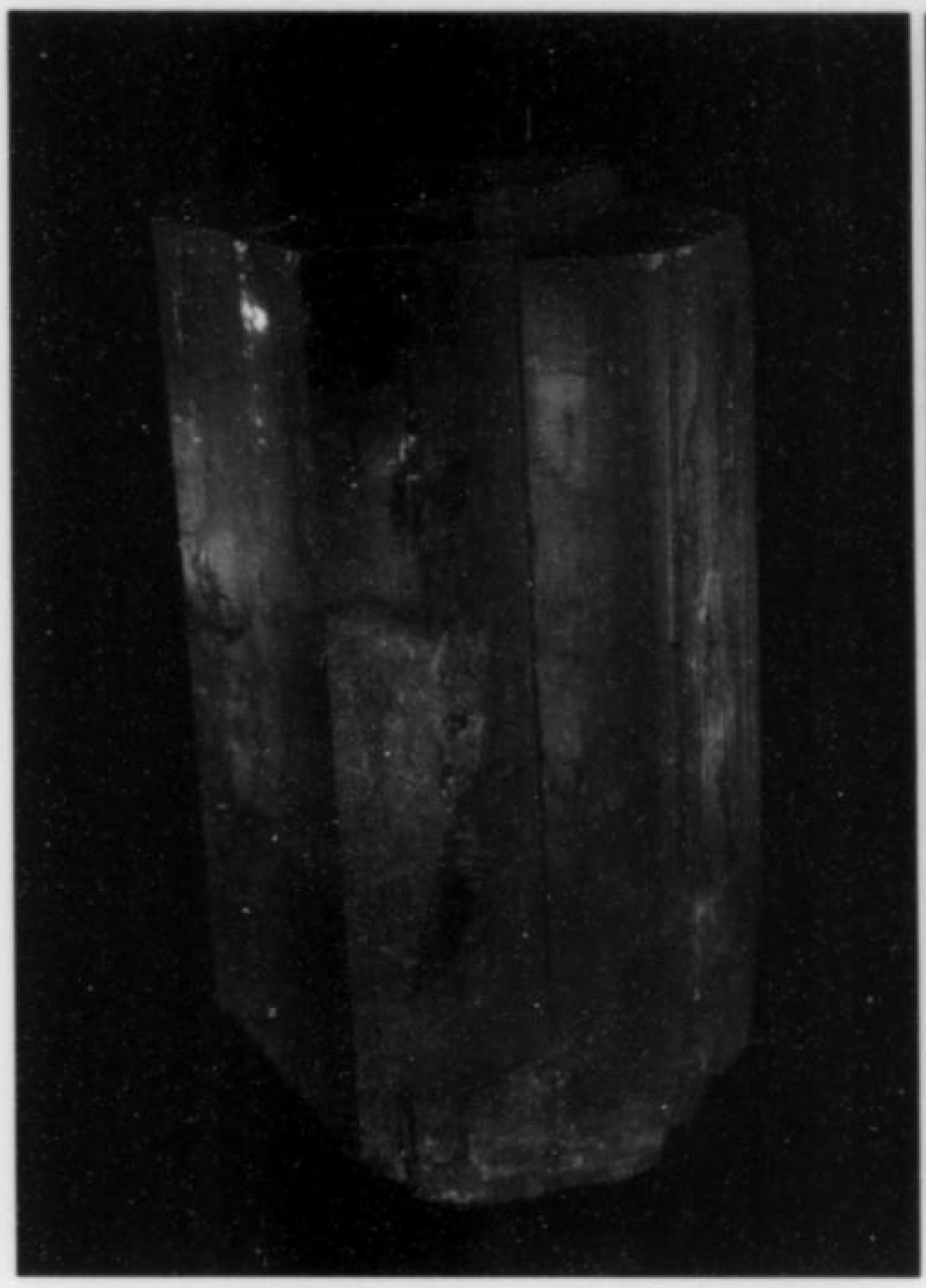


Figure 11. **Beryl crystal, 8 cm, from Thah Hoa Province, Vietnam. Larry Conklin specimen; Jeff Scovil photo.**

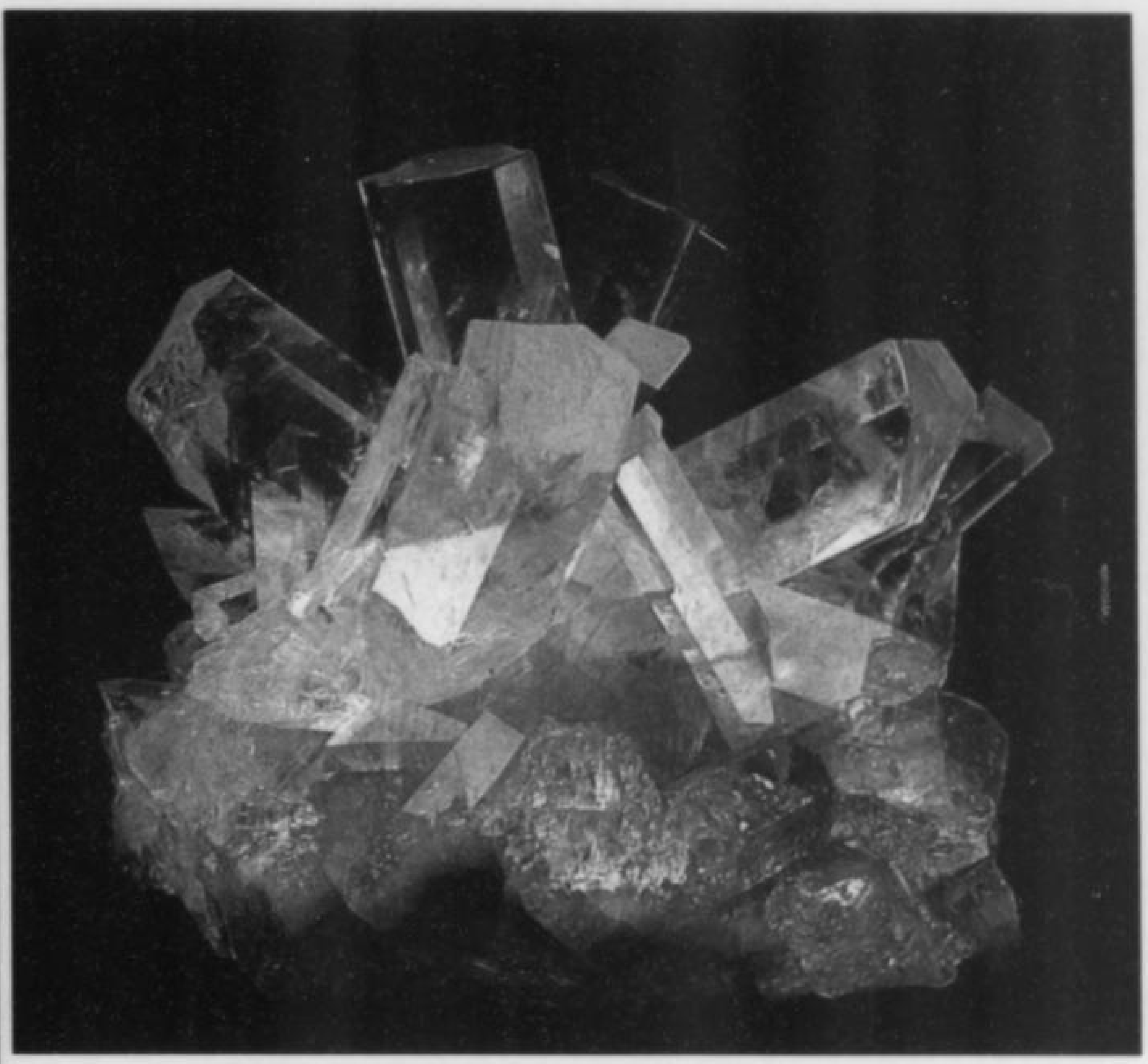


Figure 12. **Calcite crystal group, 4.5 cm, from San Martin, Zacatecas, Mexico.** ***Top Gem*** **specimen; Jeff Scovil photo.**

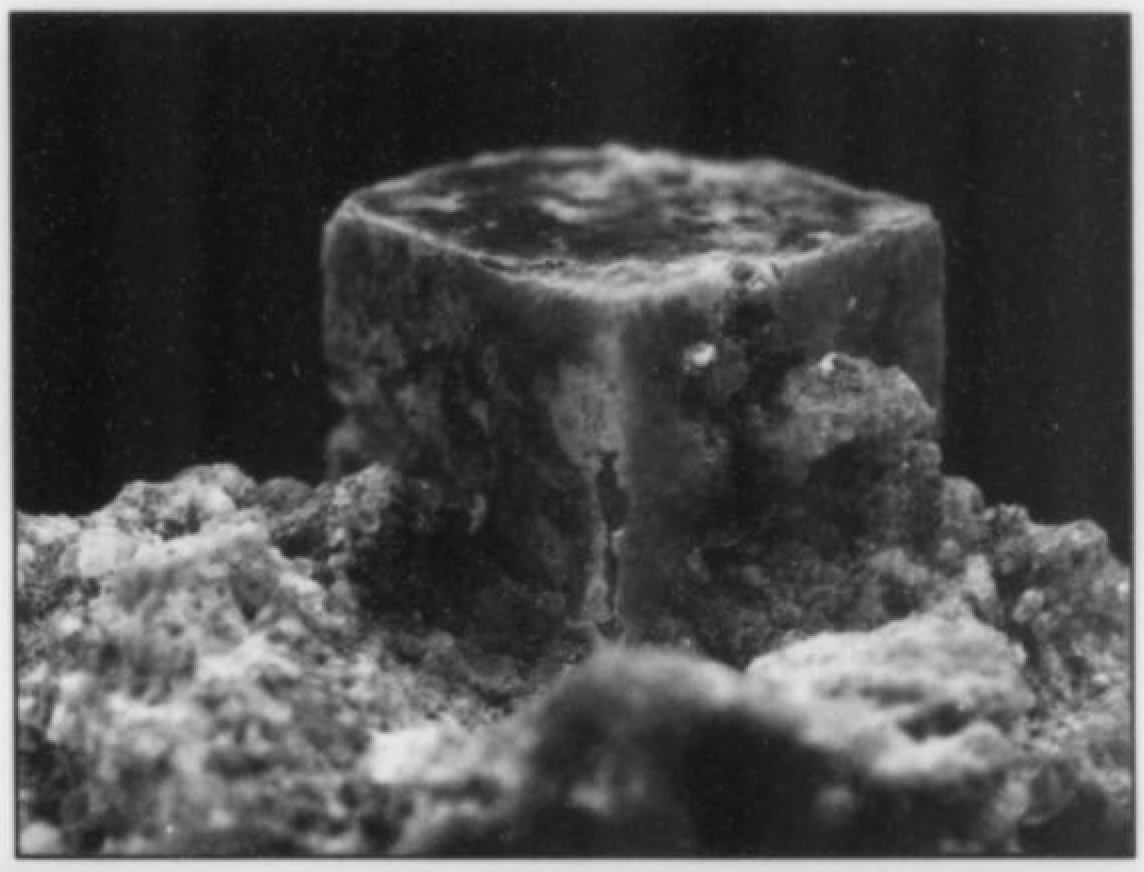


Figure 13. **Boracite crystal, 1.2 cm, on matrix from Alto Chapare, Bolivia. Alfredo Petrov specimen; Jeff Scovil photo.**

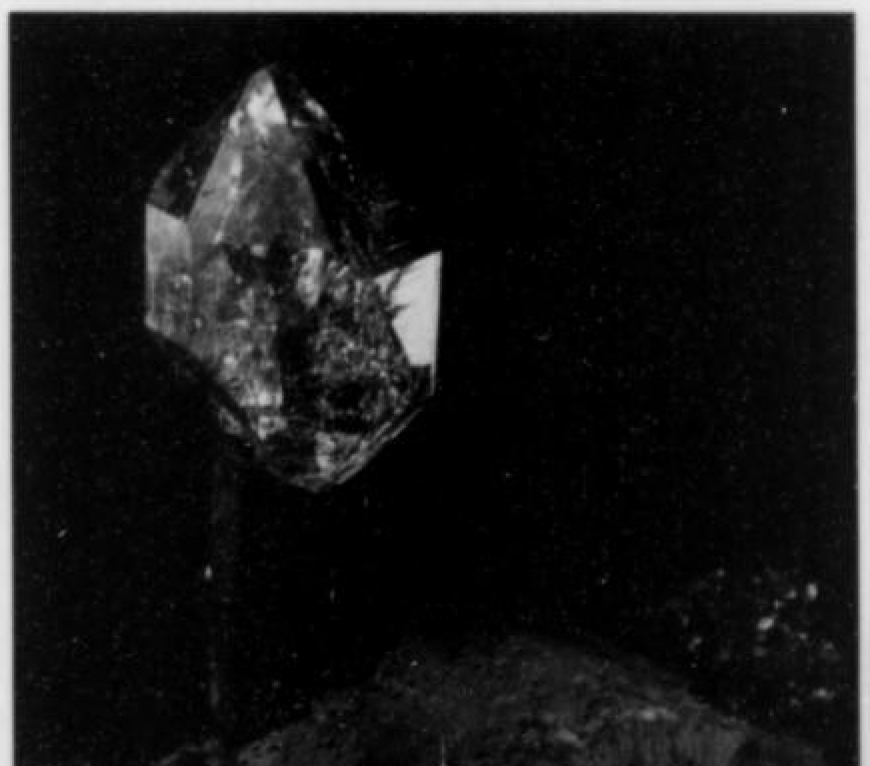


Figure 14. **Quartz scepter, 3.3 cm, on matrix from the Eastern Rock Products quarry, St. Johnsville, New York. Bill and Viki Hladysz collection; Jeff Scovil photo.**

Figure 15. **Fluorapatite crystal, 4.4 cm, from near Teofilo Otoni, Minas Gerais, Brazil.** ***The Gemmological Center*** **specimen; Jeff Scovil photo.**

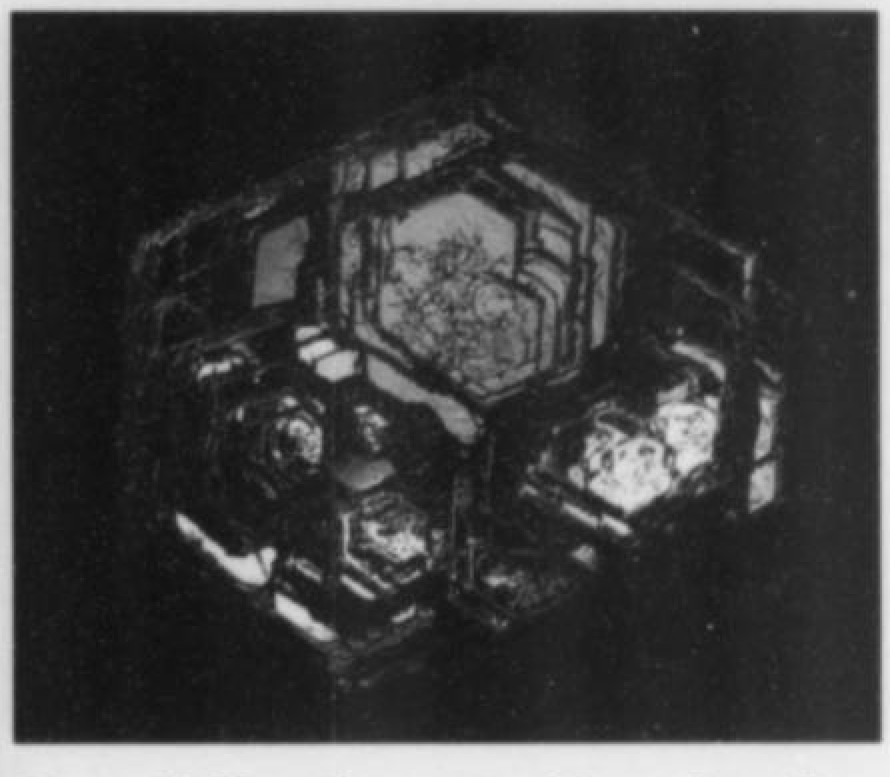


Figure 16. **Hematite rosette, 3.8 cm, from Ouro Preto, Minas Gerais, Brazil. Luis Menezes specimen; Jeff Scovil photo.**

sulfide, with some green (presumably Cu) staining. Gold specialists have here another promising locality and distinctive association to watch for—euhedral gold at home in metallic-gray nests is pretty unusual, to be sure.

Speaking of sulfides, Dennis Beals of *XTAL* (431 Lafayette Center, Suite 211, Manchester, MO 63011) speaks enthusiastically indeed of a big pocket, which last June yielded about 100 fine specimens, on level 3 of the "Manto Calavera" orebody of the Los Remedios mine, Taxco, Guerrero, Mexico. The largest of these specimens is 25 cm across (in his exhibit case there was a still larger one), on which **sphalerite** forms lustrous sharp black twins to 5 cm, and **galena** meanwhile covers the matrix backfield with bright skeletal crystal growths, while sometimes there is calcite in pale greenish druses, and 1-cm amethystine quartz prisms. The material is generally reminiscent of specimens from Trepča, Serbia, and (more recently) the Madan orefield, Bulgaria.

Further, Dennis had a couple of very beautiful **amethyst** specimens from a new pocket at the La Valenciana mine, Amatitlan, Guerrero, Mexico. A handful of others from the same find were scattered about the show. The amethyst is a *very* deep, clean, gemmy purple almost all through the crystals, which are tapered prisms in subparallel growth with increased flaring around the specimen bases; aesthetically matchless groups of this style reach 12 cm high.

Those knowledgeable, as I am not, in bragging-rock products of relatively obscure western U.S. localities tell me that the **barite** crystal groups from Point Vicente, Palos Verdes Hills, California, are fairly familiar stuff, and even today are collectible intermittently, as slumping, flooding, and other apocalyptic phenomena expose the host sedimentary beds along the seaside cliffs in this suburban Los Angeles locale. The 15 or so such barite specimens offered at Springfield by Leonard Himes of *Minerals America* (P.O. Box 540257, Orlando, FL 32854) were collected, he said, 15 to 20 years ago. They are very attractive, with lustrous, translucent, thick tabular plates to 3 cm across, of a tan color, in mostly matrixless groups from miniature-sizes up to 10 x 20 cm.

Go some tens of meters on a NNW strike across the show floor and you'd have encountered some other **barite** crystals groups interestingly comparable to these California ones—some matrixless flat-plate-group style, very similar caramel to buff-white color, and blades to 3 cm in groups to 15 cm—but these are from a new pocket (May/June this year) at the classic locality of Cavnik, Transylvania, Romania. They were being offered by Frank and Wendy Melanson of *Hawthornden* (L'Amable, Ontario K0L 2L0 Canada), who, recently back from Romania, tend towards pessimism regarding future supplies from this quirky country. There's now in Romania a dangerous combination, the Melansons say, of newly modernized, pocket-unfriendly mining techniques, old-style paranoia, and some beginnings of specimen pipelines to *Russia,* such that not much good material is likely to come to the West very soon. I'd note, though, some evident exceptions: the recent appearances of good Cavnik things, like these barites, and, from the prolific Herja mine, much fine recent **stibnite**, **berthierite**, **semseyite**, and **boulangerite**-including calcite. The new barites, anyway, are distinctively more orange and less yellow than older ones, and while not world-beaters are clean and quite pretty.

The Melansons also had a flat or two of some new Moroccan **prehnite** which was a first-see for me, although the find was made two years ago, and specimens made the scene, I'm told, at this past July's Ste.-Marie-aux-Mines show. The occurrence, however, is reportedly already mined out; it is given as Bou Arfa, Figuig Province, Morocco. The color of the prehnite is a dullish pale green, and the typical habit is as rounded aggregates on or off matrix and occasional nice coxcomb growths of 5-mm crystals with quartz prisms. Most specimens are miniatures, but there are a few matrix pieces to 10 cm across.

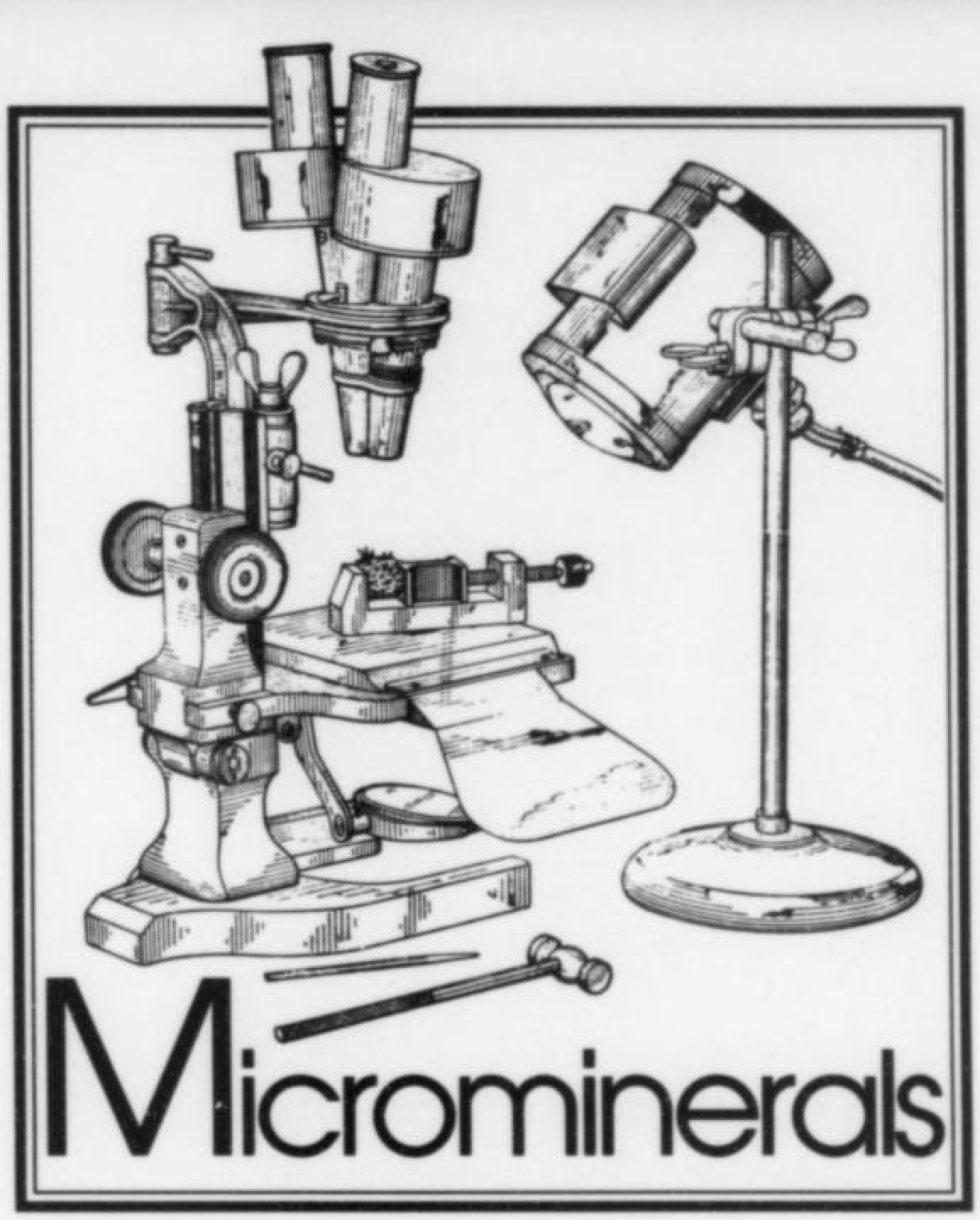
It is always pleasant for me, a graduate of the University of Delaware at Newark, Delaware, to see people and things from this little corner of the Earth (to which you really should go sometime, by the way, to see the wonderful Irenée DuPont collection on effective display in Penny Hall; ask for Peter Leavens). There is even a mineral dealership in Newark now: in Springfield I spoke with Roland Bounds of *Broken Back Minerals* (315 Stamford Dr., Newark, DE 19711), and what we spoke mostly *about* was his surprising little hoard of fine thumbnails of **pyromorphite** from Idaho. Not the incandescently great Bunker Hill mine pyromorphites of recent fame, these, rather, are from the Midnight mine near Mullan, Shoshone County, and they were collected in 1963. The highly cavernous, splintery looking, 1-cm crystals are of a very pale, chalky, greenish white; with or without the backing of limonite-stained white matrix shards, they form porcupiney, fantastically delicate groups and sprays that make highly effective thumbnails, a very nice one of which could be had for around $20. There are a few small miniatures too.

Reliable Danny Trinchillo of *DeTrin Mineral Company* had, as usual, some ex-Soviet Union exotica. About three years ago in a place somewhere in the Pamir Mountain chain (this being the most precise locality data available), in Tajikistan, some of the biggest known **hambergite** crystals were found, and with great difficulty were smuggled out of the country. The ones at Springfield (and much better ones are said to exist) are milky white, opaque loose blades to 6 cm long, somewhat rough-faced and rough-terminated. The better ones, Danny says, are sharper, gemmier, and can be very pale purple. Also purple, though much more darkly so, and often part-gemmy, are some **scapolite** crystals in loose subhedral square prisms to 4 cm long, also from the Pamirs.

Epidote from *Peru*? Yes, apparently some old iron mines on the Pacific coast have skarn zones from which have come very handsome specimens such as the five I saw in the keeping of Isaias Casanova of *I.C. Minerals* (P.O. Box 1376, Goldenrod, FL 32733-1376); the locality is given (vaguely) as "near Ica, Ica Department, Peru," and these five pieces were taken out last winter (*our* winter). They are considerable epidote specimens, somewhat similar to some of the old specimens from France or from Xanthi, Greece: highly lustrous, dark opaque blackish green prismatic crystals to 10 cm long in subparallel sprays, the sprays to 17 cm long, without matrix. A few prisms are thick enough to show pinacoid faces on which may be seen the characteristic chevron striations that betray twinning, as on many of the blocky crystals from Prince of Wales Island, Alaska. Future supplies of these excellent epidotes are (need one add?) uncertain.

Finally, the only European dealership to come to Springfield this year deserves a mention for that cosmopolitan reason alone: Christian and Petra Gornik of *Fine Minerals Worldwide* (Reutergartenweg 20, D-31319 Sehnde [Höver], Germany) had some friendly German voices and some nice German and other European minerals to proffer the weary browser. The **fluorite** specimens here were particularly educational, though not generally dramatic; they came, e.g., from Marienschacht in the Oberpfalz, or from Halsbrücke bei Freiberg, Obersachsen. Some good **barite** miniatures came from the Sauerland, or from Ehrenfriedersdorf/Erzgebirge, or from the more recently famous Pöhla mine at Crottendorf/Erzgebirge. Nor will I forget for awhile a single terrific purplish-orange Tsumeb **wulfenite** thumbnail which the Gorniks had, from a Tsumeb collection they bought.

Well, here's to conclude by wishing all fellow Easterners an end-of-summer as wonderfully, unbelievably cool and balmy as the season has so far been, and to everyone else, too, the best of collecting weather.



Italian Connections (II)—Vesuvius

Because it is arguably the most famous of all Italian mineral localities, I have reserved the Mount Vesuvius/Monte Somma complex for this second column on exchanging with Italian collectors. The complete locality designation, exclusive of quarry names, should be Monte Somma/Vesuvius, Napoli (Province), Campania (Region), Italy.

Mount Vesuvius is a strato-volcano, which is to say that it is built of alternating layers of volcanic ejecta and lava flows. Vesuvius *per se* is actually a younger and higher volcano, built gradually following the eruption of 79 B.C., in the collapsed caldera of the considerably older Monte Somma. The two are separated by the Valle del Gigante, a semi-circular depression about 500 meters wide and 4 kilometers long. The two volcanoes, one inside the other, form the complex which is the subject of this column.

The rock types found at Monte Somma/Vesuvius are largely leucitites and phonolites, both of which are high-soda volcanic rocks. They can occur either as ejecta or as parts of volcanic flows, and contain a number of mineral species. More interesting to mineral collectors are the volcanic ejecta of metamorphosed carbonate rocks derived from blocks of country rock which foundered in the rising volcanic magma. The varying degrees of metamorphism and reaction with the engulfing magma result in an interesting range of minerals. Yet another group of minerals, many

Figure 1. **Sketch map of Monte Somma/Vesuvius, showing principal collecting localities.**

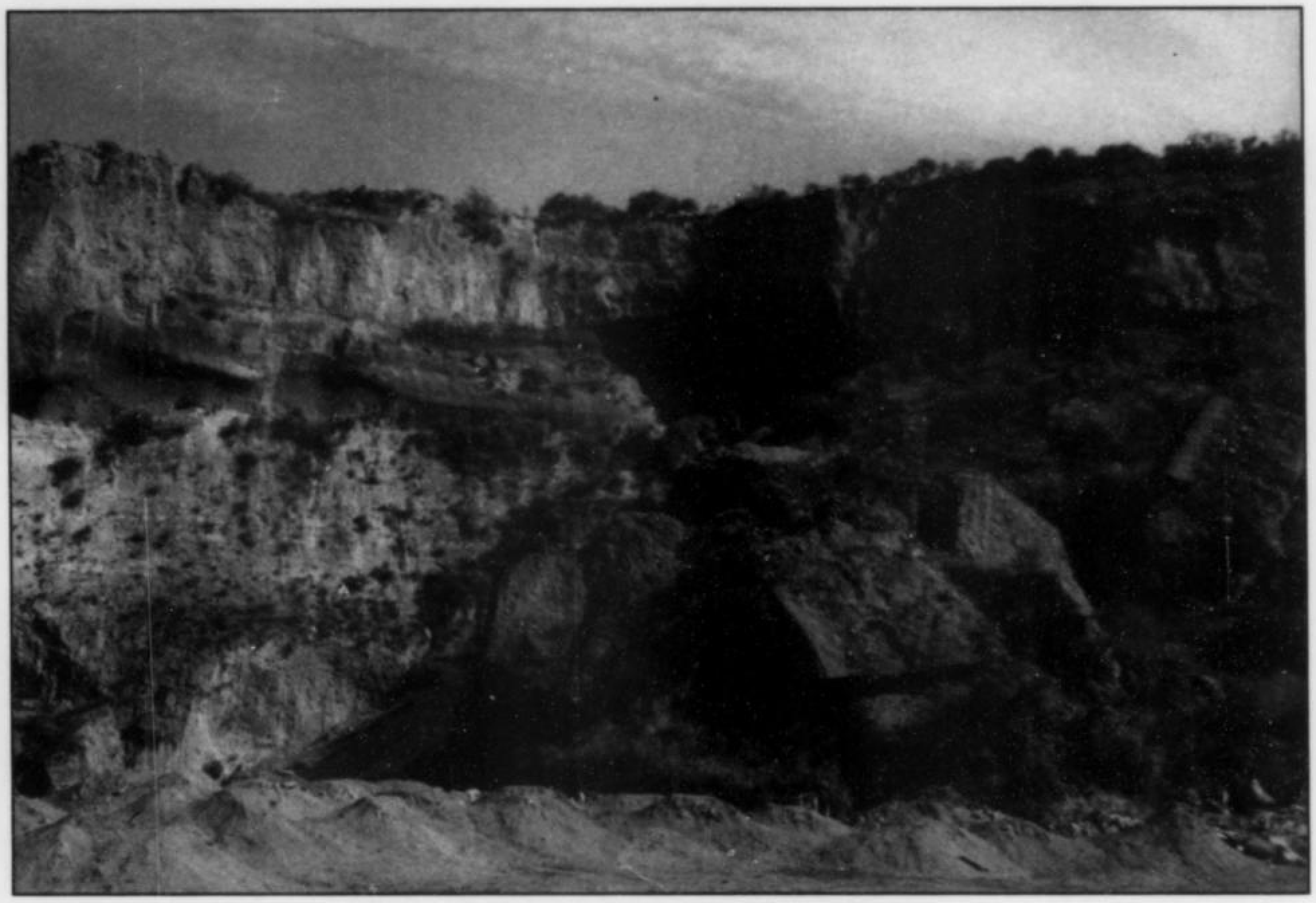


Figure 2. **Rock exposures in the Pollena quarry.**

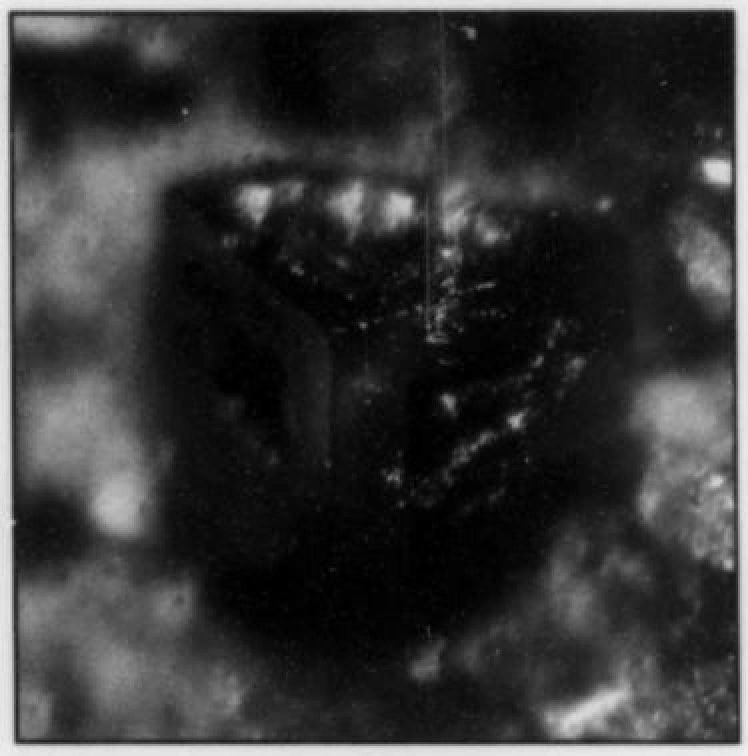


Figure 3. **A 0.6-mm, cavernous, pseudocubic crystal of hematite from Mount Vesuvius.**

Figure 4. **Jet-black, 1.1-mm crystal of spinel from Mount Vesuvius. [GG]**

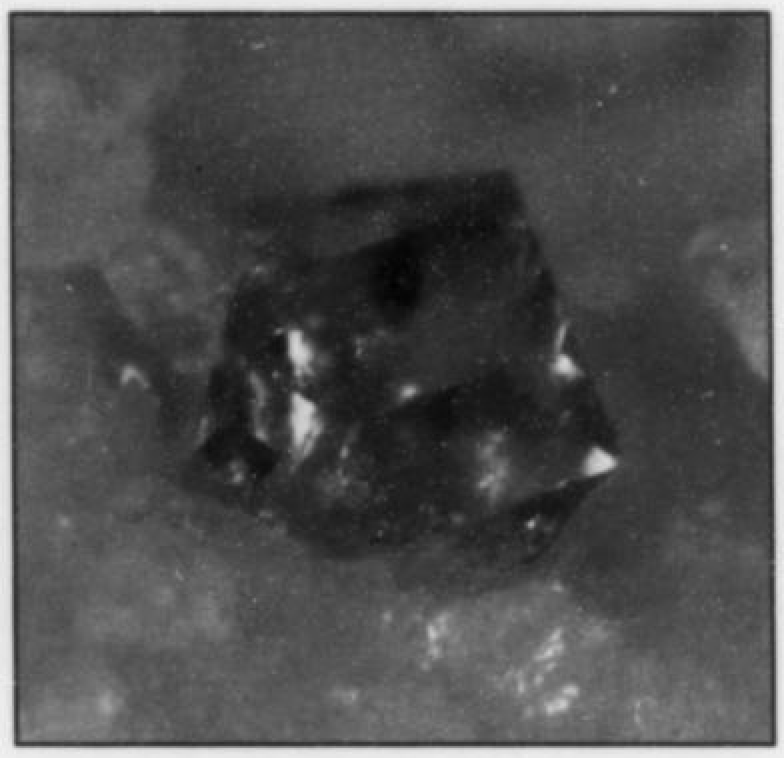


Figure 5. **Twinned, 0.3-mm crystal of the "spinello nobile" variety of spinel from the San Vito quarry, Mount Vesuvius.**

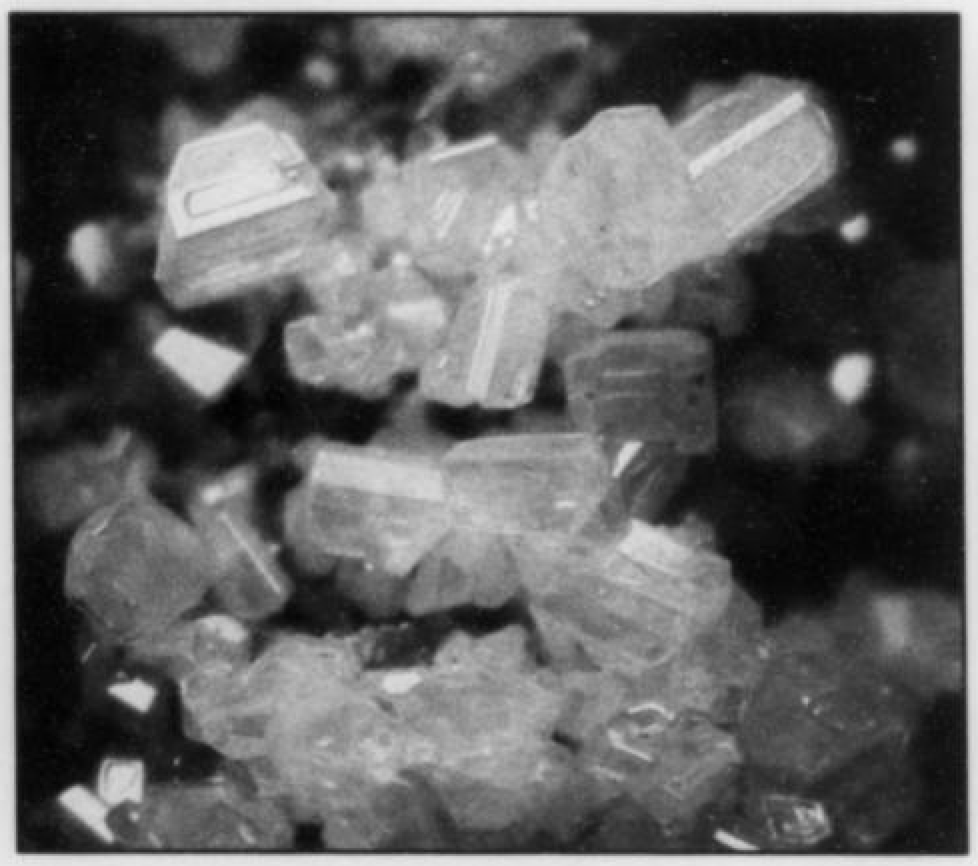


Figure 6. **Slightly cavernous crystals of cotunnite from Mount Vesuvius. Field of view = 2.4 mm.**

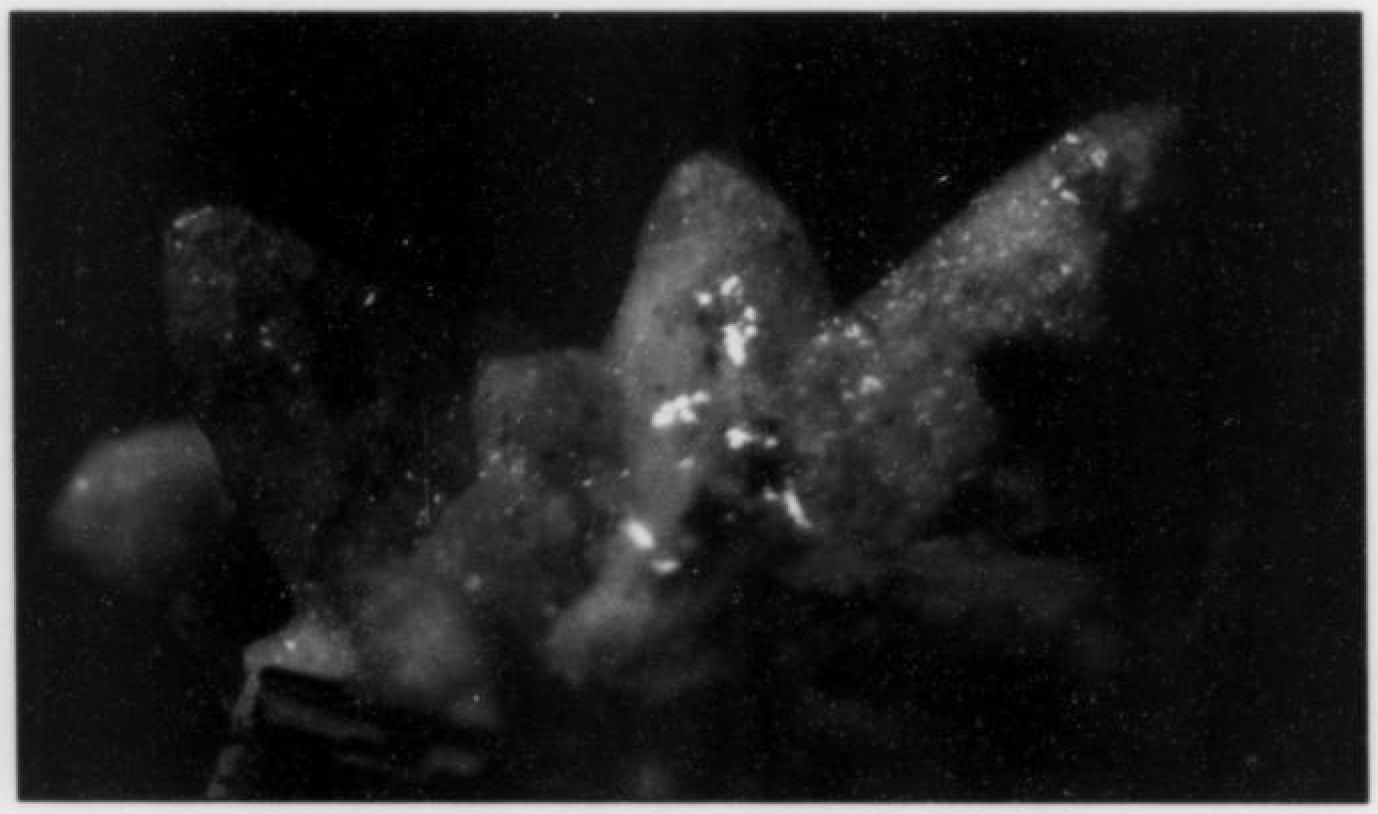


Figure 7. **Sword-shaped crystals of cuspidine to 2.2 mm in size, from the Pollena quarry. [RA]**

Figure 8. **Transparent, acicular crystals of hornblende from the San Vito quarry. Field of view = 1.8 mm. [RA]**

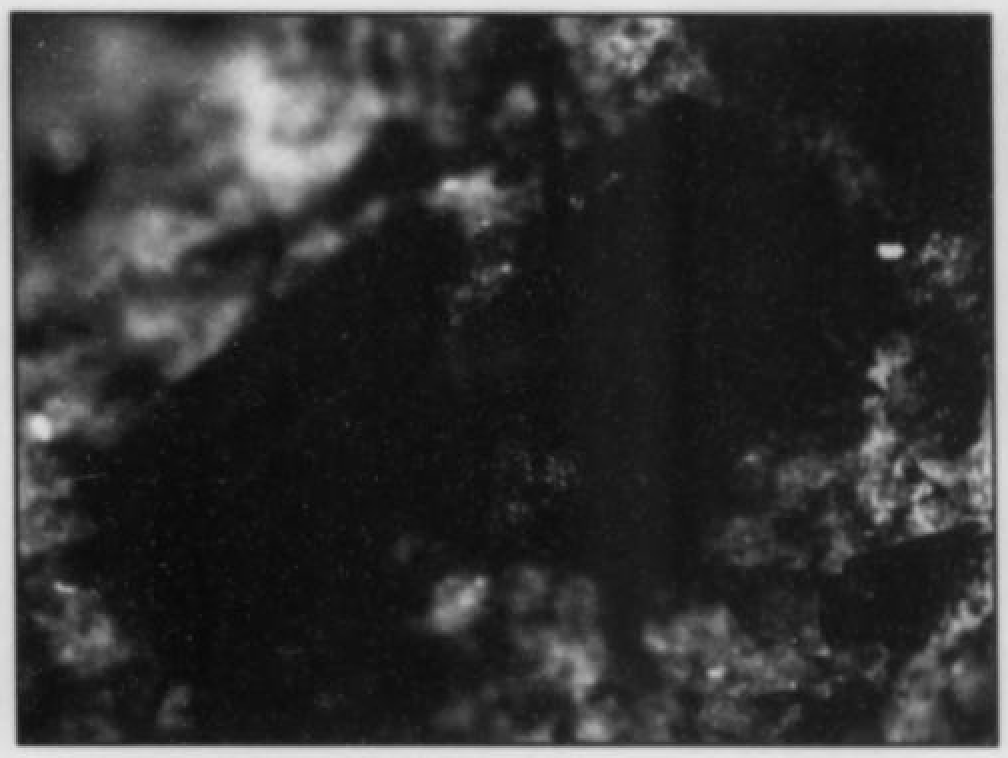


Figure 9. **Cavernous crystals of hornblende to 1.6 mm from Mount Vesuvius.**

Figure 10. **Transparent, 1.3-mm crystal of clinohumite from the Pollena quarry. [RA]**

Figure 11. **A complex, 1.2-mm crystal of davyne from the Pollena quarry. [RA]**

Figure 12. **Twinned, 2.8-mm crystal of sodalite with re-entrant angles, from the San Vito quarry. [RA]**

Figure 13. **A 1.4-mm, columnar crystal of wöhlerite on sanidine, from the San Vito quarry. [GG]**

Figure 18. (below) **Columnar merlinoite crystals in cross-shaped twins, from Lagno Amendolare. [RA]**

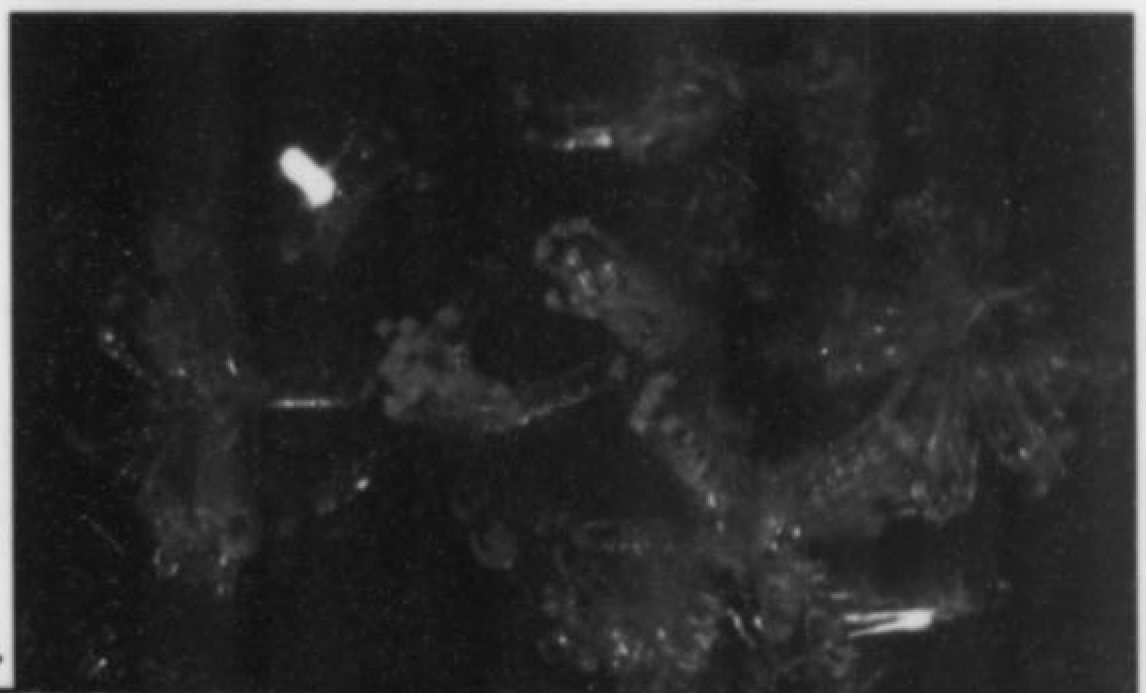
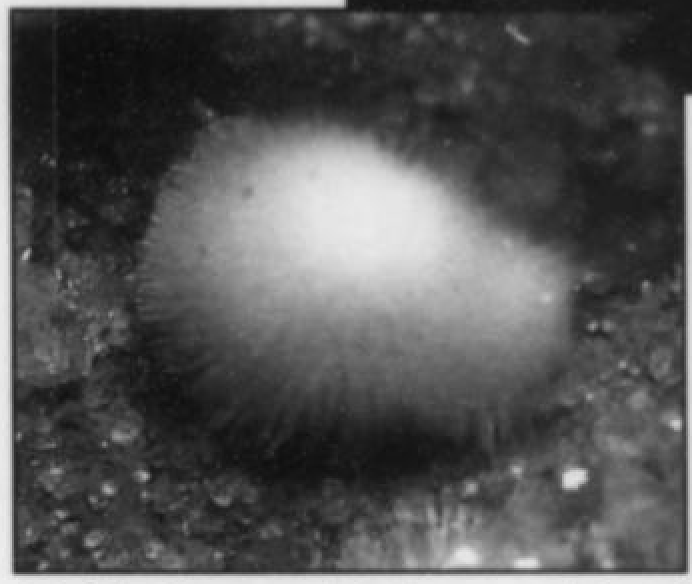


Figure 14. **Very thin, tabular muscovite crystals to 1.2 mm, from the San Vito quarry. [RA]**

Figure 16. (below) **Acicular scolecite puff, 1.5 m. Photo and specimen: Domenico Forloni.**



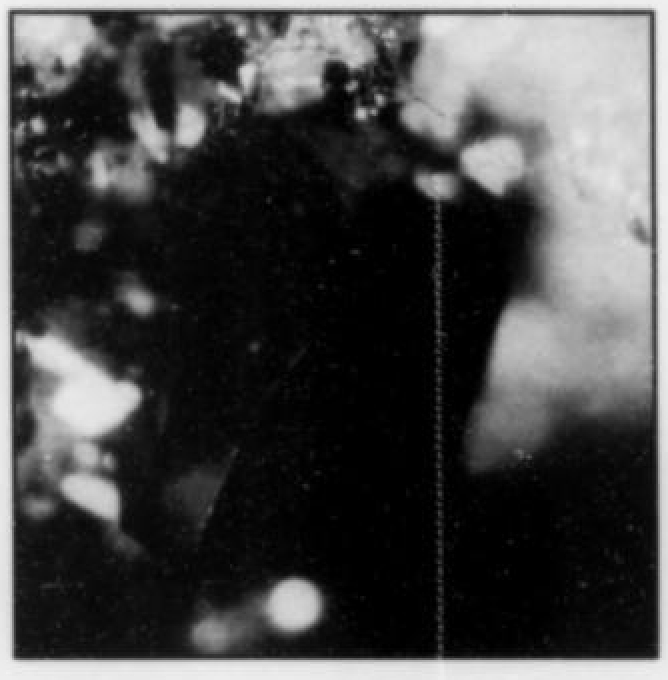
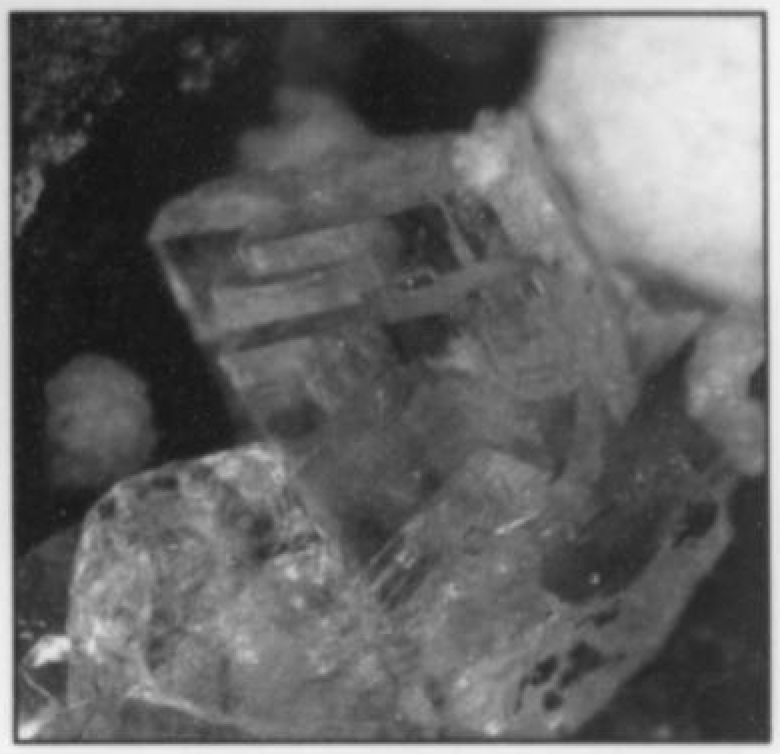


Figure 17. (right) **Square tabular crystals of thomsonite to 1.2 mm with radiating, white scolecite.**

Figure 15. (left) **Equant, rounded biotite crystal, 1.0 mm across, from the San Vito quarry, Mount Vesuvius. [RA]**



of them unusual halides, were formed by pneumatolytic processes wherein the enormous quantities of gases vented by the volcano acted as carriers of otherwise non-volatile elements and/or as reactants in formation of the minerals. Finally, it is of great importance to micromineral collectors that all the above rock types are extremely porous, with innumerable cavities in which euhedral crystals are free to grow.

Through the above processes, a large number of rare and beautiful micromineral species have been formed. Mariano Carati's book *Guida alla Mineralogia Vesuviana* (Edizioni Calderini, via Emilia Levante 31, Bologna, Italy, 1982) lists over 190 species from Monte Somma/Vesuvius, and several more have been added to the list since then.

A number of small quarries are found on the flanks of Monte Somma/Vesuvius, as shown in the sketch map in Figure 1. Of these, the Pollena and San Vito quarries (see Fig. 2) appear to be the most prolific. At least, they are the source of most of the specimens in my own collection. However, as almost all of these quarries are now closed to collectors, more and more collecting is being done in erosional depressions (locally called "lagni") on the flanks of the volcanic complex.

A number of Monte Somma/Vesuvius species obtained by exchange are illustrated in the accompanying photos. As in the first of these two columns, the initials of the Italian collectors from whom the specimens were obtained are appended to the photo captions. Readers wishing to exchange with them can do so by writing to the addresses given in Part I (vol. 27, no. 2, p. 149–152).

The first specimen shown, the pseudocubic **hematite** in Figure 3, is a prime example of a sublimate mineral formed under pneumatolitic conditions. A number of elements with very low vapor pressures are extremely volatile when combined with the halogens. Examples are ferric chloride ($FeCl_3$) and silicon fluoride (SiF_4). The gaseous emanations from Monte Somma/Vesuvius which evolved during violent eruptions and, later, from fumaroles, contain enormous amounts of halogen carriers in addition to water and carbon dioxide. When hot gases containing volatilized iron approach the surface and are cooled and exposed to air and water, the iron is precipitated as magnetite, hematite or pyrite. Other minerals thus formed at Monte Somma/Vesuvius are tenorite, boric acid, and compounds of sodium, copper and lead. Quite commonly, crystals formed from the gaseous state are dendritic or cavernous, as is the hematite crystal in Figure 3. The rate of growth of such crystals can be surprisingly high and, apparently, is only limited by diffusion rates. Gaseous constituents diffusing to the crystal surface are deposited more rapidly on crystal corners and edges because they diffuse in from a larger volume of gas phase there. Hence, the slower growth of the center of crystal faces. Not often appreciated is another factor: the heat of crystallization of material on the growing crystal is more rapidly lost from corners and edges because it is radiated to a greater volume of gas phase. This allows them to remain cooler than central crystal faces, and causes material to adhere more firmly and rapidly to the corners and edges.

Beautiful **spinels** in a variety of colors and crystal forms are also found in metamorphosed calcareous ejecta. Besides brilliant, slightly rounded, transparent crystals in dark browns, spinel is found as opaque, very sharp crystals such as the black octahedron with dodecahedral modifications shown in Figure 4. Note that the octahedron faces are etched, while the dodecahedron faces are not. Even prettier are the tiny, very hard to photograph, transparent, pink spinels such as that in Figure 5. These are called *spinello nobile* or *rubino spinello* ("noble" or "ruby" spinel) by the Italians, and are rarely over 1 mm in size. They are typically found in marble ejecta, sometimes in association with geikielite. The crystal shown is twinned by rotation about the three-fold [111] axis and is called (aptly) a "spinel twin."

Cotunnite, $PbCl_2$ (Fig, 6), is another mineral formed around fumaroles, and is one of several halides occurring at Monte Somma/Vesuvius. No fewer than 30 other halides are found there, including carobbite, sellaite, lawrencite, scacchite, molysite and malladrite. In the case of cotunnite, chloride acts both as a carrier of lead in the gas phase and as a reactant in the formation of the mineral. More commonly, cotunnite is found at Vesuvius as acicular crystals. Note also that the cotunnite crystals shown are slightly cavernous. The richest and best crystallized cotunnites, by the way, are very recent, having been formed after the eruption of 1944!

Cuspidine, a calcium fluorosilicate, is found in metamorphosed calcareous ejecta, but the fluoride is probably derived from gaseous emanations. The brilliant, white, sword-shaped crystals in Figure 7 are exceptionally well crystallized for the species.

Hornblende is perhaps the commonest of the amphiboles at Monte Somma/Vesuvius, and is found in sanidinites and metamorphosed carbonate ejecta. It occurs in a variety of crystal habits. The color is extremely variable, ranging from yellow and green to brown and black. Acicular crystals such as those in Figure 8 are commonly transparent, while the larger, columnar crystals shown in Figure 9 are opaque. The latter may be darkened by inclusions and/or coatings of hematite, which would also be responsible for their color. These crystals, too, are markedly cavernous, almost to the point of being hollow shells.

All four of the classic members of the humite group—**humite**, **clinohumite**, **chondrodite** and **norbergite**—are found at Monte Somma/ Vesuvius. All four are magnesium fluorosilicates, and all four are found in metamorphosed carbonate ejecta. They are formed by the reaction of pneumatolytic vapors carrying fluorine and silica with calcium-containing carbonates. At Monte Somma/ Vesuvius, they are found in beautiful, complex crystals, as witness the transparent, orange clinohumite crystal shown in Figure 10.

Surprisingly, only four members of the cancrinite group are found at Monte Somma/Vesuvius, although many others are known from similar volcanic rocks in Italy. They are the older minerals **cancrinite**, **davyne** and **microsommite** plus the recently described species **quadridavyne** (*European Journal of Mineralogy*, **6**, 481–487). The first three are sodium aluminum carbonate/silicates, while quadridavyne lacks carbonate; all have hexagonal symmetry. The davyne in Figure 11 shows 12 prism faces (either the first and second-order prisms or a dihexagonal prism), plus a hexagonal pyramid and small *c*-face. Since the edges of the pyramid faces meet exactly at every other edge of the prism(s), the former possibility is the correct one.

Three of the four members of the sodalite group—**sodalite**, **hauyne** and **lazurite**—are known to occur at Monte Somma/ Vesuvius, while unconfirmed tests suggest that the fourth member, **nosean**, is also present. The three are found in marble ejecta and other rocks. Lazurite and hauyne are sometimes colored an intense blue, while sodalite is commonly colorless and also rarely pink or yellow. The three are frequently twinned to form pseudo-hexagonal crystals such as the sodalite in Figure 12.

Wöhlerite (Fig. 13) is a rare zirconium fluorosilicate found in sanidinite associated with **hiortdahlite**. Both species are tabular, columnar and yellow, and are easily confused. Hiortdahlite, called guarinite in Carati's book, is another zirconium silicate. Their occurrence in sanidinite, a high-soda rock, is a reminder that zirconium and rare-earth elements are concentrated in sodic magmas.

Excellent microcrystals of several micas are found at Monte Somma/Vesuvius, as witness the sharp, very thin, transparent

muscovite crystals in Figure 14. Deep brown, much thicker but still translucent crystals of **biotite** (Fig. 15) are available as well.

Turning finally to the zeolites, Carati lists just four: **scolecite**, **thomsonite**, **phillipsite** and **chabazite**. The first two of these are shown in Figures 16 and 17. The thomsonite is particularly good for the species because it occurs in quite large, sharp, transparent crystals. More noteworthy are two zeolites not recognized at the time Carati's book was published: **merlinoite** and **montesommaite**. Merlinoite (Fig. 18) occurs in crystals looking exactly like cross-shaped twins of phillipsite, and can be distinguished from phillipsite only by the presence or absence of three not-very-prominent lines in the X-ray powder pattern. Confirmation of its occurrence at Monte Somma/Vesuvius has taken some time. In 1984, Carlo Cassinelli sent me some smallish crystals from the San Vito quarry, and suggested that they might be merlinoite. A rather poor X-ray pattern confirmed this identity. In 1994, Dr. Giancarlo Pierini (Via Campigli 91, Varese, Italy) repeatedly obtained excellent spectra of merlinoite using samples from Lagno Amendolare and the Pollena quarry, thus confirming its presence at no fewer than three locations on the mountains.

Montesommaite is, of course, a new zeolite for which Monte Somma is the type locality. It occurs in excellent but tiny, pseudo-tetragonal crystals, both singles and twins, looking a bit like another new zeolite, tschernichite. Unfortunately, their small size precludes my taking a suitable photo with a light microscope. Montesommaite is described (with SEM photos) in Rudy Tschernich's book (*Zeolites of the World*, Geoscience Press, Phoenix, Arizona, 1992).

Of course, many other desirable micromineral species are available from Monte Somma/ Vesuvius. Among the roughly 60 species in my own collection are baddeleyite, chrysotile, forsterite, geikielite, kaliophilite, microsommite, vonsenite and tenorite, all obtained by exchange. Who knows? Given another 41 years of mineral collecting, I just might get a complete collection from this locality!

I am deeply indebted to Roberto Allori for the map shown in Figure 1, and for additions and corrections he made to the text.

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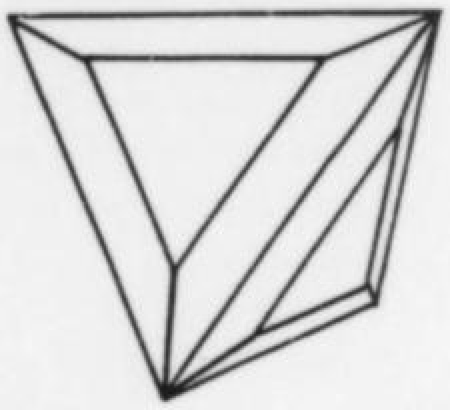

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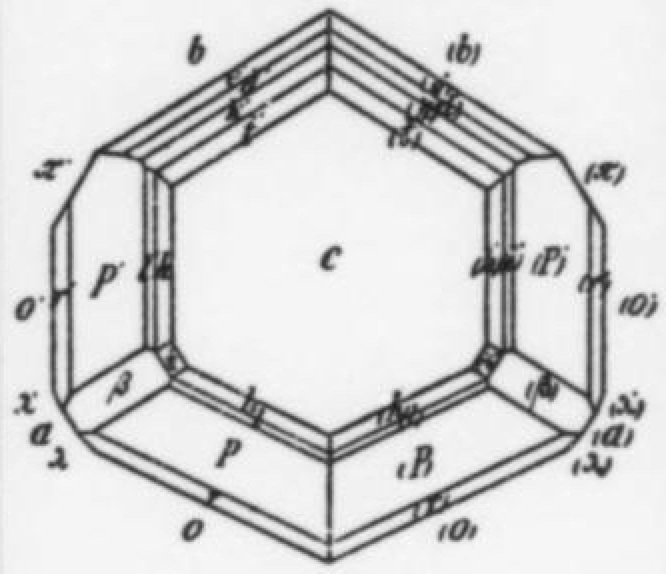

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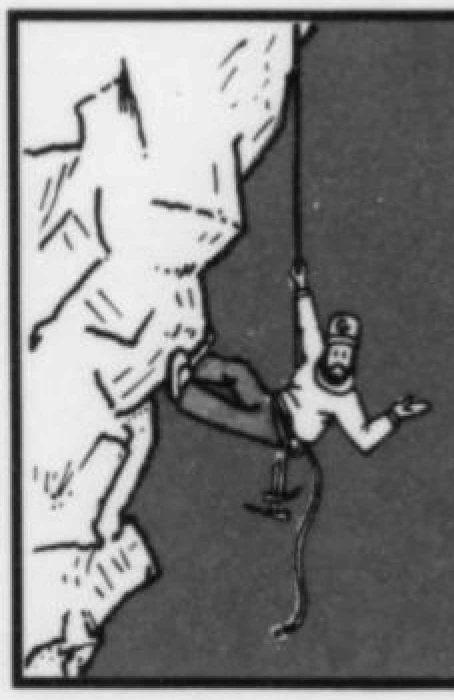

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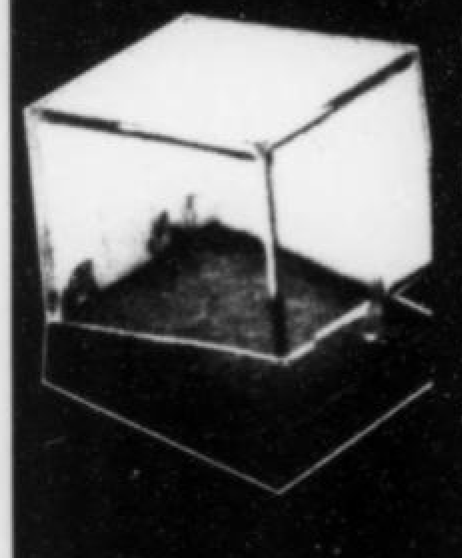

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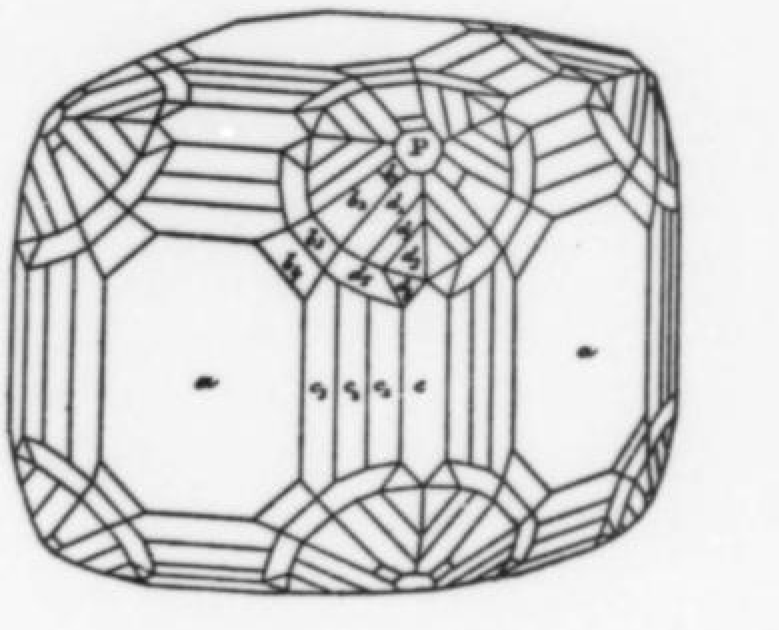


Clinoatacamite Monoclinic

$Cu_2(OH)_3Cl$

Locality: The type locality is Chuquicamata, Chile, but the mineral has been identified from six other localities.

Occurrence: Associated minerals on the holotype specimen are: atacamite, paratacamite, gypsum, alunite, and quartz.

General appearance: Simple, twinned pseudo-rhombohedral grains (up to 1 mm), complicated intergrowths of euhedra, and fine-grained, powdery aggregates.

Physical properties: *Luster:* adamantine. *Diaphaneity:* transparent to translucent. *Color:* green to dark greenish black; less commonly greenish blue. *Streak:* green to white. *Luminescence:* non-fluorescent. *Hardness:* 3. *Tenacity:* brittle. *Cleavage:* {012} perfect. *Fracture:* even. *Density:* could not be measured, 3.71 g/cm³ (calc.). ***Crystallography:*** Monoclinic, $P2_1/n$, a 6.157, b 6.814, c 9.104 Å, β 99.65°, V 376 Å³, Z 4, a:b:c = 0.9036:1:1.3361. Morphology: no forms mentioned; the habit is indistinguishable from that of paratacamite. Twinning: on (100). ***X-ray powder diffraction data:*** 5.47 (100), 4.68 (30), 2.887 (40), 2.767 (60), 2.742 (70), 2.266 (50), 2.243 (50), 1.704 (50). ***Optical data:*** Biaxial (-), indices of refraction could not be measured because the mineral reacts with the immersion liquids, 2V(meas.) 75°, 2V(calc.) 69° from extinction curves; dispersion r << v, strong; nonpleochroic; X = b, Y ^ a = 10° (in obtuse angle β). ***Chemical analytical data:*** Means of eleven sets of electron microprobe data: CuO 74.7, H_2O (13.5), Cl 16.5, sum 104.7, less O = Cl 3.7, Total 101.0 wt.%. H_2O could not be determined, but was calculated stoichiometrically and confirmed by the crystal structure determination. Empirical formula: $Cu_{1.96}O_{3.03}H_{3.12}Cl_{0.97}$. ***Relationship to other species:*** A polymorph of $Cu_2(OH)_3Cl$; the others are atacamite, paratacamite, and botallackite. ***Name:*** For the relationship to atacamite and paratacamite. ***Comments:*** IMA No. 93-060. This abstract contains a small amount of data taken from the original IMA proposal. The calculated density given here is slightly different from that given in the paper. Note that the crystal structure has been determined.

JAMBOR, J. L., DUTRIZAC, J. E., ROBERTS, A. C., GRICE, J. D., and SZYMAŃSKI, J. T. (1996) Clinoatacamite, a new polymorph of $Cu_2(OH)_3Cl$, and its relationship to paratacamite and "anarakite." *Canadian Mineralogist* **34**, 61–72. GRICE, J. D., SZYMAŃSKI, J. T. and JAMBOR, J. L. (1996) The crystal structure of clinoatacamite, a new polymorph of $Cu_2(OH)_3Cl$. *Canadian Mineralogist* **34**, 73–78.

Fluorbritholite-(Ce) Hexagonal

$(Ce,La,Na)_5(Si,P)_3O_{12}F$

Locality: Mont Saint-Hilaire. Rouville County, Quebec, Canada.

Occurrence: In vugs in nepheline syenite, marble xenoliths, sodalite syenite xenoliths and pegmatite dikes. The main associated minerals are: analcime, microcline, aegirine, zircon, biotite, pyrophanite, astrophyllite, ancylite, natrolite, monazite, fluorite, pectolite, calcite, carbonate-apatite, götzenite, lovozerite, lueshite, ussingite, eudialyte, steenstrupine, gmelinite, phillipsite, chabazite, sodalite, serandite, albite, clino-amphibole and many other rare and unidentified minerals.

General appearance: as aggregates and patches of fine needles (up to 0.5 mm) in radiating or subparallel groups. Also as nearly equant crystals.

Physical properties: *Luster:* adamantine. *Diaphaneity:* opaque to translucent. *Color:* pale yellow, tan, reddish brown. *Streak:* white to pale brown. *Luminescence:* non-fluorescent. *Hardness:* about 5. *Tenacity:* brittle. *Cleavage:* {001} distinct. *Fracture:* even to conchoidal. *Density:* 4.66 g/cm³ (meas.), 4.66 g/cm³ (calc.). ***Crystallography:*** Hexagonal, $P6_3/m$, a 9.517, c 6.983 Å, V 547.7 Å³, Z 2, c:a = 0.7337. Morphology: no forms listed, but prismatic crystals were reported. Twinning: none mentioned. Some specimens are partially metamict. ***X-ray powder diffraction data:*** 2.845 (100), 2.822 (40), 2.747 (30), 1.970 (30), 1.870 (40). ***Optical data:*** Uniaxial (-), ω 1.792, ε 1.786, nonpleochroic. ***Chemical analytical data:*** Three electron microprobe analyses were carried out. The specimen from which the foregoing unit cell, optical and X-ray powder diffraction data were measured gave the following data: Na_2O 0.85, CaO 12.87, MnO 1.39, SrO 1.18, La_2O_3 20.21, Ce_2O_3 28.70, Pr_2O_3 1.69, Nd_2O_3 4.62, Sm_2O_3 0.25, Y_2O_3 0.36, ThO_2 1.84, U_3O_8 0.11, SiO_2 16.92, P_2O_5 7.25, F 2.58, sum 100.82, less O = F 1.09, Total 99.73 wt.%. Empirical formula: $(Ca_{1.77}Ce_{1.35}La_{0.96}Nd_{0.21}Na_{0.21}Mn_{0.15}Sr_{0.09}Pr_{0.08}Th_{0.05}Y_{0.02}Sm_{0.01})_{\Sigma 4.90}(Si_{2.17}P_{0.79})_{\Sigma 2.96}O_{11.95}F_{1.05}$. One of the other analyzed samples has a much lower Ca-content and higher Ce- and Na- contents. ***Relationship to other species:*** It is the fluorine-dominant analog of britholite-(Ce). ***Name:*** For the relationship to britholite-(Ce). ***Comments:*** IMA No. 91-027. The steenstrupine and ancylite noted are probably steenstrupine-(Ce) and ancylite-(Ce), respectively.

GU, J., CHAO, G. Y., and TANG, S. (1994) A new mineral—fluorbritholite-(Ce). *Journal of Wuhan University of Technology* **9(3)**, 9–14. GU, J., CHAO, G. Y., and TANG, S. (1996) Fluorbritholite-(Ce)—A new mineral from Mont Saint-Hilaire, Quebec, Canada. *Acta Petrologica et Mineralogica* **15(1)**, 40–45.

Hanawaltite Orthorhombic

$Hg_6^{1+}Hg^{2+}[Cl,(OH)]_2O_3$

Locality: Clear Creek claim, New Idria district, San Benito County, California, U.S.A. (Lat. 36°22′59″ N, Long. 120°43′58″ W).

Occurrence: On a fracture surface in a brecciated silica-carbonate rock composed mainly of ferroan magnesite and quartz. Associated minerals are: calomel, mercury, cinnabar, and montroydite.

General appearance: Subhedral to anhedral isolated crystals (up to 0.3 x 0.3 mm, but usually less than 50 μm).

Physical properties: *Luster:* metallic. *Diaphaneity:* opaque to translucent. *Color:* black to very dark brown-black. *Streak:* black to dark red-brown. *Luminescence:* non-fluorescent. *Hardness:* less than 5 (does not scratch glass). *Tenacity:* brittle. *Cleavage:* {001} good. *Fracture:* uneven. *Density:* could not be measured, 9.52 g/cm³ (calc.). ***Crystallography:*** Orthorhombic, Pbma, a 11.790, b 13.881, c 6.450 Å, V 1055.7 Å³, Z 4, a:b:c = 0.8494:1:0.4647. Morphology: no forms were observed. Twinning: none observed. ***X-ray powder diffraction data:*** 5.25 (80), 4.35 (40), 3.164 (60), 3.053 (100), 2.954 (70), 2.681 (50), 2.411 (50), 1.747 (40). ***Optical data:*** In reflected light: bright bluish white to duller, greyish white; strong anisotropism; moderate bireflectance (strong in oil), pleochroic, white to blue-white. R_1, R_2, $^{im}R_1$, $^{im}R_2$: (22.8, 29.6, 9.17, 14.6 %) 470nm, (20.7, 25.7, 7.79, 11.4

%) 546nm, (20.15, 24.35, 7.42, 10.4 %) 589nm, (20.2, 23.2, 7.48, 9.59 %) 650nm. ***Chemical analytical data:*** An electron microprobe analysis gave: Hg_2O 96.2, Cl 3.33, sum 99.53, less O = Cl 0.75, Total 98.78 wt.%. Based on the crystal structure analysis, the analytical data were recalculated to Hg_2O 82.46, HgO 14.27, H_2O 0.34, Cl 3.33, sum 100.40, less O = Cl 0.75, Total 99.65 wt.%. Empirical formula: $Hg^{1+}_{6.00}Hg^{2+}_{1.00}[Cl_{1.43}(OH)_{0.57}]_{\Sigma 2.00}O_{3.00}$. ***Relationship to other species:*** none apparent. ***Name:*** For Dr. J. D. (Don) Hanawalt (1903–1987), a pioneer in the field of X-ray powder diffraction. ***Comments:*** IMA No. 94-036. The calculated density given here is very slightly different from that given in the paper. Note that the crystal structure has been determined.

ROBERTS, A. C., GRICE, J. D., GAULT, R. A., CRIDDLE, A. J., and ERD, R. C. (1996) Hanawaltite, $Hg^{1+}_6Hg^{2+}$-$[Cl,(OH)]_2O_3$—A new mineral from the Clear Creek claim, San Benito County, California: Description and crystal structure. *Powder Diffraction* **11(1)**, 45–50.

Jensenite Monoclinic

$Cu_3Te^{6+}O_6 \cdot 2H_2O$

Locality: The dumps of the Centennial Eureka mine, Tintic district, Juab County, Utah, U.S.A. (Lat. 39°56′38″ N, Long. 112°7′18″ W).

Occurrence: Associated minerals are: quartz, mcalpineite, xocomecatlite, unnamed $Cu(Mg,Cu,Fe,Zn)_2Te^{6+}O_6 \cdot 6H_2O$; other Cu- and Te-bearing secondary minerals from the locality are cesbronite, frankhawthorneite, dugganite, quetzalcoatlite, and four phases under study.

General appearance: Subhedral to euhedral, nearly equant, pseudo-rhombohedral crystals (up to 0.4 mm long; most crystals are in the 0.1 to 0.2 mm range).

Physical properties: *Luster:* adamantine. *Diaphaneity:* transparent. *Color:* emerald green. *Streak:* also emerald green, but less intense. *Luminescence:* non-fluorescent. *Hardness:* estimated to be 3 to 4. *Tenacity:* brittle. *Cleavage:* $\{\bar{1}01\}$ fair. *Fracture:* uneven. *Density:* could not be measured, 4.76 g/cm³ (calc.). ***Crystallography:*** Monoclinic, $P2_1/n$, a 9.204, b 9.170, c 7.584 Å, β 102.32°, V 625.3 Å³, Z 4, a:b:c = 1.0037:1:0.8270. Morphology: forms, major $\{\bar{1}01\}$; medium {110}; minor {100}; very small {301}, {201}, {203}, $\{\bar{1}02\}$, {010}. Twinning: none observed in the X-ray single-crystal study, but some interpenetrating crystals that may possess a twin plane were observed megascopically. ***X-ray powder diffraction data:*** 6.428 (100), 3.217 (70), 2.601 (40), 2.530 (50), 2.144 (35), 1.750 (35). ***Optical data:*** In reflected light: nondescript grey, but darker grey with a brownish tint if immersed in oil; bright green internal reflections at grain boundaries; anisotropism could not be observed due to the internal reflections; weak bireflectance, nonpleochroic. R_1(air), R_2(air), R_1(oil), R_2(oil): (9.8, 9.9, 1.47, 1.62 %) 589nm. ***Chemical analytical data:*** Means of two sets of electron microprobe data: CuO 50.91, ZnO 0.31, TeO_3 38.91, H_2O (8.00), Total (98.13) wt.%. H_2O could not be determined, but its presence was confirmed by crystal structure analysis and IR absorption spectroscopy. Its content was calculated to give $2H_2O$. Empirical formula: $(Cu_{2.92}Zn_{0.02})_{\Sigma 2.94}Te^{6+}_{1.01}O_{5.97} \cdot 2.03H_2O$. ***Relationship to other species:*** If the H_2O assigned as OH groups in xocomecatlite is really present as H_2O molecules, jensenite may be a polymorph of xocomecatlite. ***Name:*** For Mr. Martin C. Jensen (1959–), who first collected and recognized this mineral as a potentially new species. ***Comments:*** IMA No. 94-043. Note that the crystal structure has been determined.

ROBERTS, A. C., GRICE, J. D., GROAT, L. A., CRIDDLE, A. J., GAULT, R. A., ERD, R. C., and MOFFATT, E. A. (1996) Jensenite, $Cu_3Te^{6+}O_6 \cdot 2H_2O$, a new mineral species from the Centennial Eureka mine, Juab County, Utah. *Canadian Mineralogist* **34**, 49–54. GRICE, J. D., GROAT, L. A., and ROBERTS, A. C. (1996) Jensenite, a cupric tellurate framework structure with two coordinations of copper. *Canadian Mineralogist* **34**, 55–59.

Lenaite Tetragonal

$AgFeS_2$

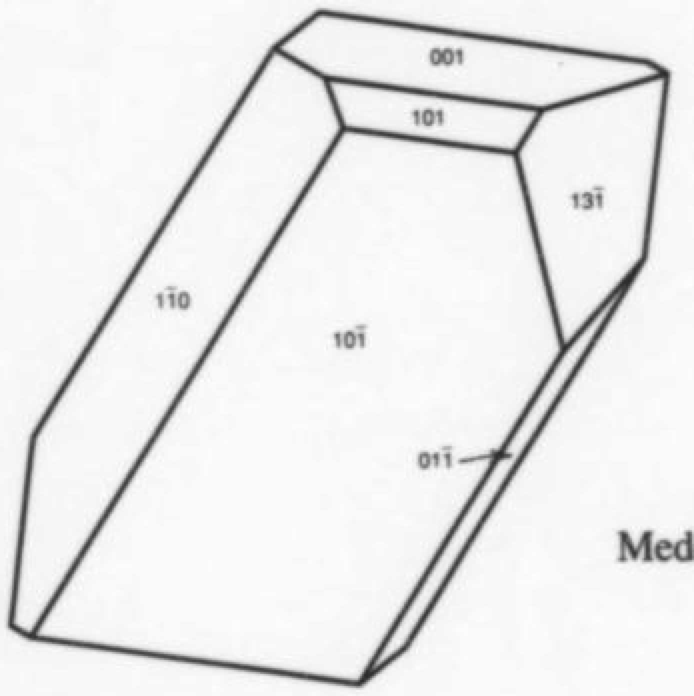
Locality: A silver-lead deposit in the Verkhoyano-Kolymskaya fold system, of the Lena River basin, Eastern Yakutia, Siberia, Russia.

Occurrence: In goethite pseudomorphs after magnesian siderite. Other associated minerals are: silver amalgam and silver-bearing minerals of the tennantite-tetrahedrite series.

General appearance: Grains and aggregates of grains (0.003 to 0.2 mm).

Physical properties: *Luster:* metallic. *Diaphaneity:* opaque. *Color:* could not be observed megascopically. *Streak:* dark grey. *Hardness:* VHN_{10} 310 kg/mm², Mohs 4½. *Tenacity:* not mentioned. *Cleavage:* not observed. *Fracture:* not observed. *Density:* could not be measured, 4.57 g/cm³ (calc.). ***Crystallography:*** Tetragonal, possibly $P4_2mc$, a 5.64, c 10.34 Å, V 328.9 Å³, Z 4, c:a = 1.8333. Morphology: no forms observed. Twinning: none observed. ***X-ray powder diffraction data:*** 3.15 (10), 2.445 (2), 2.340 (≤), 1.910 (4), 1.692 (2). ***Optical data:*** In reflected light: cream with a greyish tint, moderate anisotropism, no bireflectance, nonpleochroic. R_O & R_E: (29.2, 26.7 %) 460nm, (36.1, 32.4 %) 540nm, (37.3, 33.1 %) 580nm, (34.0, 31.2 %) 660nm. ***Chemical analytical data:*** Means of five sets of electron microprobe data: Ag 46.6, Fe 24.1, Hg 0.3, S 28.9, Total 99.9 wt.%. Empirical formula: $Ag_{0.98}Fe_{0.98}S_{2.04}$. ***Relationship to other species:*** The chemical formula and X-ray powder diffraction data indicate a relationship to the chalcopyrite group. ***Name:*** For the locality (the Lena River). ***Comments:*** IMA No. 94-008. This abstract contains data taken from the original IMA proposal.

AMUZINSKY, V. A., ZHDANOV, Yu., Ya., ZAYAKINA, N. V., and LESKOVA, N. V. (1995) Lenaite $AgFeS_2$—a new mineral species. *Zapiski Vsesoyuznyi Mineralogicheskoe Obshchestva* **124(5)**, 85–91.



Medenbachite

Medenbachite Triclinic

$Bi_2Fe^{3+}(Cu,Fe^{2+})(O,OH)_2(OH)_2(AsO_4)_2$

Locality: In a quarry near the Borstein cliff, about 1 km east of the town of Reichenbach (Lat. 49°42′49″ N, Long. 8°41′00″ E), Odenwald, Hesse, Germany.

Occurrence: In a silicified barite vein. Associated minerals are: mixite, preisingerite, alunite, goethite, reichenbachite, and malachite.

General appearance: Very small, intergrown, tabular crystals (up to 0.2 mm long), often forming aggregates of parallel intergrowths.

Physical properties: *Luster:* vitreous to adamantine. *Diaphaneity:* transparent to translucent. *Color:* yellow to brown-yellow. *Streak:* light yellow. *Luminescence:* non-fluorescent. *Hardness:* VHN_{25} 420 kg/mm², Mohs 4½. *Tenacity:* brittle. *Cleavage:* none observed. *Fracture:* conchoidal. *Density:* could not be measured, 5.90 g/cm³ (calc.). ***Crystallography:*** Triclinic, $P\bar{1}$, a 4.570, b 6.162, c 8.993 Å, α 94.56°, β 99.69°, γ 94.28°, V 247.9 Å³, Z 1, a:b:c = 0.7416:1:1.4594. Morphology: forms, {001}, $\{10\bar{1}\}$, {101}, $\{1\bar{1}0\}$, $\{01\bar{1}\}$, $\{13\bar{1}\}$. Twinning: none observed. ***X-ray powder diffraction data:*** 8.823 (62), 5.264 (44), 3.749 (100), 3.596 (77), 3.468 (58), 2.903 (69), 2.810 (51), 2.685 (48), 2.558 (44). ***Optical data:*** Biaxial (-), α 2.03, β 2.09 (calc.), γ 2.10, 2V(meas.) 43°; dispersion r > v, magnitude not stated; nonpleochroic; the values of ϕ and ρ of the principal vibration directions are: X (-14°, 74°), Y (-117°, 52°), Z (95°, 43°). ***Chemical analytical data:*** Means of seventeen sets of electron microprobe data: FeO 2.90, CuO 5.82, Fe_2O_3 8.67, Bi_2O_3 53.37, As_2O_5 26.41, H_2O 3.07 (calc.), Total 100.24

wt.%. Empirical formula: $Bi_{2.01}Fe^{3+}_{0.95}(Cu_{0.64}Fe^{2+}_{0.35})_{\Sigma 0.99}O_{0.9}(OH)_{3.00}(AsO_4)_{2.02}$. ***Relationship to other species:*** none apparent. ***Name:*** For Dr. Olaf Medenbach (1949–) of the University of Bochum, Germany. ***Comments:*** IMA No. 93-048. This abstract contains data taken from the original IMA proposal. The crystal drawing in the paper is not in the standard orientation, so it has been redrawn for this abstract. The forms listed here have been recast to conform with the faces on the front of the crystal.

KRAUSE, W., BERNHARDT, H. J., GEBERT, W., GRAETSCH, H., BELENDORFF, K., and PETITJEAN, K. (1996) Medenbachite, $Bi_2Fe(Cu,Fe)(O,OH)_2(OH)_2$-$(AsO_4)_2$, a new species: Its description and crystal structure. *American Mineralogist* **81**, 505–512.

Noélbensonite — Orthorhombic

$BaMn^{3+}_2(Si_2O_7)(OH)_2 \cdot H_2O$

Locality: The Woods mine 30 km NNE of Tamworth, New South Wales, Australia. Also found at the Cerchiara mine northern Appenines, Italy.

Occurrence: As a replacement of NaMn amphibole, namansilite and serandite and as the main or sole constituent of tiny veinlets. Associated minerals are: serandite, rhodonite, NaMn amphibole, namansilite, manganian aegirine, sugilite, braunite, hausmannite, tephroite, rhodochrosite, quartz, albite, barian potassium feldspar, barite, fluorapatite, and unidentified phases. Pectolite is noted in the paper's abstract, but not in the text.

General appearance: Aggregates of blocky to lamellar crystals ranging from a few μm up to 100 μm. Also as monomineral veinlets 0.05 to 0.25 mm thick and as euhedral crystals.

Physical properties: *Luster:* earthy to brilliantly vitreous, but the indices of refraction indicate an adamantine luster. *Diaphaneity:* translucent to transparent in thin section. *Color:* dark brown. *Streak:* paler yellow brown. *Luminescence:* non-fluorescent. *Hardness:* about 4. *Tenacity:* brittle. *Cleavage:* not observed. *Fracture:* earthy to irregular. *Density:* could not be measured, 3.87 g/cm³ (calc.). ***Crystallography:*** Orthorhombic, Cmcm, a 6.325, b 9.120, c 13.618 Å, V 785.6 Å³, Z 4, a:b:c = 0.6935:1:1.4932. Morphology: forms, {100} and {011}. Twinning: none observed. ***X-ray powder diffraction data:*** 4.85 (100), 4.557 (50), 4.322 (59), 3.416 (77), 2.869 (80), 2.849 (47), 2.729 (82), 2.543 (45), 2.428 (48). ***Optical data:*** Biaxial (-), α 1.82, β 1.845 (calc.) (erroneously given as 1.835), γ 1.85, 2V(meas.) 46°; dispersion r > v, strong; pleochroism X = orange yellow, Y = orange, Z = brownish orange; orientation, X = c, Y = b, Z = a. ***Chemical analytical data:*** Means of twenty-three sets of electron microprobe data: Na_2O 0.14, CaO 0.31, BaO 29.08, SrO 1.51, Al_2O_3 0.17, Mn_2O_3 34.76, Fe_2O_3 0.19, SiO_2 26.02, TiO_2 0.01, H_2O (7.87), Total wt.%. H_2O was calculated to give $2H_2O$. Empirical formula: $(Ba_{0.87}Sr_{0.07}Ca_{0.03}Na_{0.02})_{\Sigma 0.99}(Mn^{3+}_{2.02}Fe^{3+}_{0.01})_{\Sigma 2.03}(Si_{1.98}Al_{0.02})_{\Sigma 2.00}O_{7.00}$-$(OH)_{2.00} \cdot H_2O$. ***Relationship to other species:*** It is the Ba-Mn analogue of lawsonite and the Ba analogue of hennomartinite. ***Name:*** For William Noél Benson (1885–1957), of the University of Otago, in recognition of his pioneering research in the Great Serpentine Belt and New England Fold Belt of New South Wales, Australia, where the mineral was found. ***Comments:*** IMA No. 94-058.

KAWACHI, K., COOMBS, D. S., and MIURA, H. (1996) Noélbensonite, a new BaMn silicate of the lawsonite structure type, from Woods mine, New South Wales, Australia. *Mineralogical Magazine* **60**, 369–374.

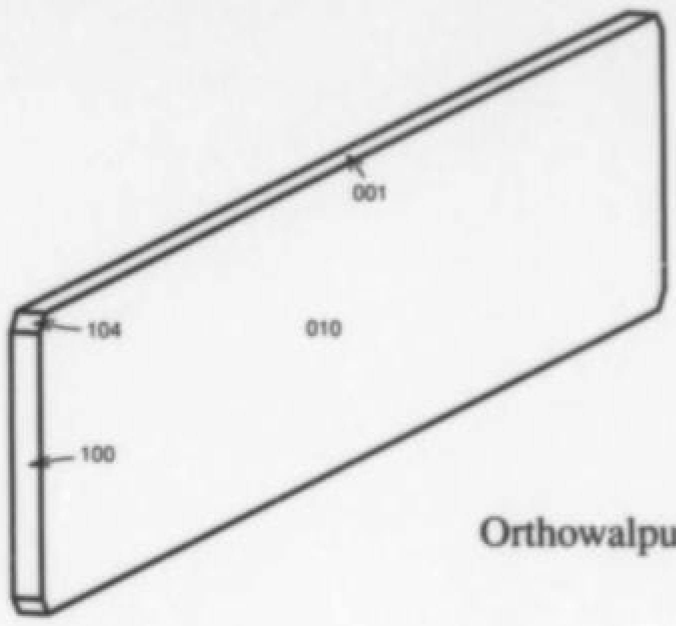
Orthowalpurgite — Orthorhombic

$(UO_2)Bi_4O_4(AsO_4)_2 \cdot 2H_2O$

Locality: The Schmiedestollen, Wittichen, Black Forest, Germany.

Occurrence: May have formed by weathering of emplectite, wittichenite or other Bi-bearing ore minerals. Associated minerals are: preisingerite, quartz, anatase and a white, powdery material whose main constituents are Al and Si.

General appearance: Crystals tabular on {010} and elongated parallel to [100] (up to 0.3 mm); usually as fan-shaped aggregates up to 1 mm. Only 2 to 3 milligrams are known to exist.



Orthowalpurgite

Physical properties: *Luster:* adamantine. *Diaphaneity:* transparent. *Color:* pale yellow. *Streak:* pale yellow. *Luminescence:* non-fluorescent. *Hardness:* VHN_{25} 330 kg/mm², Mohs 4½. *Tenacity:* brittle. *Cleavage:* {001} indistinct. *Fracture:* conchoidal. *Density:* could not be measured due to lack of material, 6.50 g/cm³ (calc.). ***Crystallography:*** Orthorhombic, Pbcm, a 5.492, b 13.324, c 20.685 Å, V 1513.6 Å³, Z 4, a:b:c = 0.4122:1:1.5525. Morphology: forms, {010}, {001}, {104}, and {100}. Twinning: none observed. ***X-ray powder diffraction data:*** 10.354 (94), 5.610 (40), 3.452 (34), 3.277 (56), 3.208 (100), 3.088 (76), 2.999 (50), 2.852 (46). ***Optical data:*** Biaxial (-), α 1.91, β 2.00, γ 2.05 (calc.), 2V(meas.) 70°; nonpleochroic. ***Chemical analytical data:*** Means of eight sets of electron microprobe data: Bi_2O_3 64.21, UO_3 17.86, As_2O_5 16.11, H_2O 2.43 (calc.), Total 100.61 wt.%. Empirical formula: $(UO_2)_{0.92}Bi_{4.06}O_{3.89}(AsO_4)_{2.07} \cdot 1.99H_2O$. ***Relationship to other species:*** It is an orthorhombic polymorph of walpurgite. ***Name:*** For the relationship to walpurgite. ***Comments:*** IMA No. 94-024. The paper also contains details of the crystal structure and a comparison with walpurgite. The crystal drawing which accompanies this abstract was deduced from an SEM photograph in the paper and the forms stated to be present. Dr. Krause confirmed that it accurately reflects the appearance of the crystals.

KRAUSE, W., EFFENBERGER, H. and BRANDSTÄTTER, F. (1995) Orthowalpurgite, $(UO_2)Bi_4O_4$-$(AsO_4)_2 \cdot 2H_2O$, a new mineral from the Black Forest, Germany. *European Journal of Mineralogy* **7**, 1313–1324.

Oulankaite — Tetragonal

$(Pd,Pt)_5(Cu,Fe)_4SnTe_2S_2$

Locality: The Lukkulaisvaara layered intrusion in the Oulanka complex, northern Karelia, Russia.

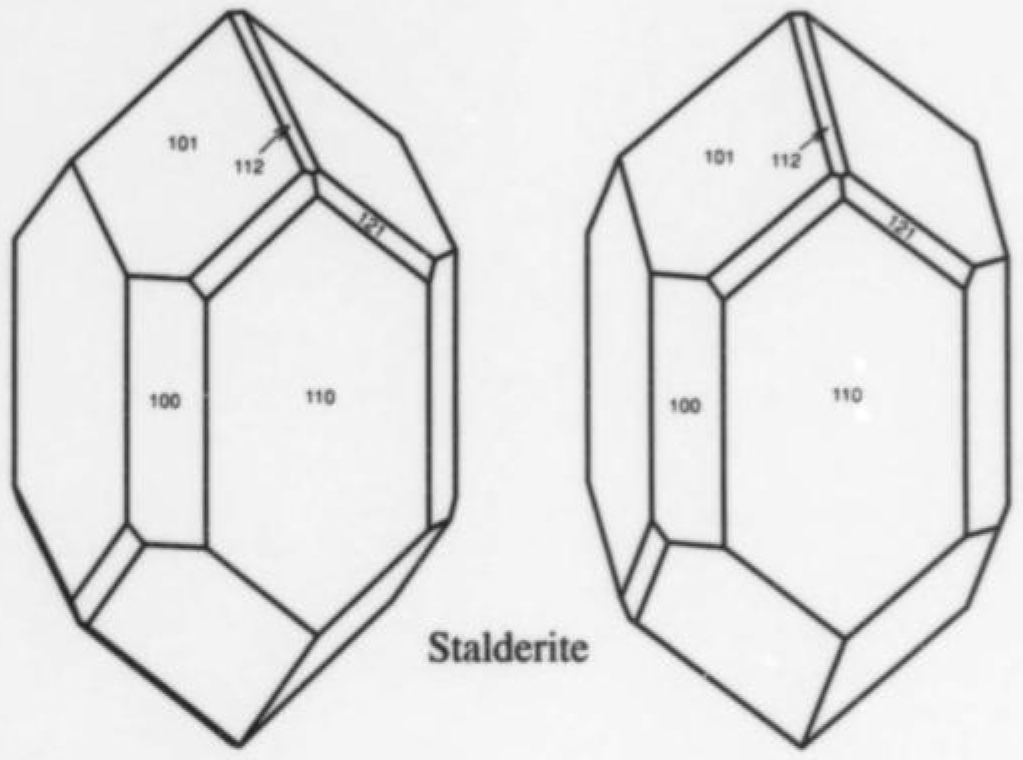
Occurrence: In pegmatoidal, plagioclase-bearing pyroxenite. Associated minerals are: orthopyroxene, chalcopyrite, bornite, millerite, pentlandite, linnaeite group minerals, sphalerite, galena, pyrite, molybdenite, telargpalite, moncheite, kotulskite, tulameenite, sperrylite, taimyrite, atokite-rustenburgite series members, zvyagintsevite, irarsite, telluropalladinite (?), tarkianite, and unnamed rhenium-rich sulfide, $(Cu,Fe)(Re,Mo)_4S_8$.

General appearance: Platy subhedral to euhedral inclusions in chalcopyrite (up to 0.2 x 0.1 mm).

Physical properties: *Luster:* metallic. *Diaphaneity:* opaque. *Color:* megasopic color unknown. *Streak:* unknown. *Hardness:* VHN_{20-40} 221 kg/mm². *Tenacity:* unknown. *Cleavage:* perfect, but not identified. *Fracture:* unknown. *Density:* could not be measured, 10.27 g/cm³ (calc.). ***Crystallography:*** Tetragonal, space group unknown, a 9.044, c 4.937 Å, V 403.8 Å³, Z 2, c:a = 0.5459. Morphology: no forms were observed. Twinning: observed in polished sections. ***X-ray powder diffraction data:*** 2.472 (10), 2.260 (9), 2.022 (6), 1.361 (4), 1.213 (5), 1.205 (5), 1.129 (5). ***Optical data:*** In reflected light: yellowish-rose, strong anisotropism, strong bireflectance, strong pleochroism. R_1, R_2; $^{im}R_1$, $^{im}R_2$: (41.6, 36.2; 29.1, 23.5 %) 470nm, (48.7, 41.0; 35.2, 29.5 %) 546nm, (51.7, 43.1; 37.1, 30.8 %) 589nm, (54.0, 44.6; 30.4, 33.8 %) 650nm. ***Chemical analytical data:*** Several electron microprobe analyses were carried out. A representative set of data is: Cu 17.4, Pd 41.3, Pt 2.6, Fe 2.7, Sn 9.6, Te 21.6, S 4.7, Total 99.9 wt.%. Empirical formula:

$(Pd_{4.85}Pt_{0.17})_{\Sigma 5.02}(Cu_{3.42}Fe_{0.60})_{\Sigma 4.02}Sn_{1.01}Te_{2.12}S_{1.83}$. ***Relationship to other species:*** None apparent. ***Name:*** For the Oulanka river, which is near the occurrence. ***Comments:*** IMA No. 90-055.

BARKOV, A. Yu., MEN'SHIKOV, Yu. P., BEGIZOV, V. D., and LEDNEV, A. I. (1996) Oulankaite, a new platinum-group mineral from the Lukkulaisvaara layered intrusion, northern Karelia, Russia. *European Journal of Mineralogy* **8**, 311–316.



Stalderite

Stalderite

Tetragonal

$TlCu(Zn,Fe,Hg)_2As_2S_6$

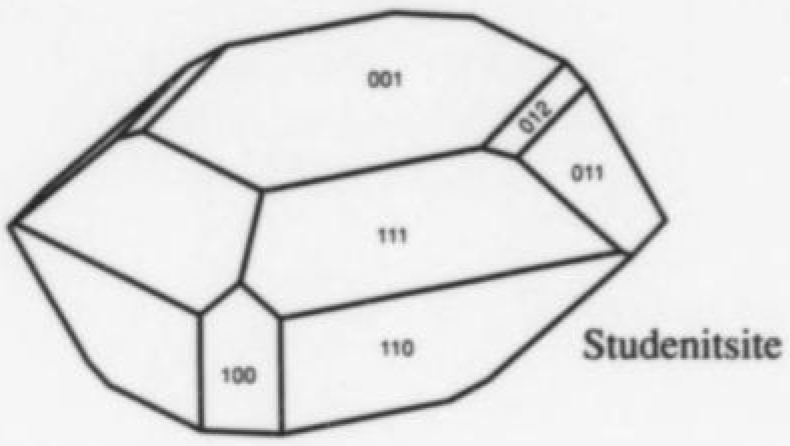
Locality: Lengenbach, Binntal, Canton Wallis, Switzerland.

Occurrence: In small cavities of hydrothermal origin in Triassic dolomite. Associated minerals are: hutchinsonite, hatchite, wallisite, edenharterite, bernardite, realgar and orpiment.

General appearance: Euhedral crystals (up to 0.5 mm).

Physical properties: *Luster:* metallic. *Diaphaneity:* opaque. *Color:* black with a slight blue and red tarnish. *Streak:* brown-red. *Hardness:* VHN_{10} 135 kg/mm², Mohs 3½-4. *Tenacity:* brittle. *Cleavage:* not observed. *Fracture:* uneven. *Density:* could not be measured, 4.97 g/cm³ (calc.). ***Crystallography:*** Tetragonal, $I\bar{4}2m$, a 9.855, c 10.937 Å, V 1062.3 Å³, Z 4, c:a = 1.1098. Morphology: forms, {110}, {101}, {100}, {121}, {112}. Twinning: none mentioned. ***X-ray powder diffraction data:*** 4.086 (51), 3.417 (34), 2.940 (100), 2.541 (20), 2.436 (39), 1.8060 (22), 1.7431 (23). ***Optical data:*** In reflected light: greyish-white, very weak anisotropism, no bireflectance, nonpleochroic. $R_{min.}$ & $R_{max.}$: (27.0, 30.5 %) 480nm, (27.0, 28.0 %) 546nm, (25.0, 27.0 %) 589nm, (24.4, 25.5 %) 656nm. ***Chemical analytical data:*** Means of three sets of electron microprobe data: Cu 7.20, Ag 0.23, Pb 2.25, Zn 9.16, Fe 3.02, Hg 8.90, Tl 25.80, As 18.48, S 24.48, Total 99.52 wt.%. Empirical formula: $Tl_{1.01}(Cu_{0.91}Pb_{0.09}Ag_{0.02})_{\Sigma 1.02}(Zn_{1.12}Fe_{0.43}Hg_{0.35})_{\Sigma 1.90}As_{1.97}S_{6.10}$. ***Relationship to other species:*** It is closely related to routhierite. ***Name:*** For Prof. Dr. (Emeritus) Hans A. Stalder (1925–) of the Natural History Museum, Berne. ***Comments:*** IMA No. 87-024. The crystal drawing in the paper is rotated slightly about [001] in order to avoid the narrow views of two faces, $\{1\overline{12}\}$ and $\{\overline{12}1\}$, which result in two very thick lines in the lower left part of the drawing. The drawings that accompany this abstract show (a) the normal orientation and (b) the same crystal rotated 12° to the left (i.e., 12° clockwise when viewed from the top).

GRAESER, S., SCHWANDER, H., WULF, R., and EDENHARTER, A. (1995) Stalderite $TlCu(Zn,Fe,Hg)_2As_2S_6$—a new mineral related to routhierite: description and crystal structure determination. *Schweizerische mineralogische und petrographische Mitteilungen* **75**, 337–345.



Studenitsite

Studenitsite

Monoclinic

$NaCa_2[B_9O_{14}(OH)_4]\cdot 2H_2O$

Locality: In the Pobrdzhsky Potok and Peskanya deposits, 280 km south of Belgrade, near the town of Balevats on the Jbar River, western Serbia, Yugoslavia.

Occurrence: In a borate deposit. Associated minerals are: colemanite, howlite, ulexite, pentahydroborite and clay minerals.

General appearance: Wedge-shaped, striated crystals (up to 5 mm long).

Physical properties: *Luster:* vitreous. *Diaphaneity:* transparent. *Color:* colorless to light dirty-yellow and light grey. *Streak:* white. *Luminescence:* non-fluorescent. *Hardness:* 5½ to 6. *Tenacity:* fragile. *Cleavage:* absent. *Fracture:* not mentioned. *Density:* 2.29 g/cm³ (meas.), 2.33 g/cm³ (calc.). ***Crystallography:*** Monoclinic, $P2_1/c$, a 11.4994, b 12.5878, c 10.5297 Å, β 99.423°, V 1503.6 Å³, Z 4, a:b:c = 0.9135:1:0.8365. Morphology: forms, {100}, {001}, {011}, {012}, {110}, {111}; flattened on {001} and elongated along [100]. Twinning: none. ***X-ray powder diffraction data:*** 5.41 (66), 5.20 (57), 4.20 (56), 3.35 (89), 3.27 (59), 3.04 (100), 2.210 (59), 1.960 (43). ***Optical data:*** Biaxial (+), α 1.532, β 1.538, γ 1.564, 2V(meas.) 54°, 2V(calc.) 52°; dispersion $r > v$ medium; nonpleochroic; X = b, $Y \wedge c = 10°$ (in obtuse angle β), Z = a. ***Chemical analytical data:*** A wet chemical analysis gave the following data: Na_2O 5.96, K_2O 0.08, MgO 0.02, CaO 20.84, MnO 0.01, SrO 0.09, B_2O_3 59.64, Al_2O_3 0.05, Fe_2O_3 0.05, SiO_2 0.09, H_2O 13.64, Total 100.47 wt.%. Empirical formula: $(Na_{1.01}K_{0.01})_{\Sigma 1.02}Ca_{1.95}B_{9.01}O_{14.00}(OH)_{3.94}\cdot 2.01H_2O$. ***Relationship to other species:*** None apparent. ***Name:*** For the Serbian cloister Studenitsa near the occurrence. ***Comments:*** IMA No. 94-026. This abstract contains data taken from the original IMA proposal. The crystal drawing in the paper is in a non-standard orientation so it has been redrawn here.

MALINKO, M. A., ANICHICH, S., YOKSIMOVICH, D., LISITSYN, A. E., DOROKHOVA, G. I., YAMNOVA, M. A., VLASOV, V. V. and OZOL, A. A. (1995) Studenitsite $NaCa_2[B_9O_{14}(OH)_4]\cdot 2H_2O$—the new borate from Serbia, Yugoslavia. *Zapiski Vsesoyuznyi Mineralogicheskoe Obshchestva* **124(3)**, 57–64. ☒

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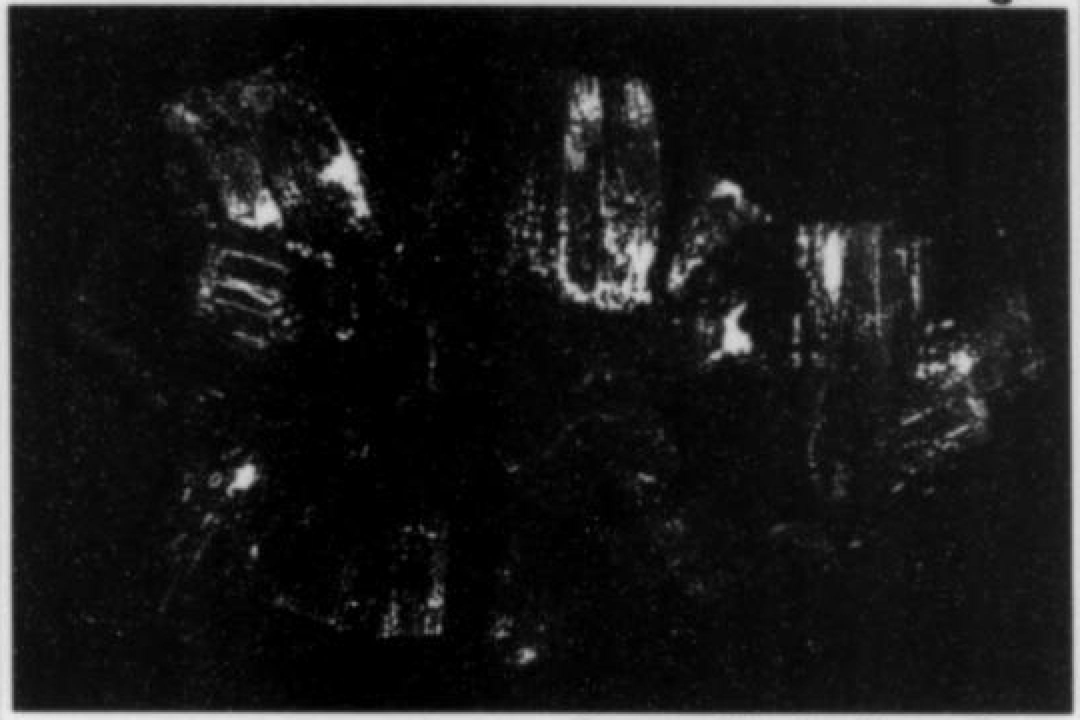
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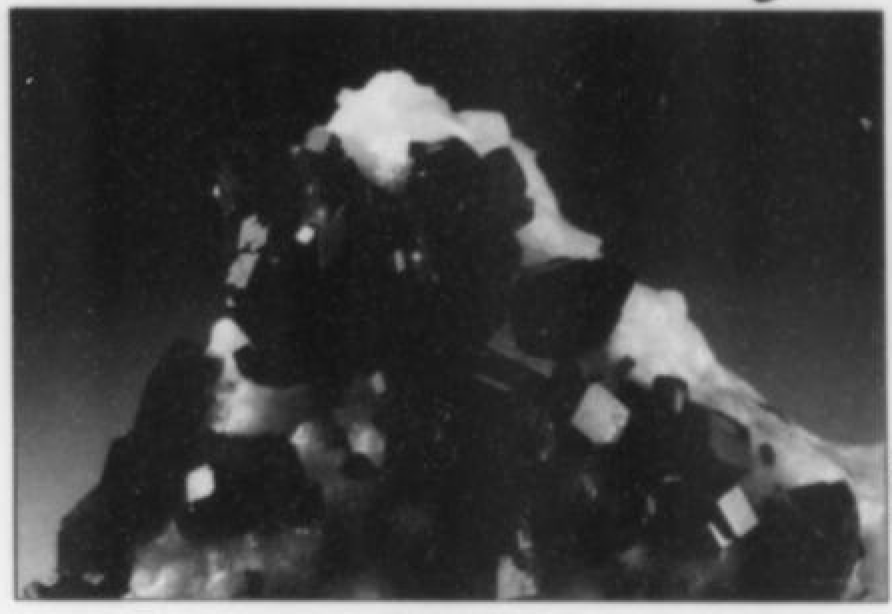
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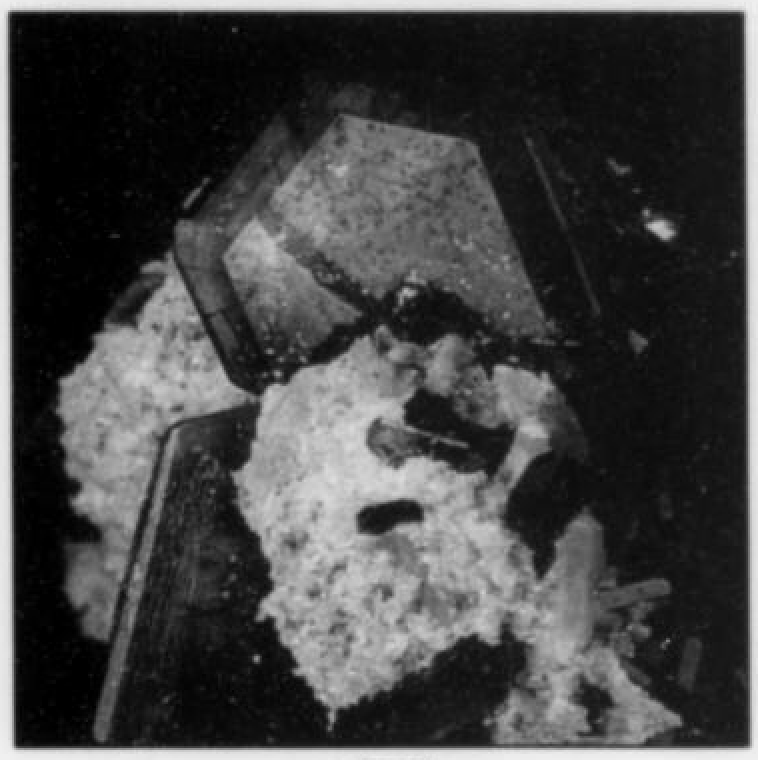
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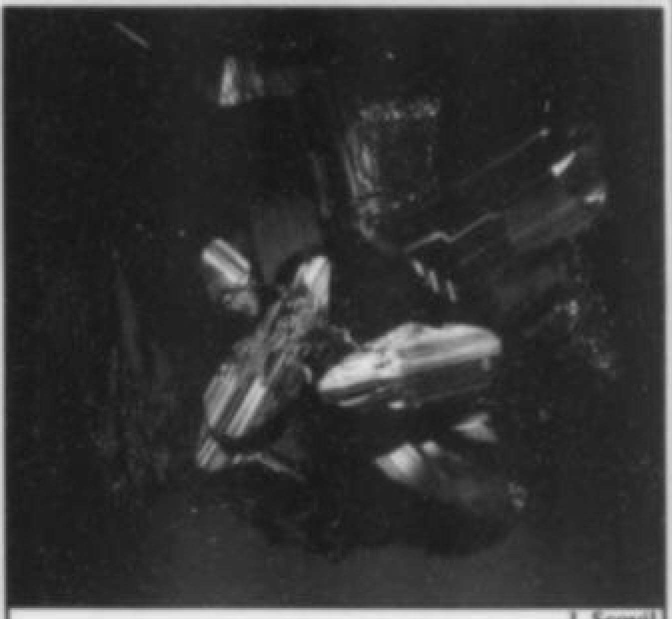
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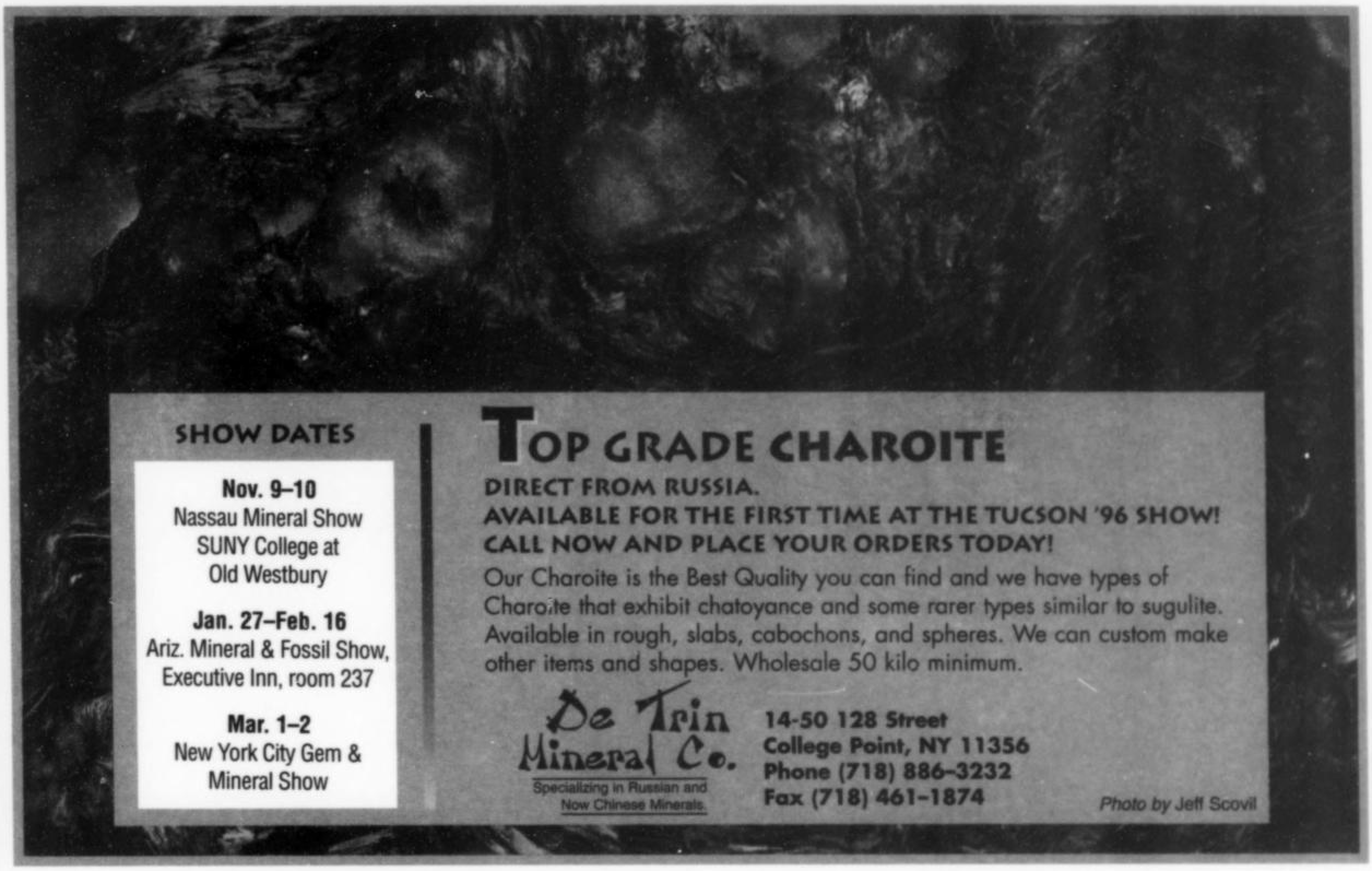

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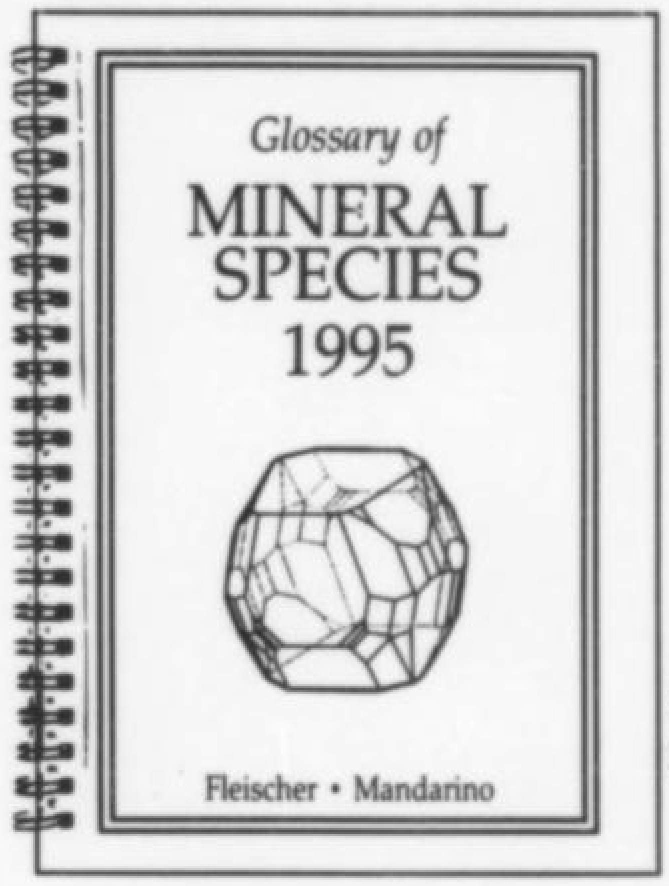
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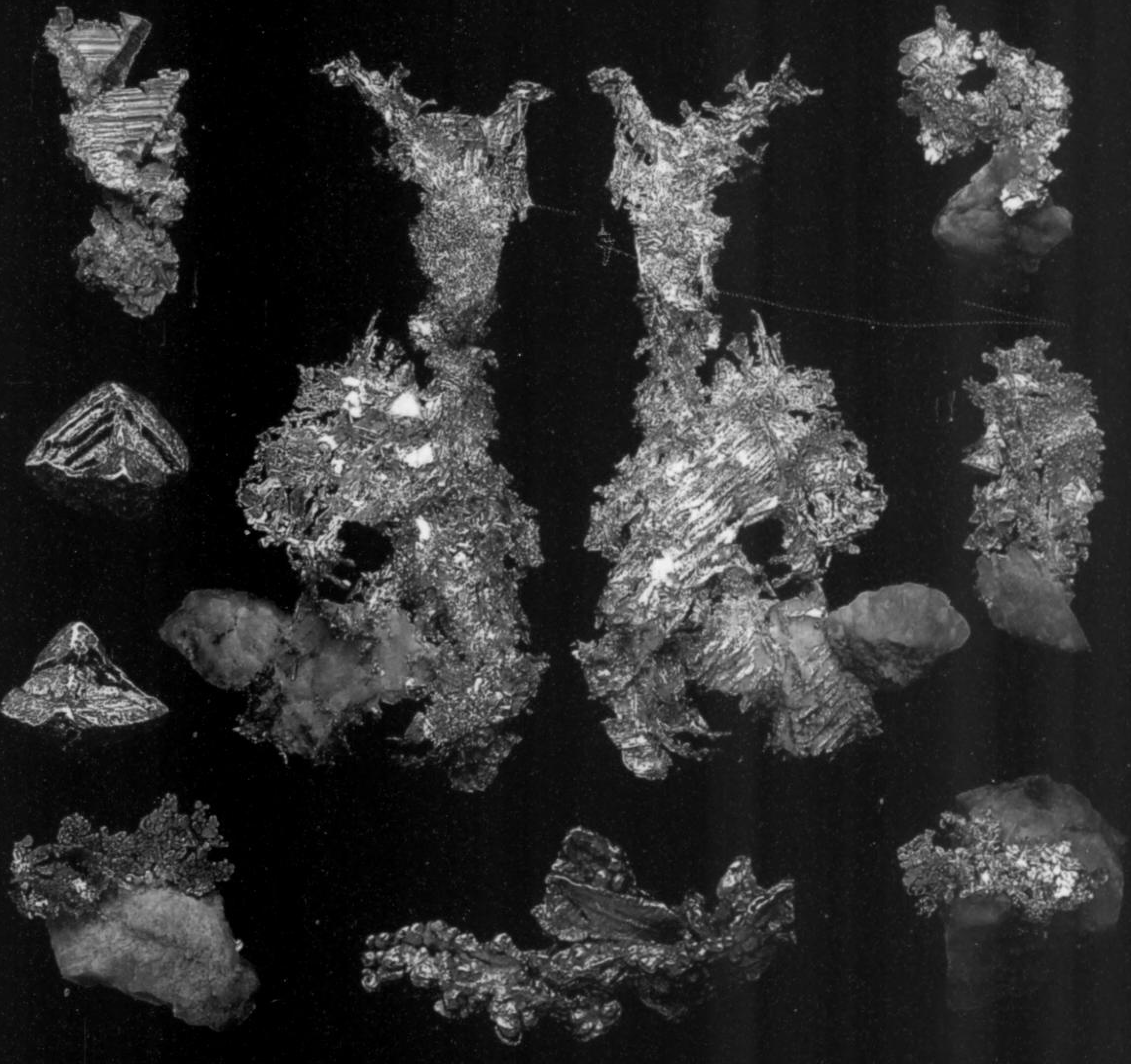

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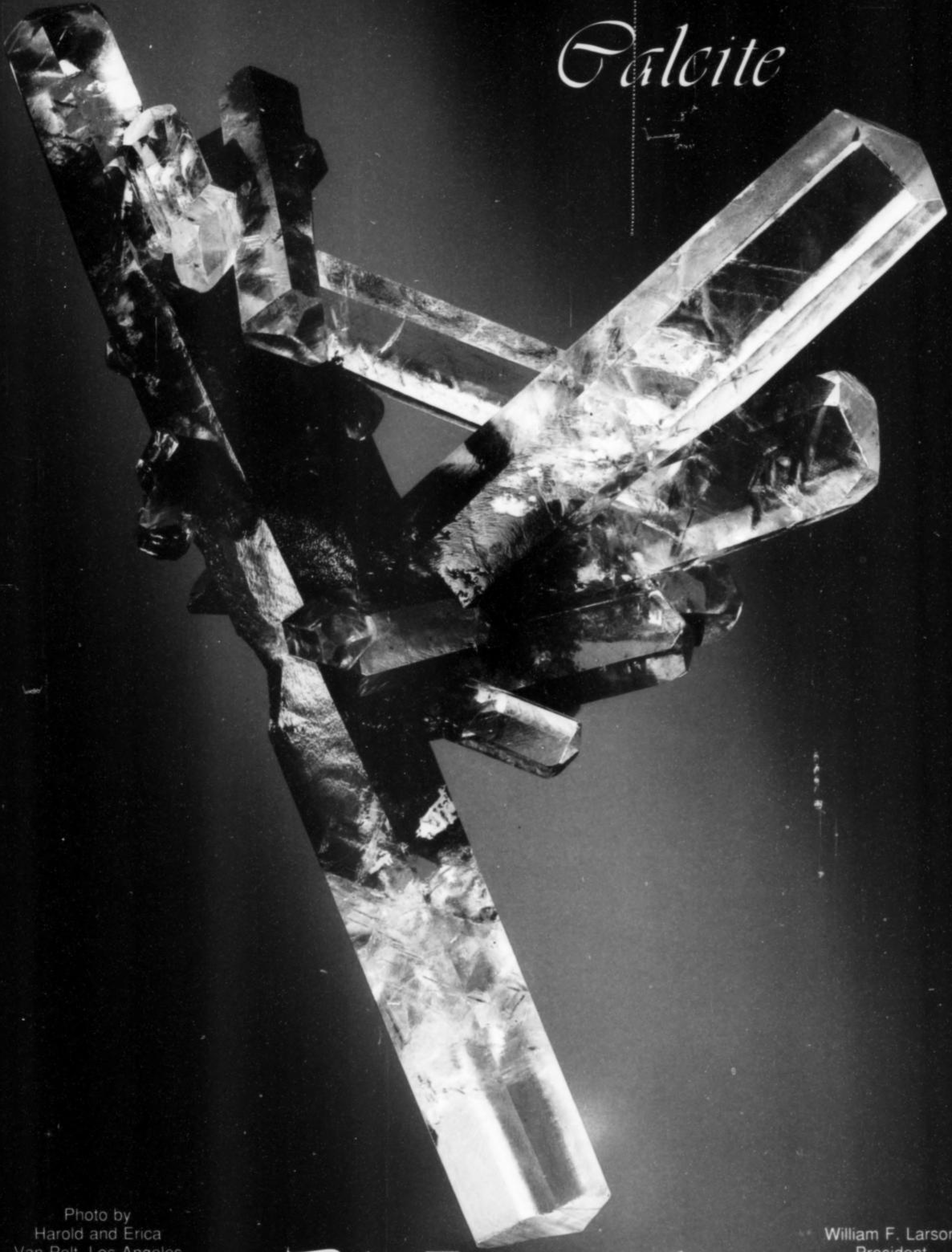

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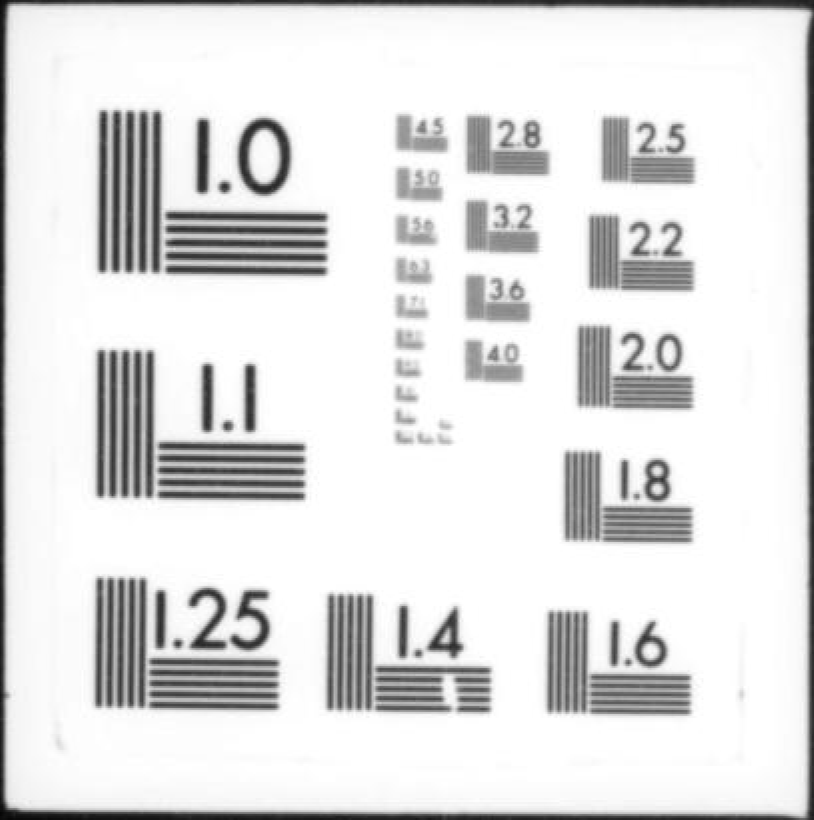
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