the Mineralogical Record

Volume Twenty-seven, Number Two
March–April 1996
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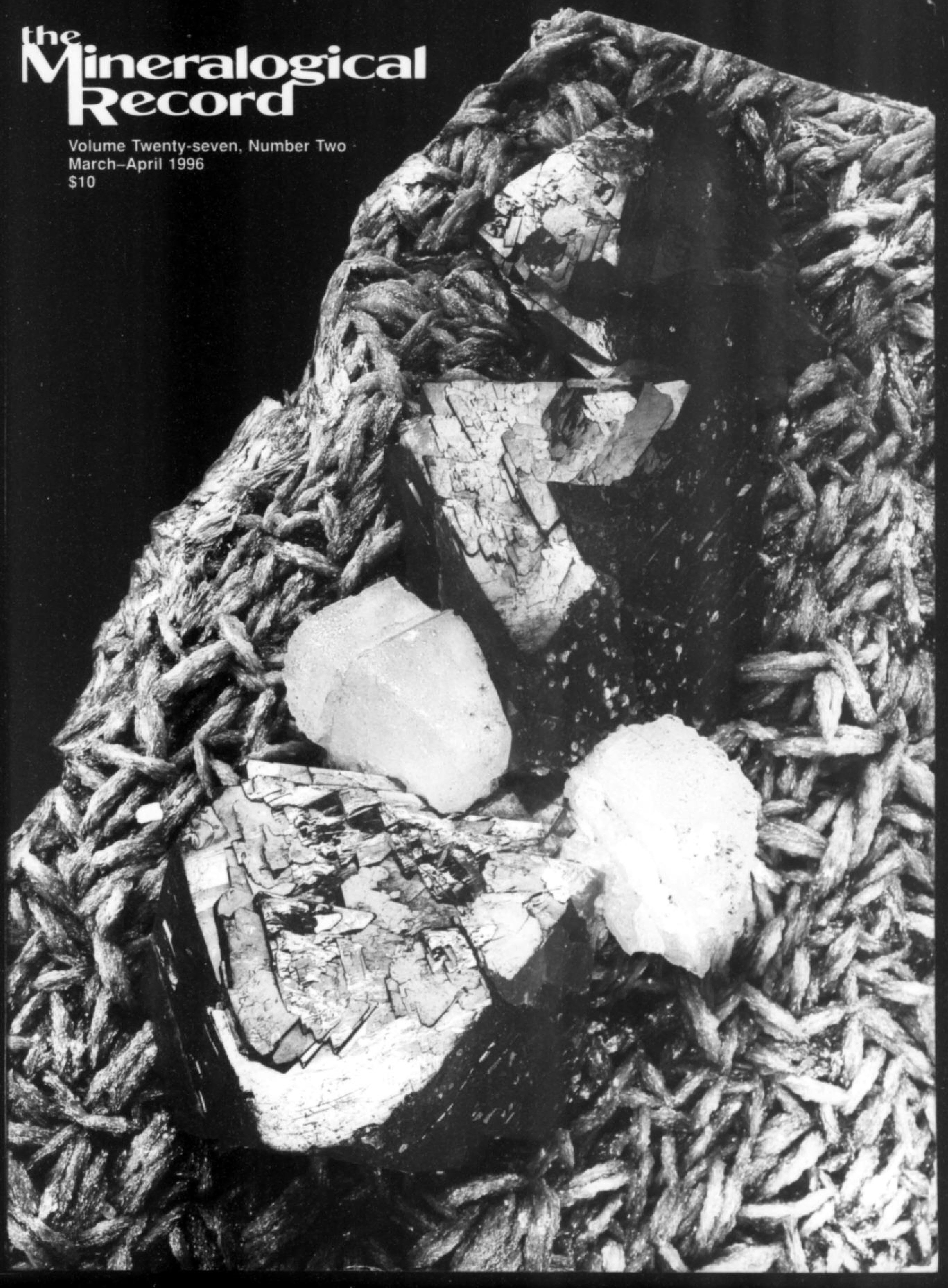

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THE MINERALOGICAL RECORD

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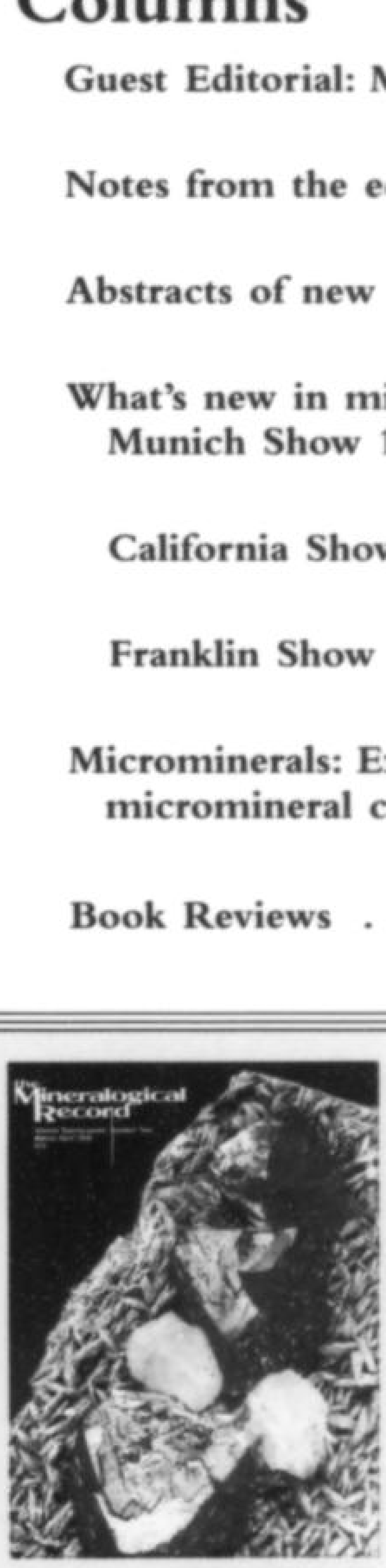
Articles

Columns



COVER: SCHEELITE with calcite on muscovite, from Xue Bao Diang Mountain north of Chengdu, Sichuan, China. Jeff Scovil photo; Marvin Rausch collection.

The Mineralogical Record (ISSN 0026-4628) is published bi-monthly for $39 per year (U.S.) by Mineralogical Record, Inc., a non-profit organization, 7413 N. Mowry Place, Tucson, AZ 85741. Special second-class postage paid at Tucson, Arizona and additional mailing offices. POSTMASTER: Send address changes to: The Mineralogical Record, P.O. Box 35565, Tucson, AZ 85740.

Guest Editorial

MINERAL COLLECTING IN THE CYBER* AGE

Hardly a day passes without another headline touting the coming of the "information superhighway" and how it is going to change the world as we know it. Everything from banking and shopping to entertainment can be accessed from a personal computer "hooked" to the Internet. Electronic transactions are becoming the norm. For example, the President of the United States receives more electronic mail (e-mail) than ink-and-paper letters. Cyberspace, the rapidly expanding world of electronic communication, provides some exciting opportunities for the mineral collector. I think that the entire hobby will be significantly affected over the next few years by changes in how we use published information, market specimens and attract new collectors. In fact, the *Mineralogical Record* will soon be available in an electronic version. Larsen Enterprises has contracted with Mineralogical Record Inc. to put *all* the back issues in an electronic archive that can be browsed via a link to the Internet. State-of-the-art scanning will allow the photos to be reproduced with high fidelity. The most limiting factor in quality reproduction is the resolution of the viewing screen on your personal computer (which is improving dramatically with each new model!). The electronic version of *Mineralogical Record* will never replace the hard copy, but it will provide a new way to access articles and photographs of interest and may someday replace the local library.

The activity of mineral collecting is also changing with the advent of cyberspace. The age-old problem for mineral dealers is how to advertise their stock to prospective customers. *Mineral shows* provide the ideal setting; customers can view the entire stock, and dealers can apply the charm of salesmanship. But, outside of shows, how does the dealer market his or her specimens to the collector several hundred kilometers away? Many dealers send potential customers photographs of specimens for possible purchase. The problem with this approach is that the dealer has to identify the customer *a priori* and, further, guess at the type of specimen the customer is looking for. In the last few years some enterprising dealers have tried to improve on this scheme by videotaping whole suites of minerals and then distributing the videotape. Many of these "home movies" are of high quality, and I have heard that some fine minerals have been sold this way. But the videotape medium is severely limited: the whole tape needs to be edited and updated as material is sold. Further, marketing is limited to readers of magazines like *Mineralogical Record,* where ads for videotapes can be found.

The limitations of videotape and direct mailing are removed with the use of electronic catalogs on the World Wide Web (WWW). The web is a marvelous electronic network which allows Internet users to view documents with pictures, sound and text. For example, a mineral collector in Cornwall, England, can connect to my computer at the University of Arizona and peruse a catalog of color photos of specimens in the University of Arizona Mineral Museum. All a "virtual collector" needs is a computer and direct access to the Internet. Internet access is provided by hundreds of companies in every corner of America. The computer user enters the WWW with software called a browser, which provides a point-and-click interface for easy cyberspace travel. There are many browsers available, though the most popular are *Mosaic* and *Netscape*. The browser allows the user to search through the WWW for specific information located on *all other computers* connected to the web! This information is contained in archives known as *web sites.* Web sites are documents which are maintained by their owners and can be continually updated. Web sites can contain an extraordinary variety of text, graphics, photos and interactive programs.

Web sites provide the mineral dealer many of the advantages of a mineral show. Potential customers look through the dealer's stock at their leisure and are assured that the material is still for sale. However, the customer never has to leave home and can visit the dealer's booth at 2:00 a.m.! The downside for potential cyber dealers is that merchandise must be photographed and scanned. However, this is becoming an increasingly easy task, and every town has computer service companies which can provide the service.

There are two main reasons why I think electronic stores are going to have a dramatic impact on mineral collecting. The first is ease of access. Collectors can literally shop for minerals daily. The second reason is more subtle: it will attract new customers to the hobby. Hundreds of thousands of computer users "surf" the web daily looking for new and

*Cyber is now a noun used to mean electronic communication.

interesting sites. Some fraction of these surfers will stumble onto a beautiful photo of a mineral, become intrigued, and buy a specimen. Think about how you got interested in buying minerals. You were probably dragged along to a mineral show by friends or family. There you saw a really neat rock and you bought it! Wendell Wilson has long been of the opinion that most people who *could* become serious mineral collectors have a strong natural predisposition in that direction, and require only a proper introduction to the field in order to quickly realize how much they like it. Much of the general population has never had the chance to be exposed to minerals, but the Internet will change all that.

Several mineral dealers have recently begun to advertise on the web. These documents can be accessed by visiting a marvelous web site called *Bob's Rock Shop*©, maintained by Bob Keller. Bob's Rock Shop is a starting point to explore software, mineral news, museum announcements and, of course, mineral dealers on the web. The web address of Bob's Rock Shop is www.rtd.com/~bkeller/rockshop/table.html. I think you will enjoy a cyber visit where you can ponder the future of collecting.

Terry C. Wallace
Curator, University of
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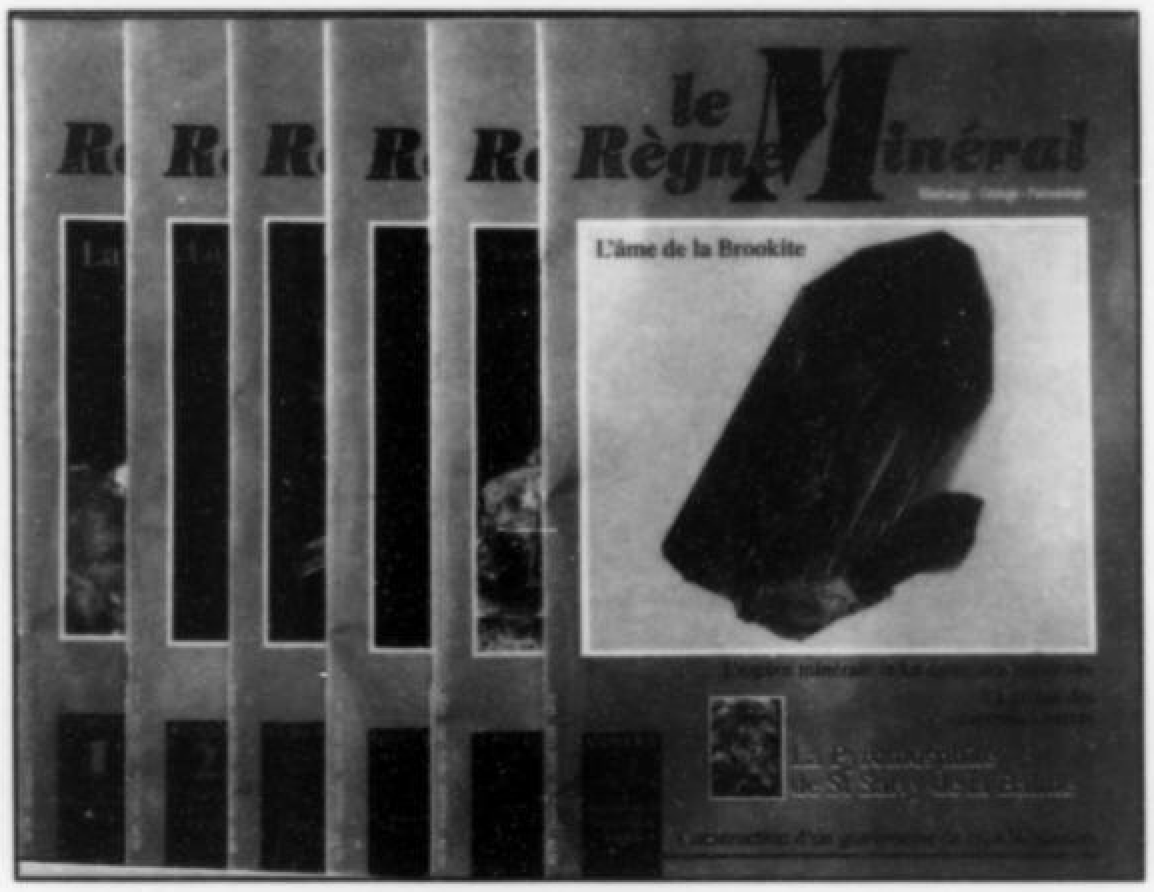
Tucson, Arizona 85721

notes from the EDITOR



NEW FRENCH MAGAZINE!

With the conclusion of 1995, six regular issues and one special, separately priced issue of the new French mineral magazine *Le Règne Minéral* ("The Mineral Kingdom") are now in hand, and what a beautiful production it is! The year's regular issues, in tall format (like *Lapis*) and averaging about 50 pages each, are pitched directly to the mineral collector. Large, high-quality specimen photographs decorate topical articles (e.g. "wulfenite," "septaria," "color in minerals," "minerals from coal deposits," etc.), topographical mineralogy ("Gold in France," "The rare minerals of Sardinia," "Garnet, actinolite and magnetite from Tyrol," "Pyromorphite from Saint-Salvy de la Balme," etc.), notes on new museum exhibits, features on private collections, book reviews and so on. One article describes and pictures a fantastic cave filled with crystals and formations of bright green aragonite. Another tells how to construct a Wollaston-type one-circle goniometer. Yet another discusses the basics involved in the naming of minerals. There are abstracts of new mineral descriptions, and a show calendar.

The editor, Louis-Dominique Bayle, and his board of technical consultants and photographers have done a fine job of assembling consistently interesting (though often rather short) articles and excellent photography covering a pleasantly broad range of mineralogical subjects. Although the level of technical difficulty is usually quite low, they are not afraid to present the occasional more challenging article.

Like the *ExtraLapis* series of separate magazine-format issues put out on special topics by *Lapis* magazine in Germany, there is also the *Hors Série I* ("External Series issue no. 1"), which is entitled *Le Règne Microminéral*. This 60-page issue consists entirely of one page of text paired with one of excellent color photography for each of 26 species found as superb microcrystals in France. Micromounters, whether French-speaking or not, will love this issue and will find it a useful supplement to their French specimens.

A seven-issue subscription including the *hors serie* costs 300 French Francs (400 F outside of France), or the *hors serie* issue on micromounts can be purchased separately for 100 F. Write to Editions du Piat, 1 bis, rue de Piat, 43120 Monistrol-sur-Loire, France. Tel./Fax 71-66-54-67.

NOTICES

Died, Fred C. Kennedy, 87, of Rochester, Minnesota. Born in South St. Paul, Minnesota, in 1908, Fred Kennedy attended the University of Minnesota and rose to become President and Chief Executive Officer of the Waters Conley Company in Rochester in the early 1950's. He retired in 1965, but continued to pursue a lifelong interest in minerals and mineral collecting, especially species collecting, housing his extensive collection in its own concrete-block building. He ultimately acquired specimens of over 3,500 species, a remarkable accomplishment exceeding the total owned by Harvard and the Smithsonian. Among his holdings at one time was one of the few known red diamonds, perhaps the most valuable of all gem species (one sold at auction a few years ago for approximately $1,000,000 per carat). In 1993 Kennedy gave his entire collection to Carleton College in Northfield, Minnesota; selected specimens are on display at the Smithsonian Institution. Kennedy was active in civic and church affairs, and was well known among micromounters and species collectors.

Famous Mineral Localities

THE ONGANJA MINING DISTRICT NAMIBIA

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The Onganja mine is famous for the huge, well-formed cuprite crystals found there in 1973, and the fine specimens of non-pseudomorphous malachite recovered in 1974. A number of other species in display-quality specimens have also come to light. The mine is now closed and flooded, making it unlikely that further specimens will emerge.

INTRODUCTION

The Onganja mining district, famous among mineral collectors for some of the world's finest cuprite and malachite crystals, is situated in Namibia about 60 km northeast of the capital city of Windhoek and about 30 km north of the town of Seeis. The site is at an altitude of 1800 meters on the Damara Plateau, in an area considered to be the northerly extension of the Khomas Highland. Here a number of small copper and molybdenum mines are situated in the upper drainage basin of the Swakop River.

Although blocky cuprite is the mineral most commonly associated with the locality, molybdenum in the orebody has also resulted in some fine molybdenite crystals. In addition, specimen-grade native copper, calcite and acicular cuprite have been collected. Until a few years ago, good quality specimens could still be collected from the old discard dumps. The mine is currently inactive and access to the property is prohibited. The underground workings where the cuprites were found have been flooded since 1974.

HISTORY

The Onganja* district has had a long and checkered history, dating back to well before the period of European settlement in the territory.

During those early times, copper mining and smelting had

*Pronounced "On-gahn-yah."

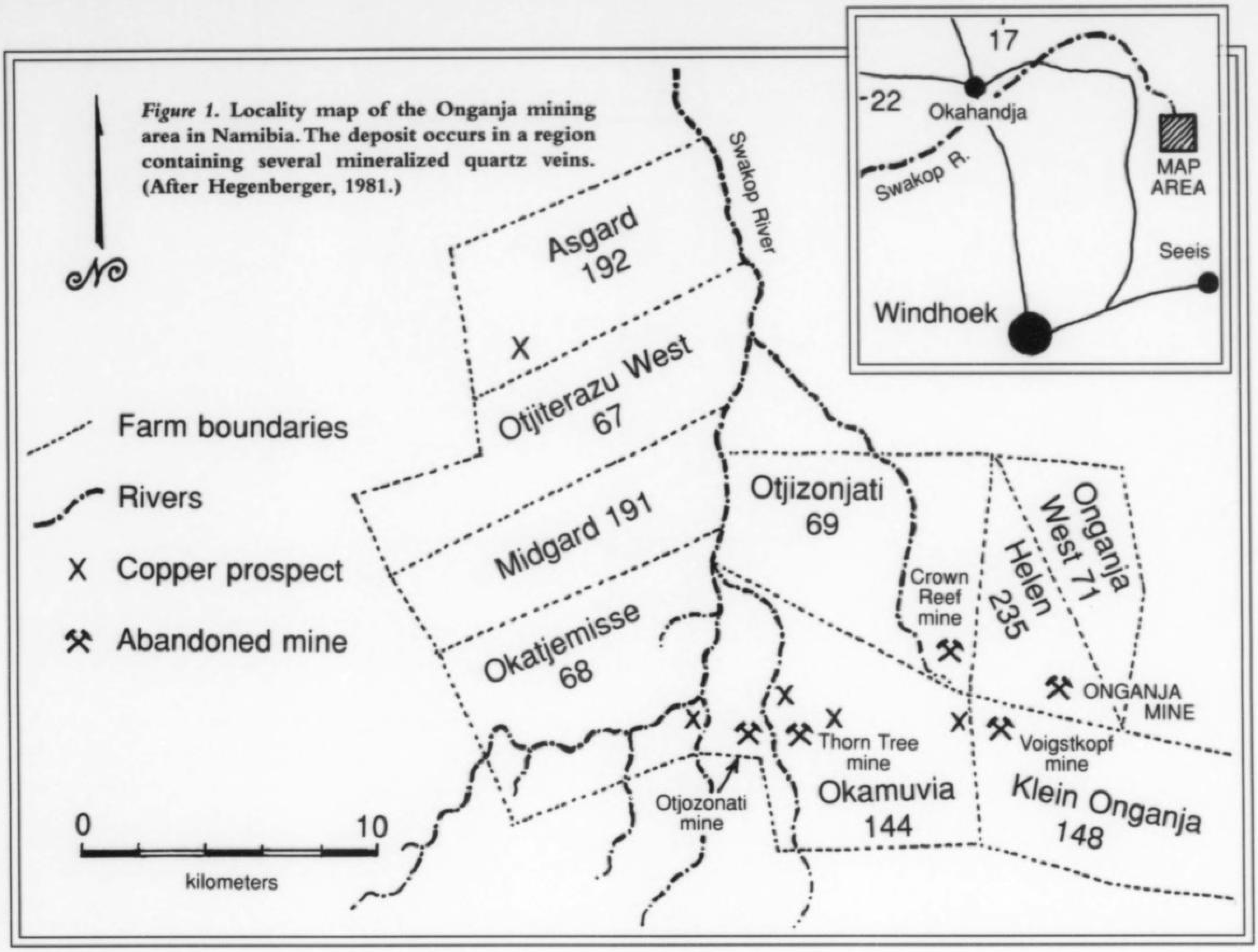

Figure 1. **Locality map of the Onganja mining area in Namibia. The deposit occurs in a region containing several mineralized quartz veins. (After Hegenberger, 1981.)**

been undertaken by local Ovambos who, it has been speculated, traveled from their traditional homeland in the north to mine the cuprite and chalcocite that cropped out on the surface (Miller, 1980). Evidence for this early mining activity comes in the form of copper slag deposits (Hälbich, 1968), stone constructions and several tuyères (blast furnace nozzles) found in the vicinity. The tuyères were made of talc and chlorite schist (Sandelowsky and Pendelton, 1969), and were used in the copper smelting process. These archeological artifacts are housed in the local Windhoek museum. Similar historical small-scale mining operations took place at the Matchless mine west of Windhoek, and some of these have been dated to not later than 500 years before present, although most appear to date from the 17th century (Kinahan and Vogel, 1982). Evidence for early copper mining operations at Onganja was also discovered during Rio Tinto's 1962 exploration program; Sharpe (1962) reported:

> Several pieces of copper slag from native smelters . . . show that copper was worked in the area long before the coming of the white man.

European mining operations date back to the 19th century, when German development was in its infancy in what was then known as German South-West Africa. In fact, the first copper ore shipped to Germany from Namibia originated from the Onganja mine (Westphal, 1914). In 1900, an Englishman named Stanley prospected the main copper veins and the area was subsequently divided into four mining areas each measuring approximately 1 square kilometer. Two of these were worked by Stanley and the others by a local company, Wecke and Voigts. One of the workings, Voigtskopf (now referred to as the VT area), is named after one of the partners (Westphal, 1914). Following the outbreak of the Herero rebellion in 1904, mining ceased but resumed in 1906, continuing until 1915. At this time the mine was owned and operated by Otjozongati Minensyndikat, a partnership formed by Wecke and Voigts together with Boysen, Wulff and Company. The mine was therefore known for a time as the Otjozonjati mine. Mining was carried out during this period via tunnels and shallow shafts on the eastern portions of Otjozonjati 69, Helen 235 and Okamuvia in the Swakop Valley (Hegenberger, 1981). The so-called VT-vein was one of the main sources of copper mineralization. As mining techniques were relatively primitive at that stage, only hand-sorted ore (containing up to 25% copper) was shipped. The highest grade portions of the orebody were selectively depleted, and the veins were soon abandoned as the copper values dropped off. The concentrate was bagged and transported via ox-wagons to the Okahandja railhead, transferred to the coast at Swakopmund and then on to the smelter in Germany (Hegenberger, 1981). This output was modest and did not exceed more than several hundred tons per year.

After World War I, the mining rights to Onganja changed hands several times. The South-West Africa Company continued mining until 1934, after which the mine was sold to Emka Mining and Trading Company (Pty.) Ltd. The new

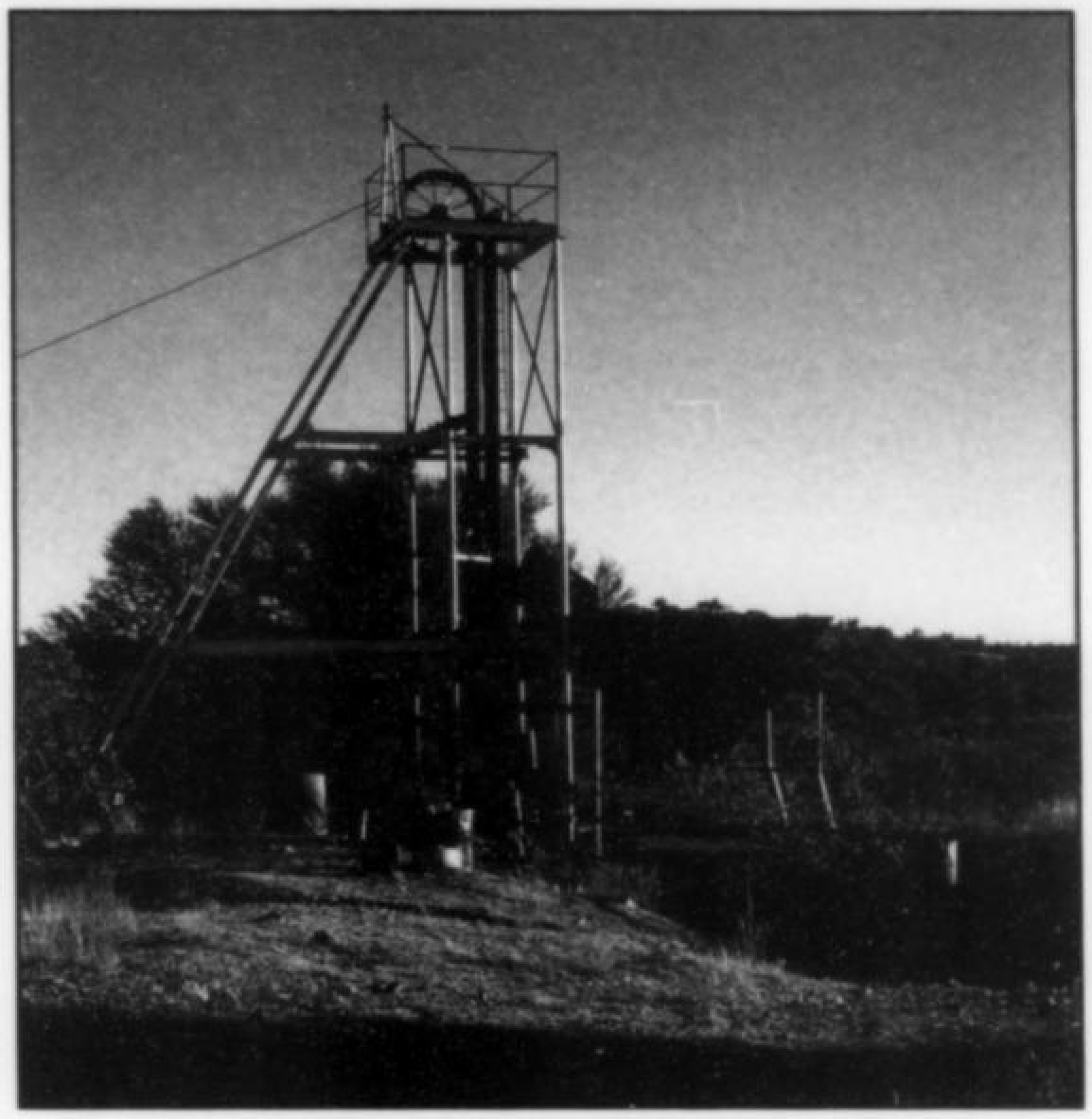

Figure 2. **The headframe alongside earlier opencast excavations. Photo by Roger Dixon taken in December, 1977.**

owner continued development in a modest way, hand-cobbing ore from surface outcrops. Rio Tinto (S.A.) Limited, in association with Nippon Mining Company, obtained an option to purchase the property in 1959, and this was exercised in 1960. When Rio Tinto took over its option, Emka Mining and Trading Company had developed an area of 100 by 600 meters (Sharpe, 1960). Rio Tinto extended exploration in the area; 14 diamond drill holes were sunk to obtain more geological information on the mineralized veins. In addition, during 1960 a 14-meter drive was cut on the 16-meter level from existing workings in the Onganja mine, a depth at which the operation was still in the supergene-enriched ore. At this stage in the mine's history, a larger-scale operation was introduced, with expanded exploration development and production. New prospect shafts were sunk on several veins, including the known VT-vein system. A small 50-tons-per-day pilot flotation plant was also constructed (Linsell, 1975). Unfortunately, Rio Tinto sustained mining losses, and in 1962 the property was sold back to Emka Mining and Trading Company who continued their development as before. In June of 1966, Navarro Exploration (Pty.) Ltd. (a subsidiary of Canadian Grenville concern) obtained an option to purchase Onganja and exercised this right in January, 1967. They opened the mine on two levels, and during their tenure, produced 250,000 tonnes of ore at 2.8% copper (Jacobsen, 1976). This was treated in a 150-tons-per-day flotation plant and the concentrate railed to the smelter at Messina in South Africa.

Around 1970 the claims on the Okamuvia farm were leased to Luigi Dodesini; he subsequently ceded these to Mr. Ferrari. This became known as the Otjizonjati mine, causing confusion because Onganja was originally called by this name. Otjizonjati was operated continuously utilizing a 30-ton-per-day flotation plant until its closure in 1987.

In 1972 Navarro sold its interests to Zapata Mining, who expanded the operation to include three vertical shafts, one 60-degree incline and two trackless decline shafts. The famous cuprite pocket was discovered during development of a vent shaft to serve the Mill Decline Shaft in 1973. Such was the interest in this find that local management continued to develop in this oxide zone, causing copper recoveries in the sulfide flotation plant to drop below 50%! This, coupled with the low copper prices and a ball mill failure, caused the mine to close in September 1974.

Transterra, an exploration group based in Johannesburg, undertook some further work in 1975 before they were liquidated. Sometime in 1979 the Zapata/Grenville Group of Vancouver sold their worldwide mining interests to Noranda Mines, and along with them, the rights to Onganja. In 1980 M.T.D. (Messina Transvaal Development Corporation) undertook a sampling program to assess the gold potential that they had recognized while custom smelting the concentrates during the early 1970's. Although some interesting gold contents (up to 20 grams/ton) were recorded in the gossans M.T.D. never pursued the project. Meanwhile, South-West Africa was gaining the attention of international pressure groups because it was controlled by the then-apartheid South African government. Noranda was undoubtedly embarrassed by their acquisition, and apparently never visited the mine. They created the operating company, WCC Mining (Pty.) Ltd., which they subsequently sold to the current owners John Gurney and Stuart Moir of Cape Town in 1984. As a note of interest, the name WCC Mining was derived from "World Council of Churches"—an active pressure group during the apartheid era.

The new owners' intention was always to find a way of exploiting the potential of the cuprite, and it had been hoped that a mining partner could be found to undertake underground operations leaving Gurney and Moir access to any crystals uncovered. It was soon evident, however, that in those times of depressed copper prices few people were interested in exploiting a small underground vein deposit. An attempt was made in 1984 to pump out sufficient water to obtain access to the area from the Mill Decline Shaft but, although some very adventurous diving/swimming attempts were made, the area was never reached.

In 1985, Stuart Moir rehabilitated the plant and processed material stockpiled on the surface by the previous operators after their ball mill had collapsed in 1974. Severe separation problems were encountered in this flotation exercise, and the operation was shut down after 12 months. As a result of the metallurgical problems, X-ray diffraction studies were undertaken back in Cape Town where it was discovered that a principal "oxide" ore, previously described as malachite or pseudomalachite, was in fact brochantite, an extremely easy mineral to acid-leach but not simple to float.

After much experimentation, Gurney and Moir returned to Onganja in 1987 where they proceeded to heapleach material abandoned by others over the previous 100 years. This very successful, though small-scale, operation continued through to March 1995 when the operation was stopped due to lack of "acid-leachable" reserves. The mine is currently managed on a care-and-maintenance basis.

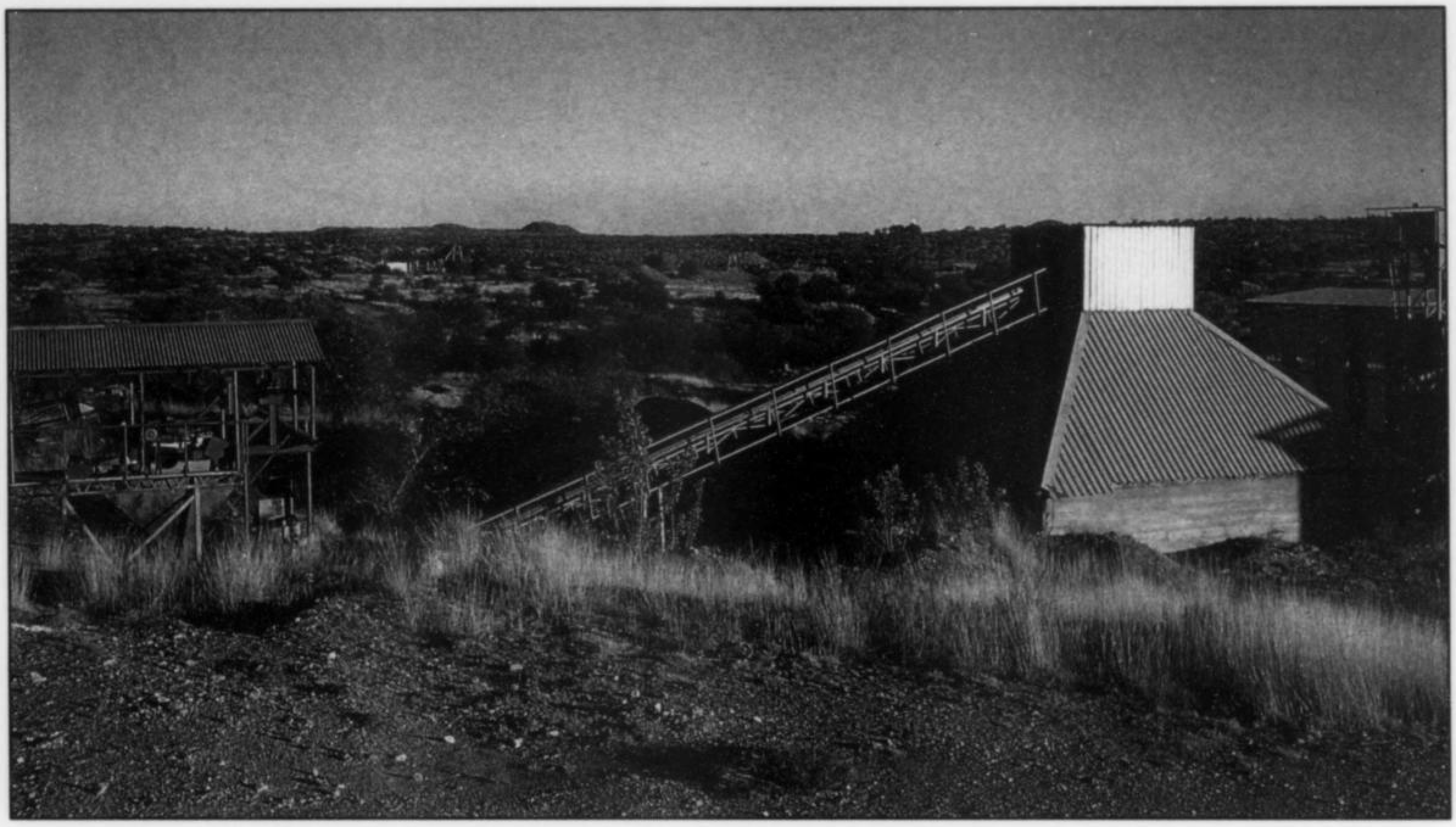

Figure 3. **The crusher plant, December 1977. Photo by Roger Dixon.**

GEOLOGY

The economic copper-molybdenum deposits occur in schists assigned to the Damara Supergroup. The country rocks consist mainly of quartz-garnet-biotite schists, phyllitic schists, epidote-bearing quartzites, and graphitic schists (Sharpe, 1962; Charles, 1985) of the Kuiseb Formation (Khomas Subgroup, Damara Supergroup). The Onganja ore deposit is associated with a broad anticline with a west-northwest axis that plunges to the west. The copper mineralization occurs in fracture-filled veins that appear to be tensional features associated with an anticlinal fold (Linsell, 1975). Some of the geological features of the deposit were recognized by early workers. For example, they noted the existence of vein-type systems (Gatham, 1903; Kuntz, 1904; Duft, 1906). Voit (1904) visited the territory and published one of the earliest detailed descriptions of the geology and mineralogy of the deposit:

> By far the most interesting occurrence that I visited in German South-West Africa was that of Otyosongati (Onganja). . . . The locality is practically that of a high plateau, called by the Hereros, the Onandjengendje Mountains. The Swakop has its source in the heights . . . crystals of rutile are very common in the rock. The cap (gossan) contains but little of the copper ores, copper pyrites, copper glance, and the customary oxidized ores, azurite, malachite, cuprite and native copper. On the other hand, the surrounding rock is found rich in small and large patches of oxidized ores, chiefly cuprite and native copper. . . . Immediately beneath the surface, however, the veins, some twenty of which are opened up, exhibit at times an extraordinary ore body. The commonest ore at depth is chalcosine. . . . At the outcrop, azurite, malachite, chryscolla [*sic*], copper glance are much mixed with iron ores. . . . One of the quartz veins showed individual feldspars of some size, and in considerable numbers. One vein in thinning out consisted almost entirely of calcite, with very large crystal faces, and was strongly impregnated with azurite, malachite and chrysocolla. There was a chance occurrence of an extraordinary number of octahedra of martite on the surface of the surrounding rock, a schistose-veined biotite gneiss.

Most of the mineralized veins are steeply dipping towards the east and the west. Vein thickness varies between 1 and 9 meters. Four types of veins have been described, based on their mineralogy (Linsell, 1975):

(1) Calcite-quartz veins
(2) Quartz veins
(3) Potassium-feldspar-quartz veins
(4) Quartz-apatite veins

These veins are brecciated and impregnated with quartz. There is a clustering of these veins at Onganja, but they appear only erratically further to the west where some sporadic exploration has also been undertaken. The mineralized veins therefore occur along a 45-km zone (see map) stretching from Onganja (Helen 235, Klein Onganja 148, Otjozonjati 69) through Okamuvia 144, Okatjemisse 68, Asgard 192 and Onganjira (Hegenberger, 1981).

The veins are not pegmatitic, and are distinctly different from the older pegmatite quartz veins associated with the Damara schists. Oxide minerals and supergene sulfides such as bornite and chalcocite give way at a depth of about 50 meters to chalcopyrite and molybdenite, which occur as

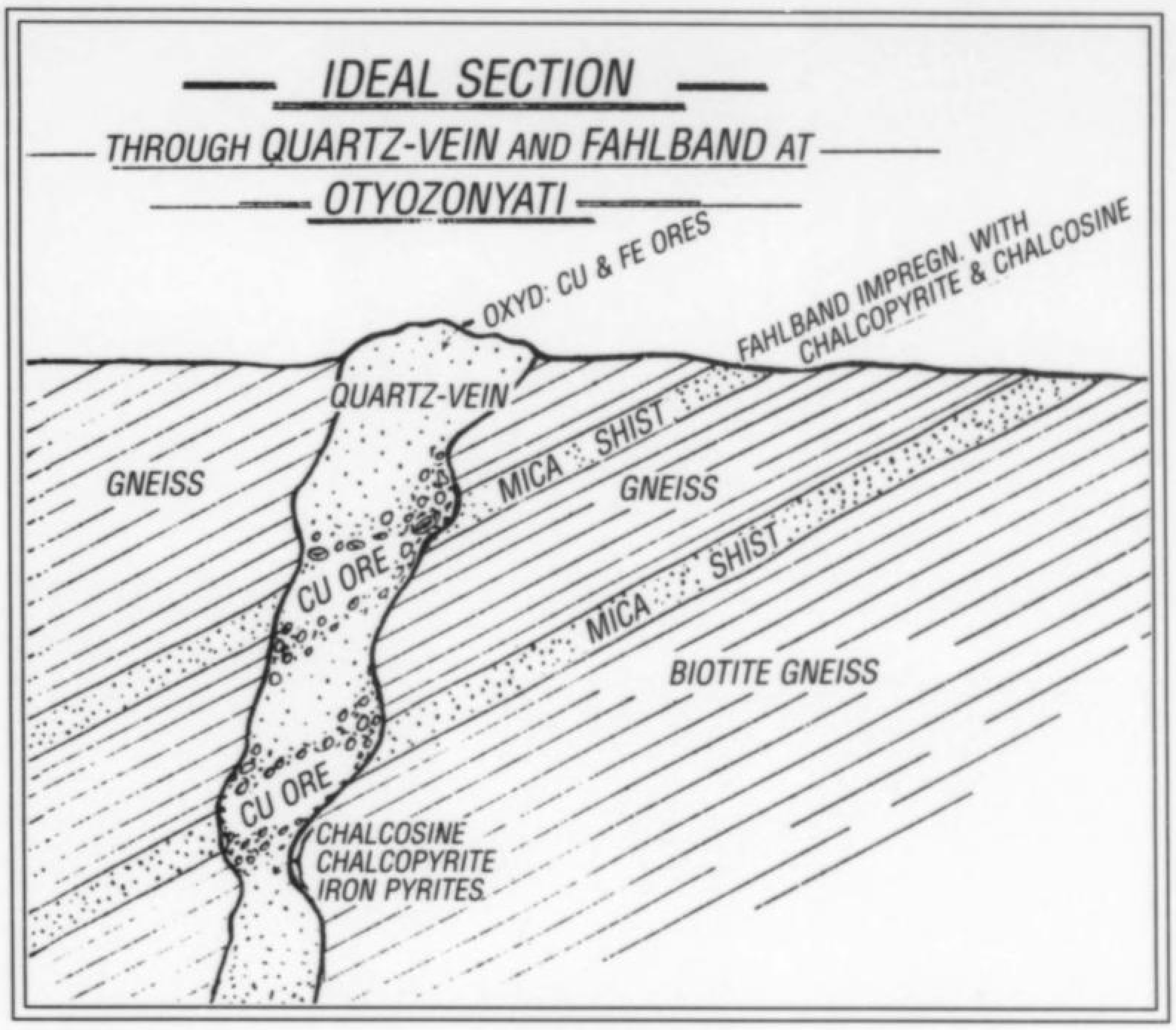

Figure 4. **An idealized geological cross-section through a mineralized quartz vein at Onganja, *circa* 1903 (after Voit, 1904).**

blebs and veinlets cementing the breccia. The economic veins were named "MY" 1-14, an abbreviation referring to the German Maygitt ore vein. The main production at Onganja originated from the MY6 orebody in the east. Much of the ore mined was from this system, together with the westerly located MY12 and MY14 veins.

Approximately 30 brecciated quartz veins plunge steeply, striking north-south, and cutting at right angles across the surrounding Kuiseb schists. The veins in the Onganja mine vary in length from 50 to 400 meters along strike, pinching and swelling erratically. Most of the veins are less than 1.5 meters wide, with a maximum width of about 20 meters. The copper ore produced during the early stages of mining was very high grade and was characterized by an absence of lead, zinc, silver, arsenic, antimony and bismuth (Westphal, 1914). Calcite is a very common gangue mineral associated with coarse-grained quartz, particularly in one productive vein that consisted of breccia laced with quartz, calcite, rutile, chalcopyrite, chalcocite and molybdenite. Where cavities were formed by leaching, cuprite crystals and other oxide minerals were encountered.

During 1961 when Rio Tinto was developing the area, a shaft called the VT1 Shaft was sunk at the Voigtskopf/Onganja mine to the 16-meter level, and an old German shaft, renamed the VT2 Shaft by Rio Tinto, was also reopened to the 37-meter level. This phase of work revealed the presence of four mineralogical zones within the veins (Smedley-Williams, 1961):

(1) An upper zone composed of oxidized vein material containing "irregularly dispersed carbonates, silicates and copper oxides." (Most of the fine display-quality specimens came from this zone.)

(2) An underlying leached zone, with no copper mineralization.

(3) A thin layer of secondary chalcocite enrichment 5 to 6 meters thick.

(4) A zone of unoxidized primary ore.

MINES

Several mines have operated in the past in the informally designated Onganja mining area and nearby neighboring farms. Descriptions of these have been published by Schneider and Seeger (1992); some of their information is summarized below.

Onganja Mine

There has been some confusion about the naming of the Onganja mine. The name Onganja was reportedly first introduced by Martin (1965). The correct spelling is Onganja (not Onganya, despite the pronunciation). The mine had previously been called the Emka (or Emke) mine, after the company that mined the deposit, and Otjozonjati 69, after the farm now on the western border of Helen 235. Otjizongati had also been used (originally by Kuntz, 1904), but recent spelling of the farms favor "-jati" rather than "-gati." Hegenberger (1981) shows three prospects clustered together, namely Helen, Maygift (Voigtskopf) and Crown Reef (old Otjozonjati mine). Hegenberger states that Voigtskopf is the Onganja mine *per se*. These three prospects have been grouped together as the "Onganja Mining Area."

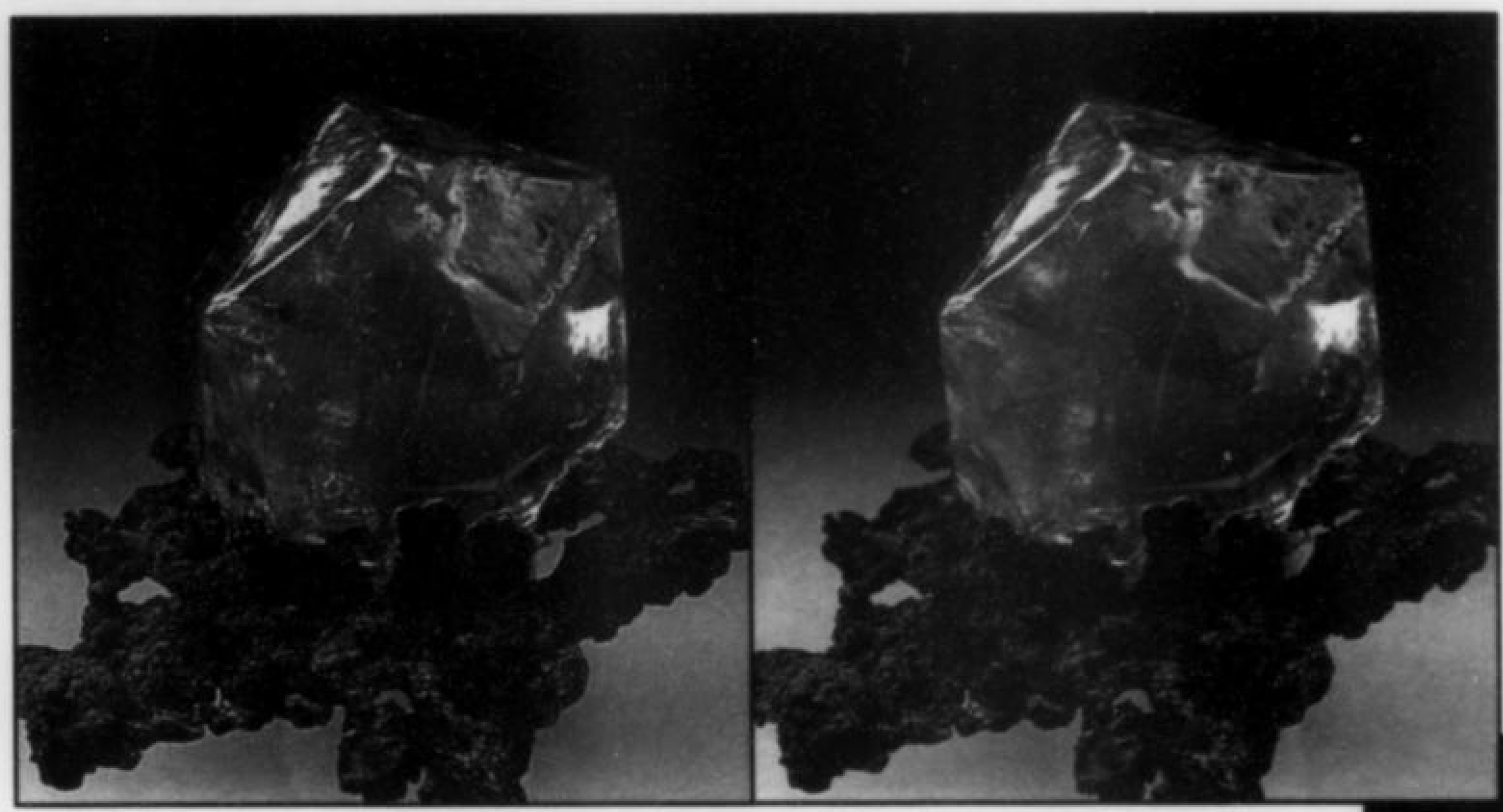

Figure 5. **Calcite crystal, 1.7 cm, with a red cuprite-impregnated phantom in the center, on native copper. Carolyn Manchester collection. (Stereopair.)**

Figure 6. **Group of transparent calcite crystals enclosing chalcotrichite and native copper, 3.3 cm. Bruce Cairncross specimen and photo.**

Figure 7. **Calcite crystals with native copper, 3.2 cm. Bruce Cairncross specimen and photo.**

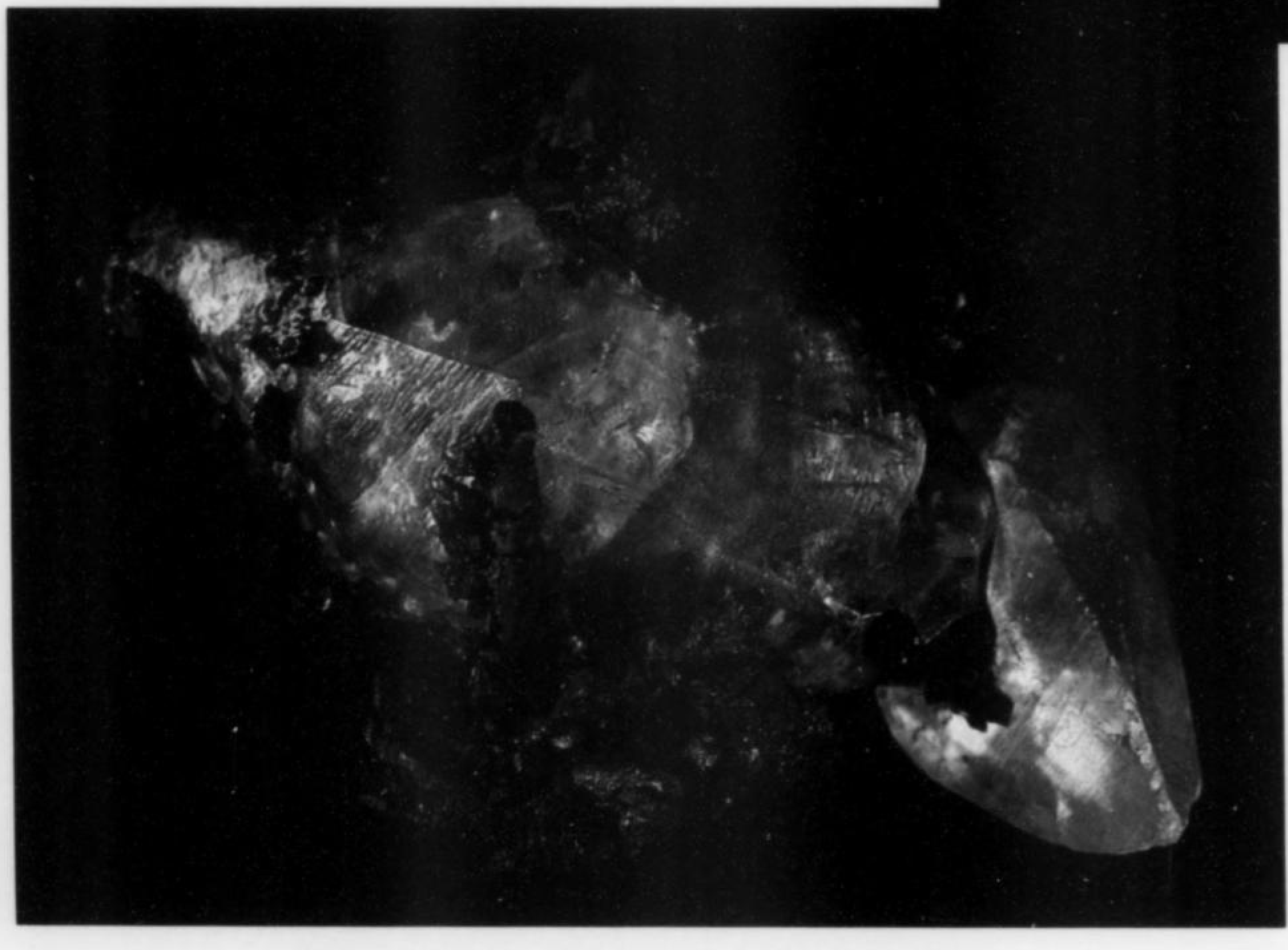

Figure 8. **Calcite crystals overgrowing native copper, 7.8 cm. Desmond Sacco collection; Bruce Cairncross photo.**

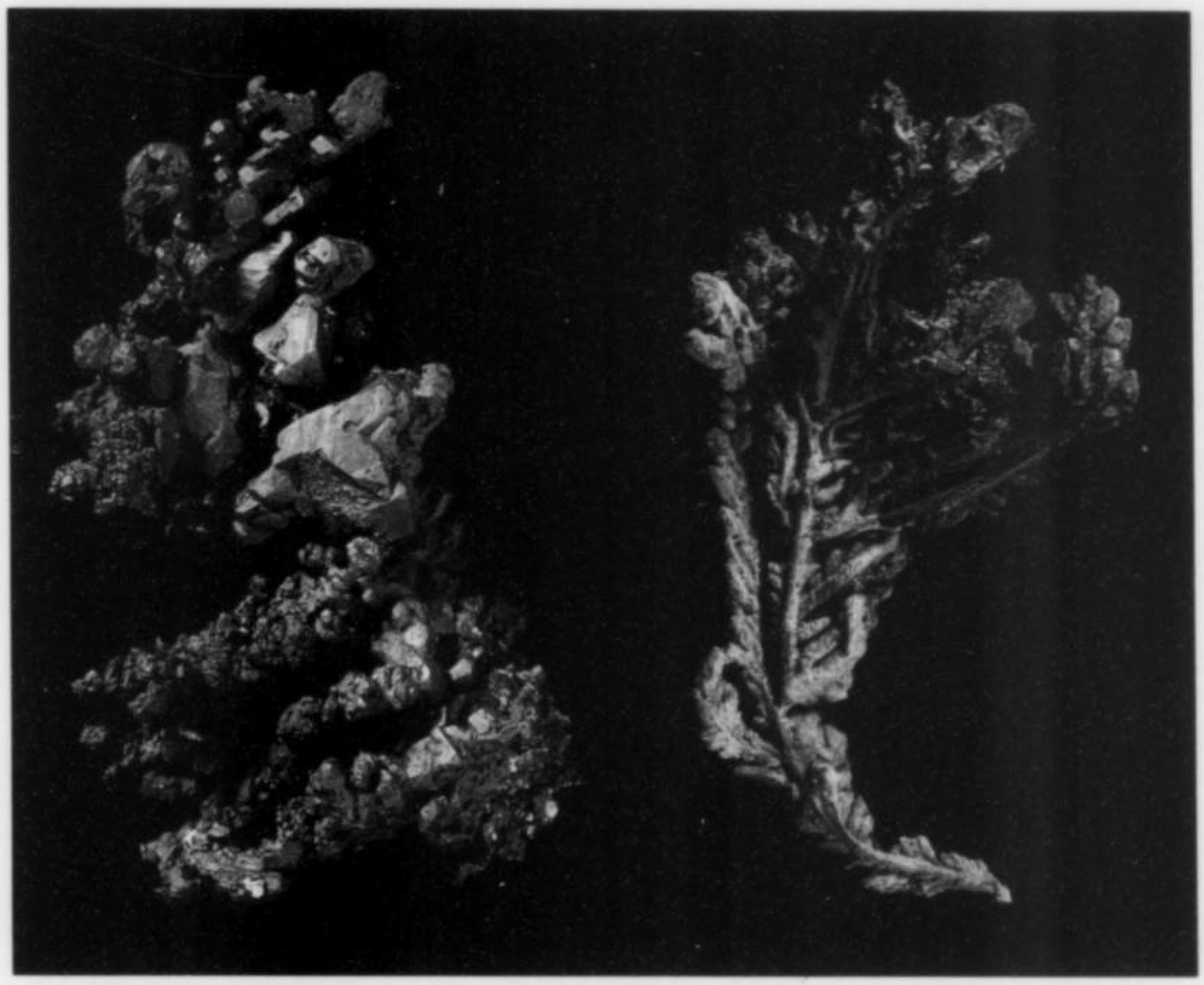

Figure 9. (far left) **Native copper crystals, 4.5 cm. Bruce Cairncross specimen and photo.** ***(near left)*** **Dendritic native copper, partially coated by chrysocolla, 8.7 cm. Bruce Cairncross specimen and photo.**

Figure 10. (below) **Feather-like sprays of native copper, 3.6 cm, with small calcite and acicular cuprite attached at the bottom left. Bruce Cairncross specimen and photo.**

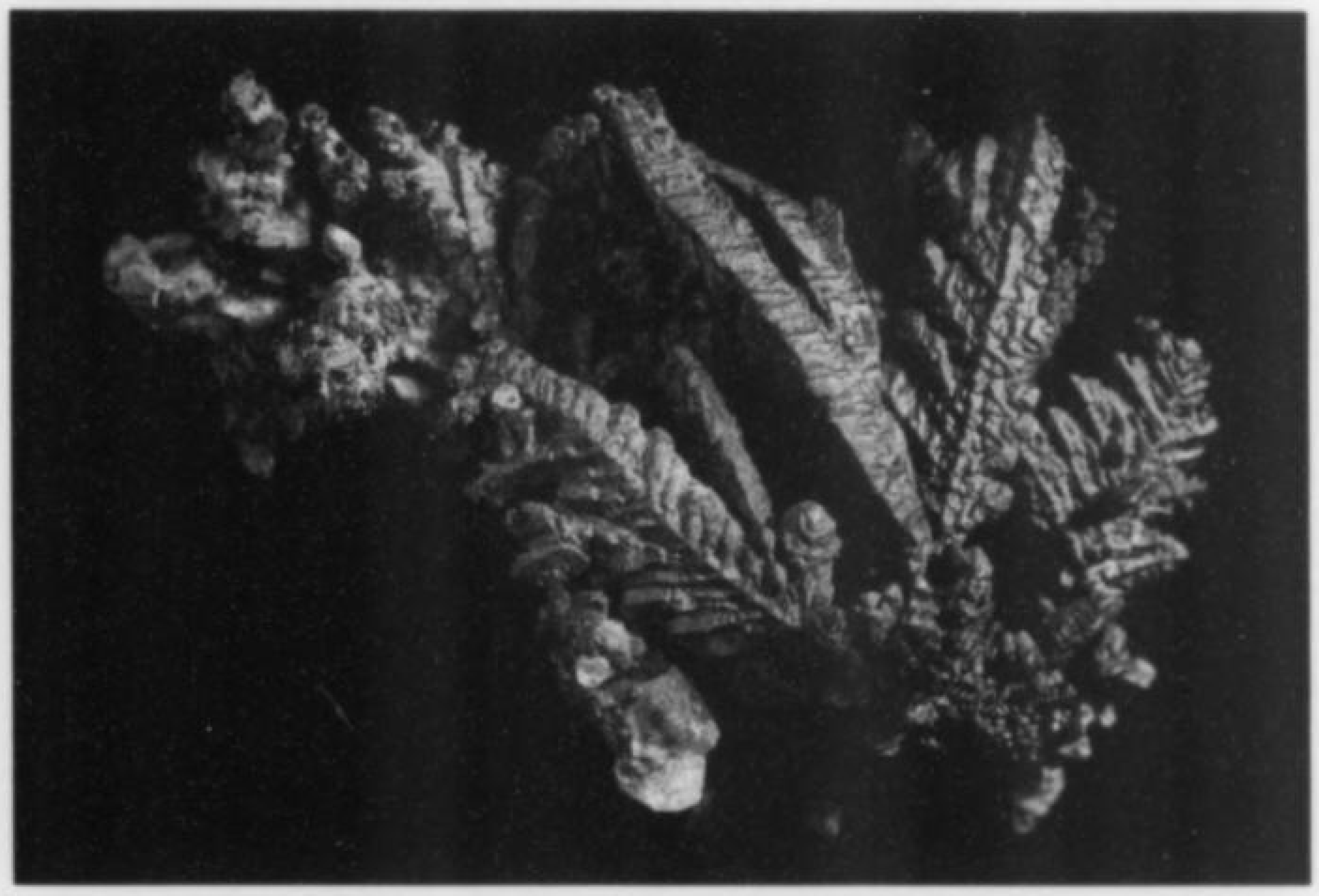

Figure 11. **Native copper crystal group, 4.5 cm, showing primarily dodecahedrons. Wendell Wilson collection.**

Figure 12. **Calcite, 8 mm, on native copper. Bruce Cairncross specimen and photo.**

To the west, the Thorn Tree mine (Snyman's Claims) and the Otjozonjati mine are located on the Okamuvia 144 farm. The Onganja mine is situated where the copper-bearing quartz veins, located on the dome of an anticline, plunge toward the west. Several shafts have been sunk in the area, some to depths of 120 meters (Miller, 1980).

Most of the various mineral species from the district which reside in collections today originated from the Onganja mine.

Other Mines

The Otjozonjati mine, located on the Okamuvia 144 farm (not to be confused with the old Otjozonjati mine on the Otjozonjati 69 farm to the north) was mined from 1969. A brecciated quartz vein 0.2–1.5 meters wide contained a variety of ore minerals such as massive chalcocite, pyrite, chalcopyrite, bornite, malachite, chrysocolla and minor molybdenite associated with gangue minerals. Mining operations terminated in 1987, by which time 8,025 tonnes of copper concentrate averaging about 60% copper had been produced.

The Thorn Tree mine is located to the east of the Otjozonjati mine within the old Snyman's Claims. Copper was mined here prior to World War I, with work ceasing in 1914. Mining was sporadically undertaken by several groups during the 1950's and 1960's. From 1981 to 1985 development was continued; a 35-meter inclined shaft was sunk and about 100 meters of drifting were undertaken within the mineralized vein. The ore at the Thorn Tree mine contained minor amounts of gold, silver and molybdenum.

MINERALS

Azurite $Cu_3^{2+}(CO_3)_2(OH)_2$

Azurite was reported by early workers as occurring in the oxidized zone of the orebody. Inclusions of azurite in calcite have been reported (Voit, 1904). Crystals up to 1.2 cm have been observed, often pseudomorphed to malachite. In veins in the country rock, azurite crystals mostly 1 to 3 mm, but some up to 1 cm, have been found.

Calcite $CaCO_3$

Colorless and transparent calcite crystals were relatively common, particularly from the Onganja mine. Complex forms and habits are a feature of the Onganja calcite. Some specimens consist of water-clear crystals enclosing brass-colored, unoxidized native copper wires, with or without scarlet-colored acicular cuprite. Much of the coarsely crystalline calcite has a yellow to orange-yellow color, the cause of which has not been determined.

During very early stages of mining (Voit, 1904), a vein of massive calcite vividly colored by inclusions of azurite, malachite and chrysocolla was encountered.

Chrysocolla $(Cu^{2+},Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$

Chrysocolla was a relatively common supergene mineral in the district. Thin, bright blue to sky-blue veneers of chrysocolla were found coating some native copper specimens. Chrysocolla occurs as massive, fist-sized aggregates in veins.

Copper Cu

Native copper is a common species at Onganja, and up until fairly recently it could still be collected on the mine dump. The size and habit of the copper specimens is highly variable. The Museum of the Geological Survey in Pretoria has a specimen that weighs approximately 150 kg.*

The largest known (documented) copper specimen originating from Onganja, weighing about 400 kg, was owned temporarily by one of us (SM). During the "lean period" (1986/87), between their unsuccessful copper flotation operation and heapleach project, Luka Lingongo, the caretaker-manager made a spectacular find. The area had been experiencing some heavy rainfall, and the Tenne River had come down in flood, severely eroding the river bed. This erosion exposed two large pieces of native copper weighing an estimated 250 kg and 400 kg respectively. These were lifted using a front-end loader onto a light truck and taken to Windhoek to be sold as specimens. All the specimen dealers in Windhoek were visited and, although they all expressed a great deal of interest in the pieces, they felt they would never be able to sell them, especially as most of their clients came in by air, and therefore could never transport them home. Back at the mine, the last of the flotation concentrate was being dispatched to the Tsumeb smelter and, as this constituted a relatively small load, Moir decided (foolishly) to add the copper specimens to the consignment to at least realize their copper value. They were duly shipped and probably ended up in the smelter. We have, however, an unconfirmed report that the larger of the two pieces was rescued and placed with other minerals in the museum at Tsumeb.

Onganja copper specimens vary greatly in their quality. Some pieces are merely ugly lumps partially imbedded in massive quartz and calcite, while others consist of the finest filigree of delicate, dendritically-arranged wires and crystals. Many specimens in collections have been cleaned with nitric acid, but those that have not been treated show an interesting array of associated minerals. These include clear, euhedral calcite crystals on the copper. The calcite sometimes encloses acicular cuprite. Small, clear, euhedral quartz crystals are also occasionally found partially coating the copper and imparting a sparkling appearance. Surface coatings of blue chrysocolla may also be present.

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*This particular piece has an interesting story attached to its final placement in the museum. The specimen originally belonged to the well-known Johannesburg mineral dealer Clive Queit. During a visit to his home in 1992, one of us (BC), together with another local collector, Karl Messner, saw the copper specimen on the floor in Clive's garage. On enquiring what the purchase price was, Clive replied (rather self-assuredly) that if Karl could pick the heavy copper up by himself, he could take it away for free, a just reward for performing this Herculean task. Karl Messner is known in local circles as the "Alpine Crusher" for a good reason, and without hesitation he lifted the copper specimen up and instructed Clive to open the trunk of his car! This immediately prompted a reaction from Clive that he was only joking. The piece was subsequently purchased by the Museum.

Euhedral copper crystals are fairly common and may occur either as crude forms on the massive copper, or as well-formed cubes, dodecahedrons and modified octahedrons up to 3 cm perched on dendritic copper wires or intergrown with massive copper matrix. Free-standing, well-formed crystals are rare.

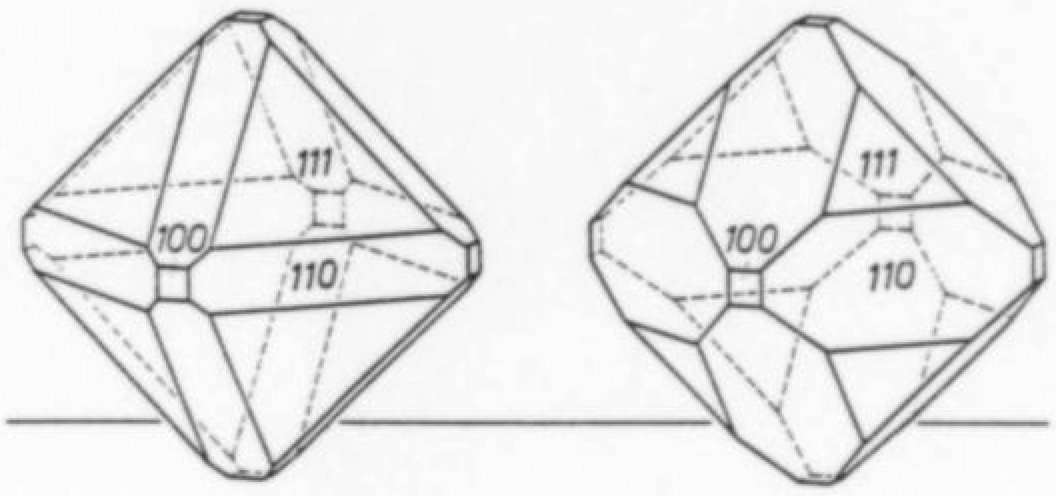

Figure 13. **Idealized crystal drawings of cuprite from Onganja, showing a combination of octahedron, dodecahedron and cube. (From Strunz and Wilk, 1975.)**

Cuprite Cu_2O

Cuprite is the mineral that made the Onganja mine famous amongst mineral collectors worldwide. During 1973 a sensational pocket was found in the underground workings which yielded an estimated 2,000 perfect cuprite crystals, the largest measuring *14 cm* in diameter and weighing 2.1 kg (Strunz and Wilk, 1975). The crystals are of octahedral to dodecahedral habit, sometimes also exhibiting cube faces. A common feature of these crystals is the partial to complete coating of the outer surface by a thin film of malachite. However, some crystals were found that are "clean" and not possessing the malachite coating. Some attempts were made to etch the outer malachite off using acid, but the cuprite surface below usually proved to be dull or pitted.

Another feature of many of the cuprite specimens is their gemminess, making them highly desirable among collectors of unusual colored stones (White, 1974a). Some large masses of flawless, completely transparent cuprite weighed up to 2 kg, and stones up to 300 carats have been cut (Arem, 1987). The Smithsonian Institution has a round-cut cuprite weighing 182 carats, and there is a 180-carat emerald-cut stone in the Desmond Sacco collection.

Most of the larger cuprites that were recovered are loose crystals or groups of crystals. Matrix specimens are uncommon, but some fine examples are known (see the front cover of the *Mineralogical Record,* Vol. 15, No. 5, 1984). Common forms include dodecahedra and octahedra modified by cubic faces and rare trapezohedron faces. The crystals are typically sharp-edged and very well formed.

Acicular cuprite is also present in the deposit, usually as fine crystals enclosed in calcite. It was also found on the dumps as free-standing masses composed of radiating, acicular crystals.

As mentioned earlier, the discovery of the cuprite crystals was in part responsible for the closure of the mine. Such was the interest and demand for specimens, that the on-site management continued mining in the "oxide" zone where the crystals were discovered. This caused a significant drop in the copper yield from the flotation plant which, coupled with other problems, led to the untimely closure of the operation in September 1974.

Fluorapatite $Ca_5(PO_4)_3F$

Apatite is a species reported from the country rock and also occasionally associated with the copper mineralization. Pale green, euhedral apatite crystals have been found up to 1.5 cm in length (White, 1974b).

Goethite $\alpha\text{-}Fe^{3+}O(OH)$

Specimens of pseudomorphous goethite after platy ("eisenrosen") hematite were collected off the dump during the 1970's and early 1980's. These specimens consist of groups of flattened octahedral crystals, some individuals measuring up to 4 cm on edge. The replaced hematite still displays sharp-edged crystal faces and contact edges.

Gold Au

Gold has been reported as a minor element at the Thorn Tree mine (Schneider and Seeger, 1992). An estimated 0.2 grams/tonne of gold in the ore at Onganja was concentrated into the flotation concentrate. The gossans sometimes produce high values of up to 30 grams/tonne. Some specimen gold was collected from the dumps during 1977 which consists of thumbnail-sized chrysocolla with native gold grains up to 2 mm (Roger Dixon, personal communication).

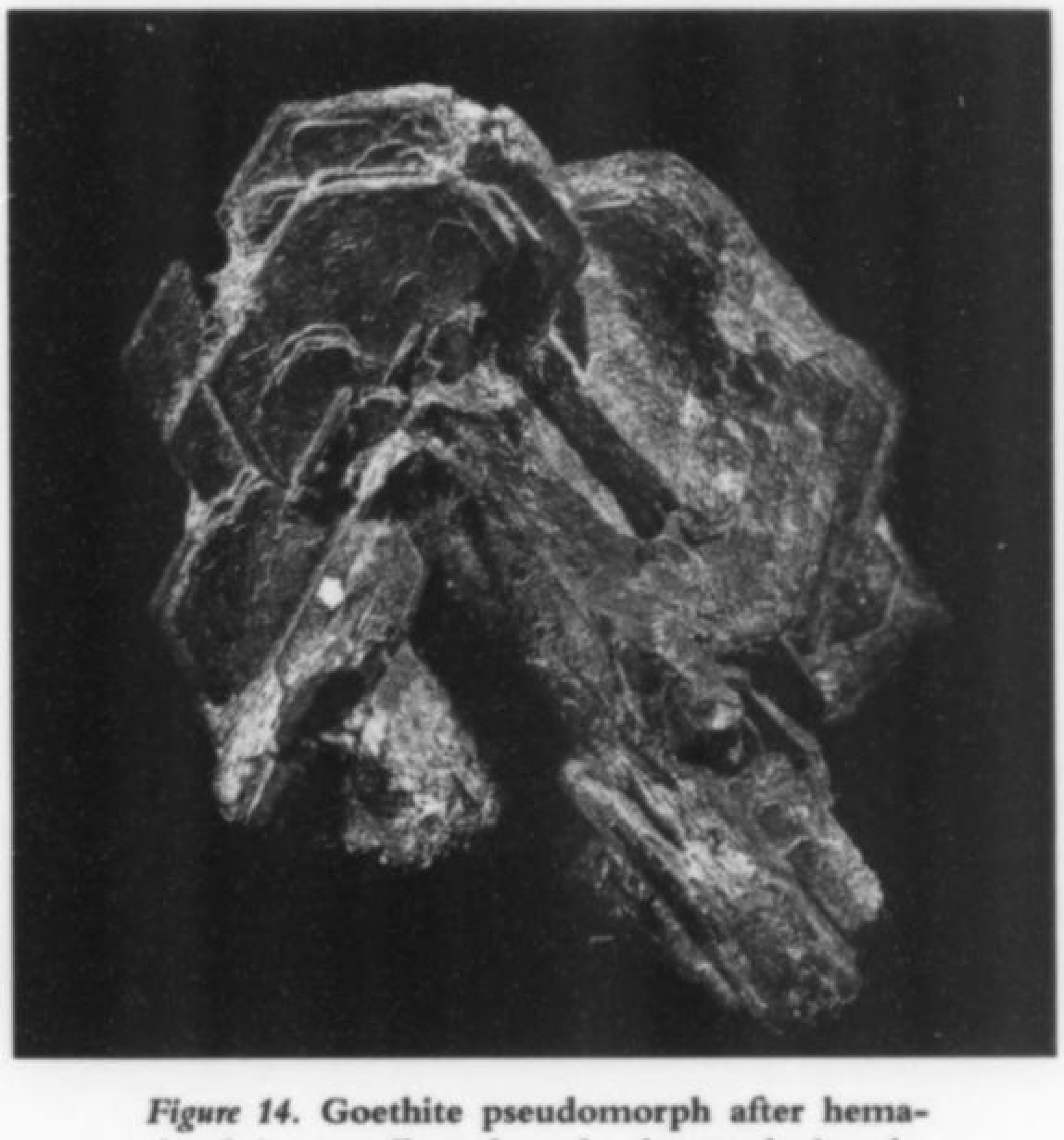

Figure 14. **Goethite pseudomorph after hematite, 5.4 cm, collected on the dumps during the mid-1970's. Bruce Cairncross specimen and photo.**

Hematite $\alpha\text{-}Fe_2O_3$

Small, silver micaceous flakes of specular hematite occur in parts of the mineralized veins, associated with the main copper ores.

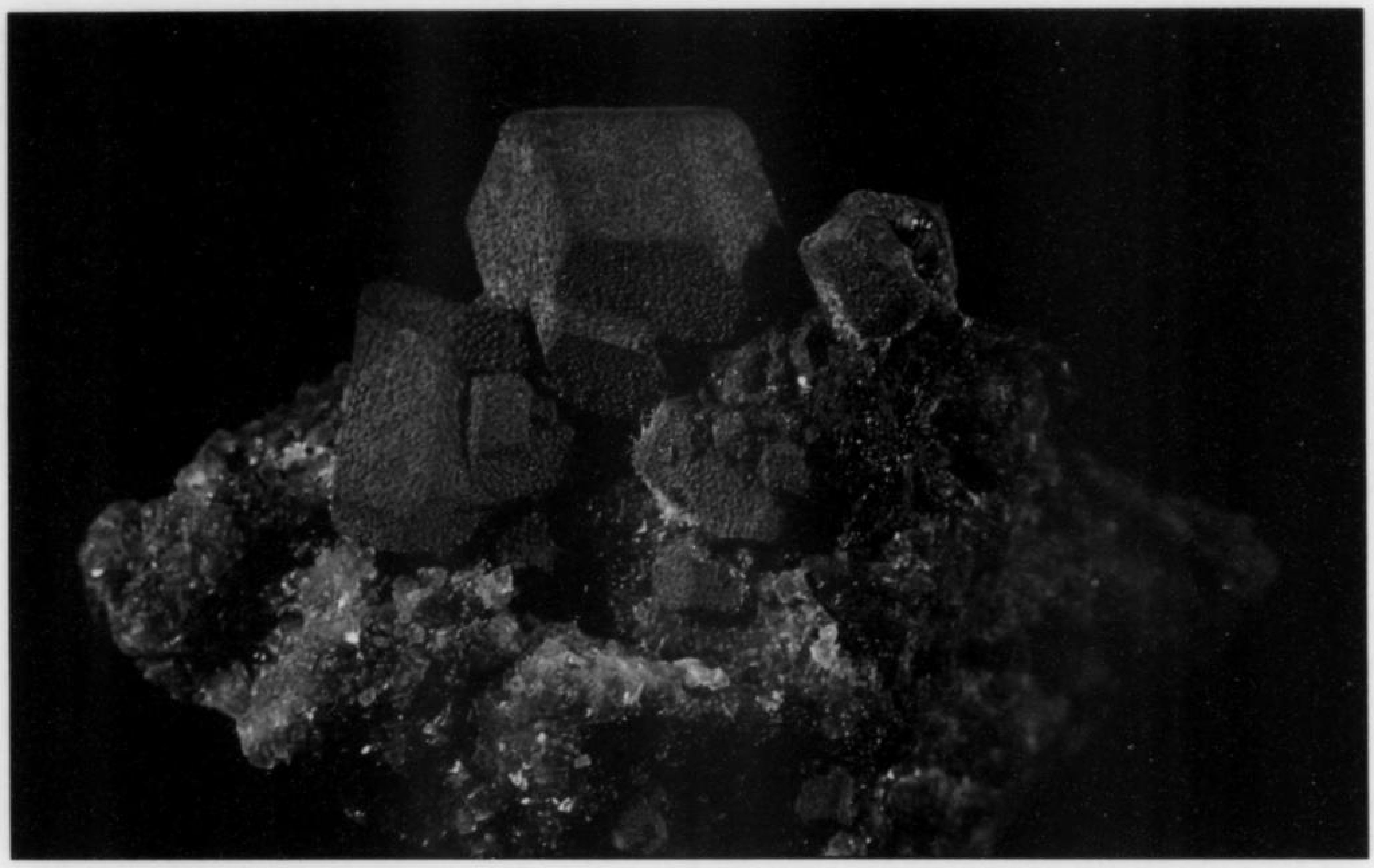

Figure 15. **Small group of cuprite crystals on calcite matrix. Largest crystal is 9 mm. Bruce Cairncross specimen and photo.**

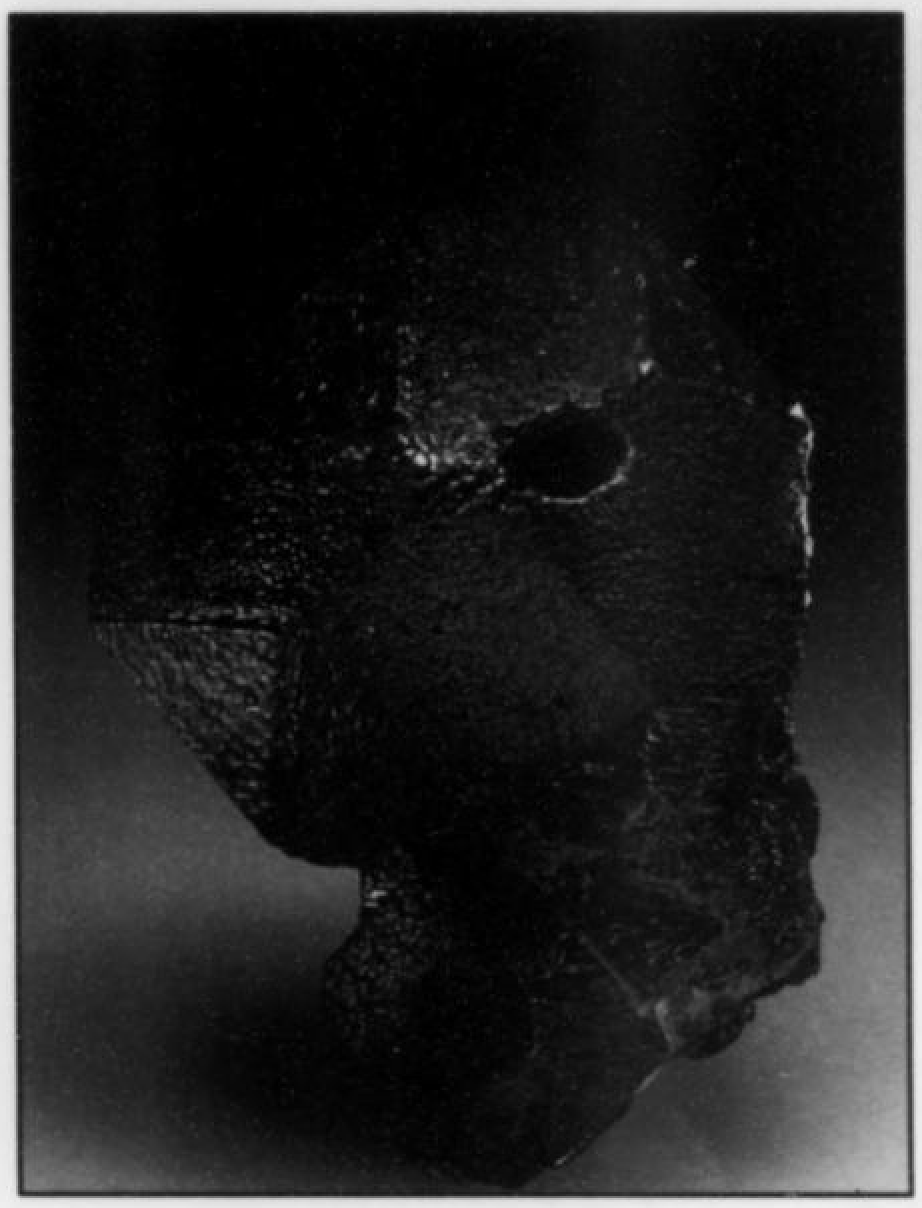

Figure 16. **Large cuprite crystal, 5.8 cm across, from which the malachite coating has been chemically removed to reveal the pitted surface and gemmy interior. Gene Schlepp specimen.**

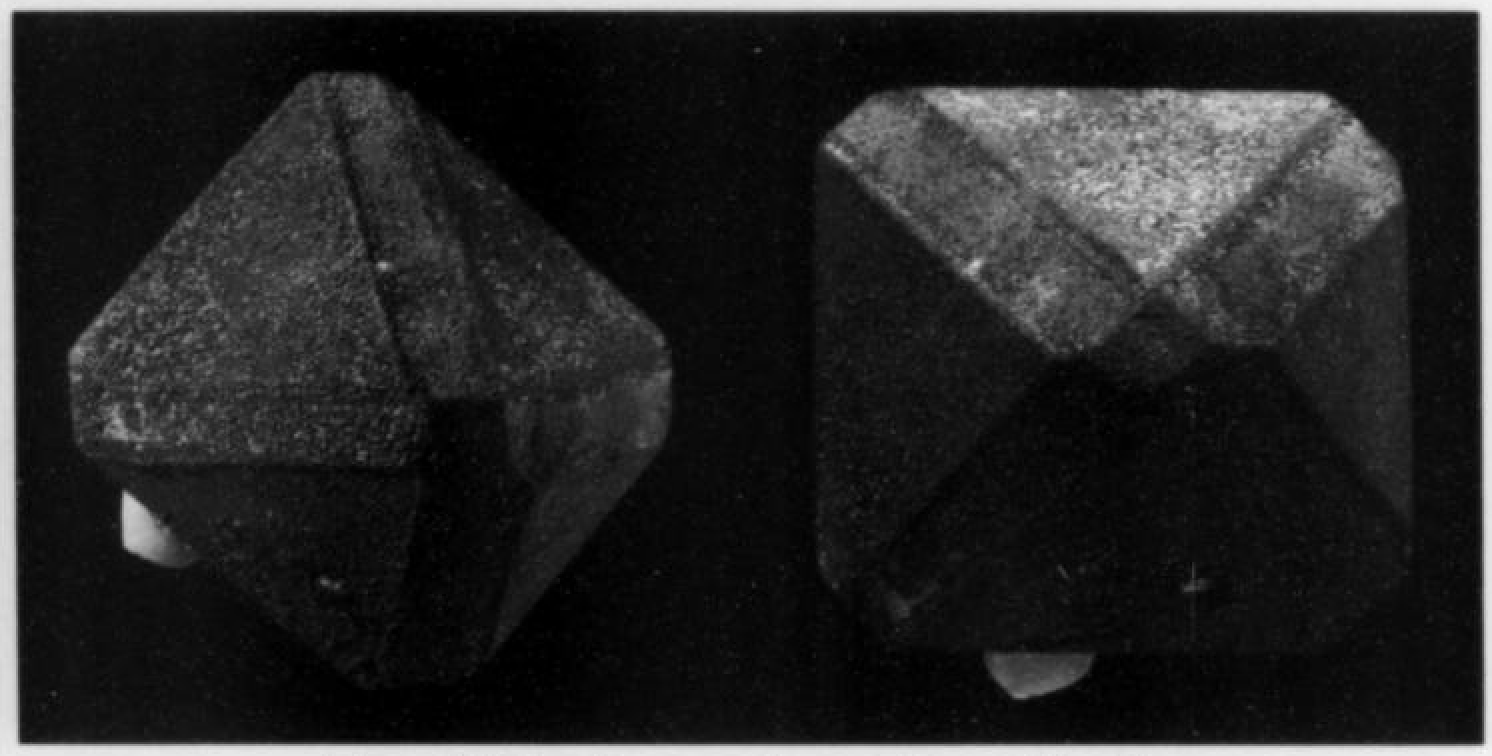

Figure 17. **Cuprite crystal, coated by a thin film of malachite, 6 x 6 cm. The crystal is entirely facetable. Compare with the idealized diagram of crystal forms. Desmond Sacco collection; Cairncross photo.**

Figure 18. **Gemmy cuprite crystal, 8 mm, with good luster and lacking the usual coating of malachite. Neal Pfaff specimen. (Stereopair.)**

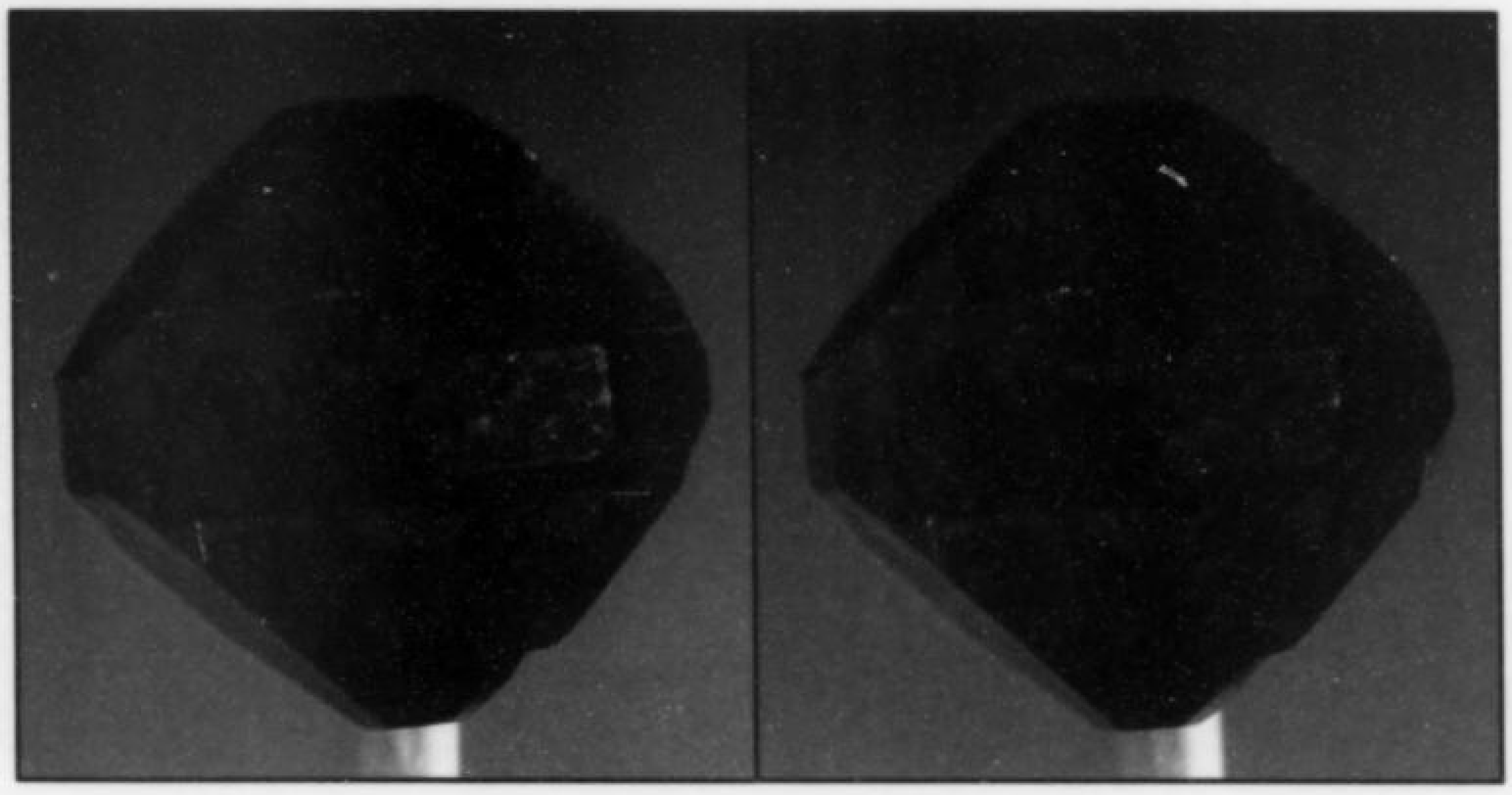

Figure 19. **Malachite crystals on calcite matrix, 3.3 cm. George Godas collection.**

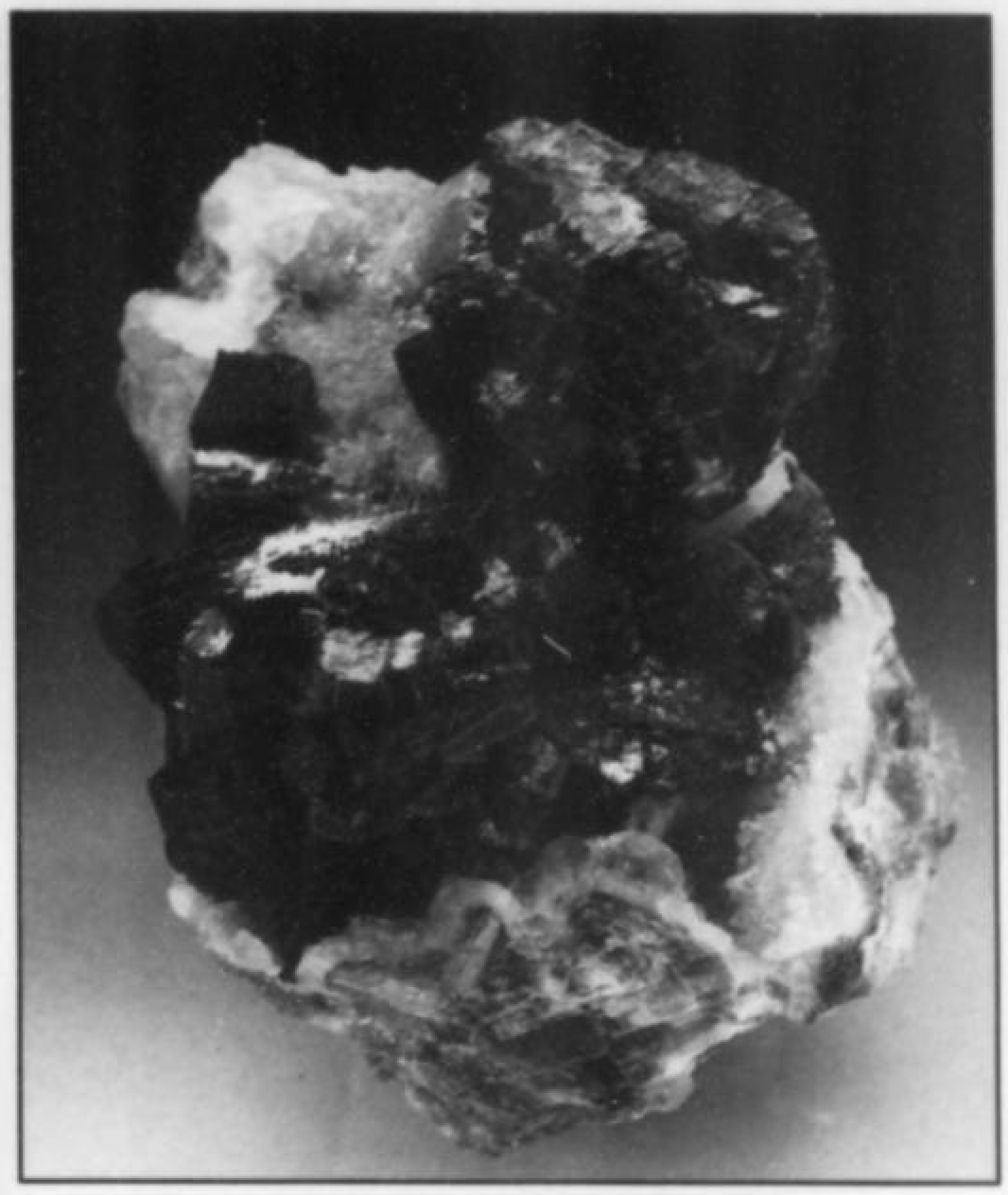

Figure 20. **Malachite crystal group on matrix, 6 cm. Gene Schlepp specimen.**

Figure 21. **Malachite crystals to 2 cm on calcite. Gene Schlepp specimen.**

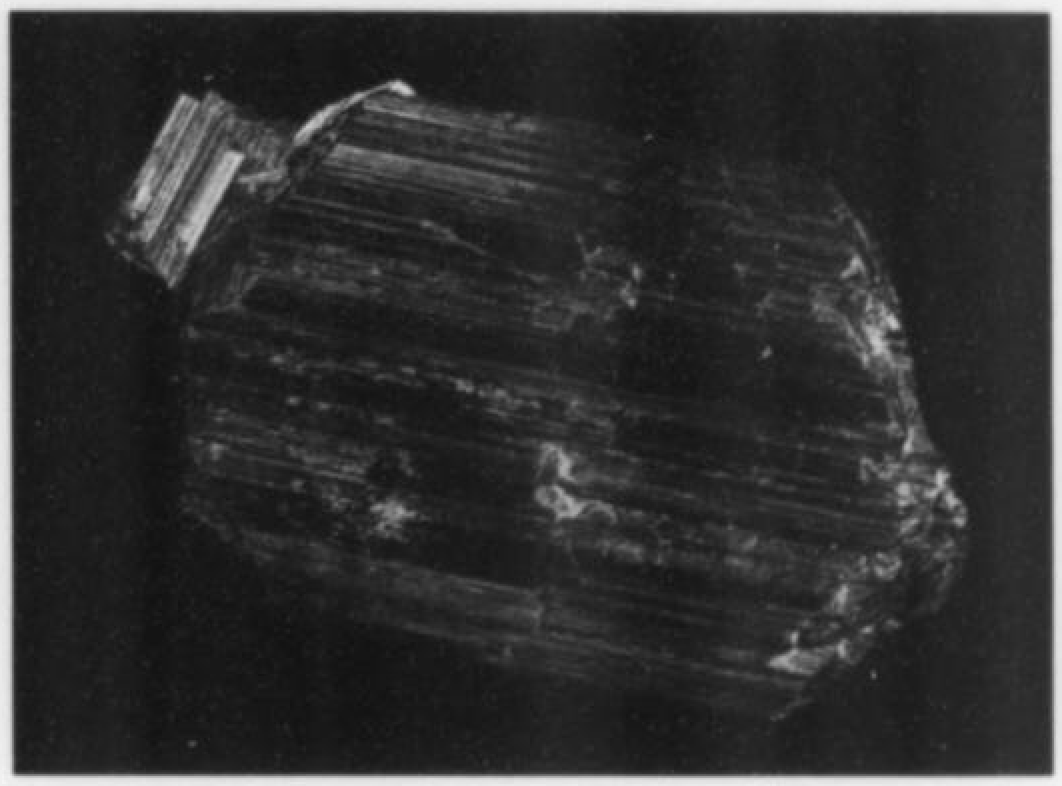

Figure 22. **Doubly terminated rutile crystal, 5.8 cm, with smaller rutile attached. Karl Sprich specimen; Bruce Cairncross photo.**

Figure 23. **Molybdenite crystal, 3.2 cm, on a matrix of vein quartz, muscovite and native copper. Karl Sprich collection; Bruce Cairncross photo.**

Figure 24. **Molybdenite crystal, 4.5 cm. Forrest Cureton collection.**

Magnetite $Fe^{2+}Fe_2^{3+}O_4$

Magnetite is present in the country rock as euhedral, sharp-edged octahedral crystals up to 5 cm on edge. Some have been replaced by hematite to form the so-called "martite" pseudomorphs.

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

Malachite is a relatively common species at Onganja. Of interest to collectors was the discovery of so-called "primary" (i.e. non-pseudomorphous) malachite during 1974 (Wilson, 1976). These consist of dark-green crystals resembling some of the malachite recently discovered at the Mashamba West mine in Zaire (see vol. 23, p. 278). The crystals are generally blocky, up to 2 cm in size, and have a diamond-shaped cross-section with lustrous prism faces and rough terminations. Matrix specimens on calcite are fairly common. The crystals are a very dark, translucent green to almost black-green. Some, after exposure on the dumps, assumed a lighter green color and a silky, fibrous texture. Malachite also occurs as delicate sprays on calcite and quartz matrix, and as thin veneers coating the faces of cuprite crystals. Malachite pseudomorphs after azurite have been collected on the dumps in crystals measuring 1.2 cm.

Molybdenite MoS_2

Molybdenum is the other important economic element that occurs associated with copper in several of the quartz veins in the Onganja mining area. Although molybdenite crystals have not reached the famed status of the cuprite, outstanding specimens of perfectly formed molybdenite crystals have been recovered. Up until the mid-1980's, excellent thumbnail and miniature specimens on matrix could still be collected on the old dump. The molybdenite is most commonly found in the contact zone between the quartz veins and the host rock. Hexagonal crystals and rosettes up to 18 cm in diameter have been found (Roesener and Schreuder, 1992). Because of the extreme softness of the species, undamaged specimens are fairly rare, but do exist. Loose thumbnail crystals are fairly common. The molybdenite usually occurs either on massive quartz matrix, or subhedral cream-colored calcite. Associated minerals include chalcopyrite, muscovite, minor malachite and cuprite.

Quartz SiO_2

Because the economic mineralization occurs in quartz veins, quartz is the most common and widespread gangue mineral. It is usually massive and milky white, but forms transparent and semi-transparent euhedral crystals in cavities and along fracture surfaces. Some native copper specimens are coated by brilliant, small (<2 mm) sparkling quartz crystals.

Rutile TiO_2

Rutile is a relatively common species in the Onganja mining area and was reported as early as 1916, as ". . . rutile in very large prismatic crystals . . ." from the Otjizongati (Onganja) mine (Wagner, 1916). The crystals are typically loose singles with well-developed terminations; some measure over 10 cm. The prism faces are characteristically heavily striated parallel to the c-axis. Twinned crystals are fairly common, and were regularly recovered by mineral collectors from shallow excavations in the Stanley area of the mine.

Siderite $Fe^{2+}CO_3$

Dark brown to chocolate-brown rhombohedra of siderite are relatively common at Onganja, although most specimens consist of crudely intergrown aggregates.

Silver Ag

Native silver has been found as rare coatings and micro-crystals on native copper. It was also reported as a minor constituent of the ore at the Thorn Tree mine.

Other Minerals

Barite was reported by Wagner (1916) from the orebody at the Otjizonjati mine. The copper sulfides **bornite**, **chalcocite**, **chalcopyrite**, **covellite** and **digenite** occurred with **pyrite** in essentially massive form as part of the copper ore. **Tenorite** ($Cu^{2+}O$) occurs as thin black coatings on rutile crystals associated with calcite. **Brochantite**, a copper sulfate, was sufficiently abundant on the old dumps to be heap-leached for copper during the post-1987 period. **Ilmenite** occurs as a minor constituent of the country rock. Small, euhedral, blue-green **beryl** crystals have also been found in the country rock, associated with **biotite**, rutile and quartz. The biotite sometimes forms euhedral crystals and rosettes up to 5 cm across in the country rock and in veins in biotite schist.

CURRENT STATUS

The area from which the cuprite crystals were removed in 1973 has been flooded for many years. It is not known for certain whether all of the crystals were systematically removed or whether more remain to be discovered should the mine be de-watered and re-commissioned. Virtually no specimens of any quality are found on the dumps today, and access onto the property is not permitted. The authors do not have specimens for trade from the Onganja mine.

ACKNOWLEDGMENTS

G. McGregor and Dr. W. Hegenberger of the Geological Survey, Namibia, provided copies of open file reports and other data pertaining to Onganja. Most of these reports are unpublished but are available from the Geological Survey offices in Windhoek. Desmond Sacco, Carolyn Manchester, Forrest Cureton, Gene Schlepp, Dr. Wendell Wilson, George Godas, Tim Sherburn and Karl Sprich are thanked for loaning specimens for photography. Roger Dixon provided additional mineralogical information that was not available in the literature.

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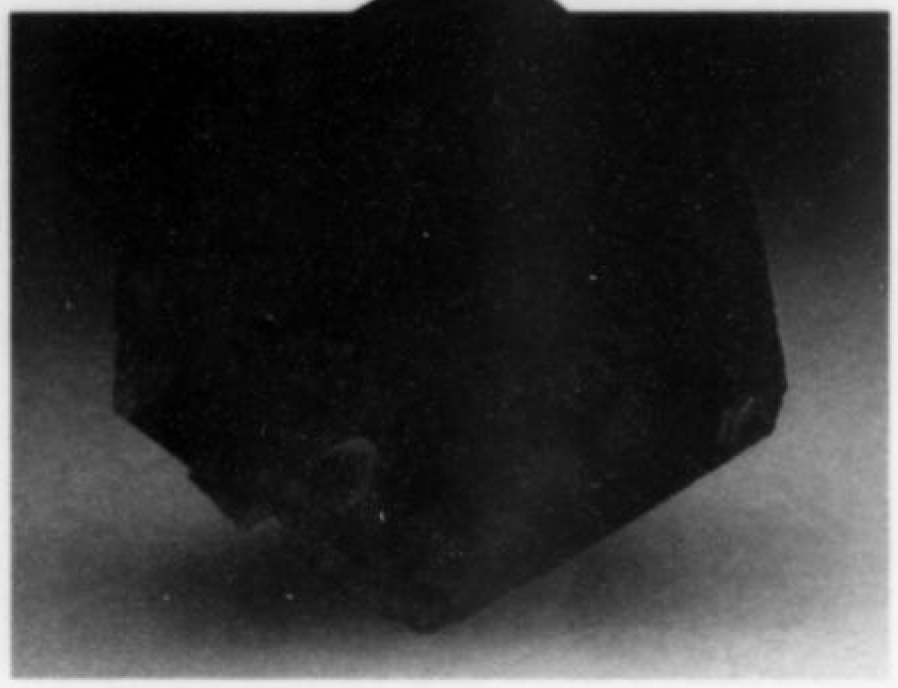
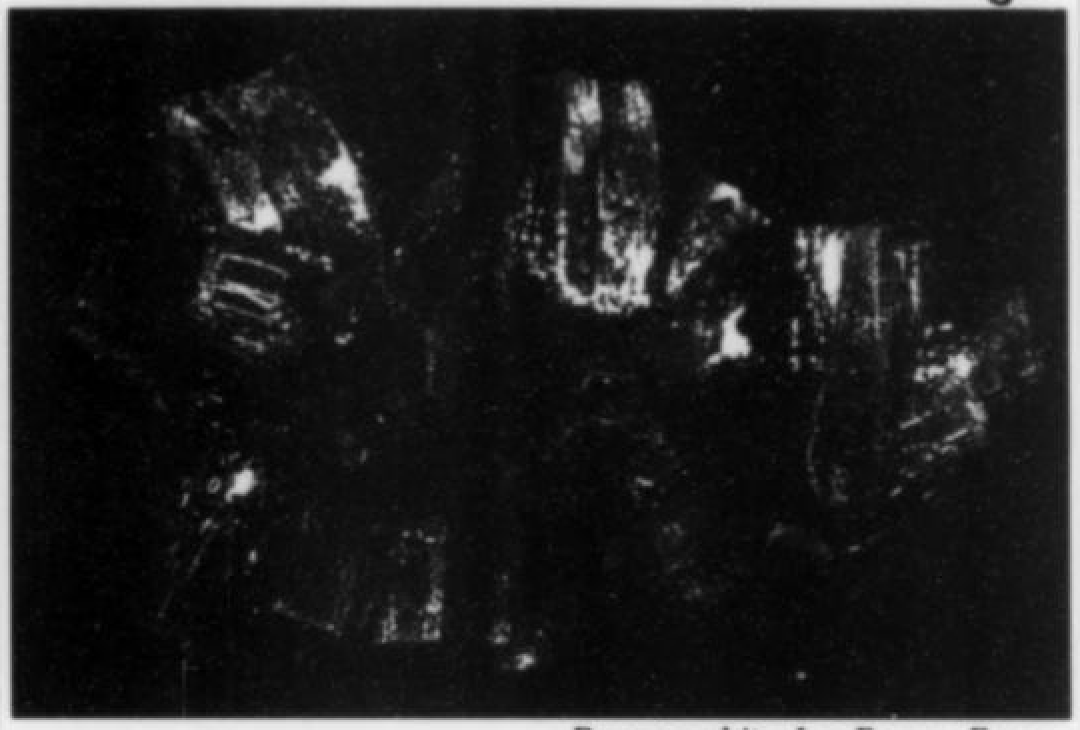
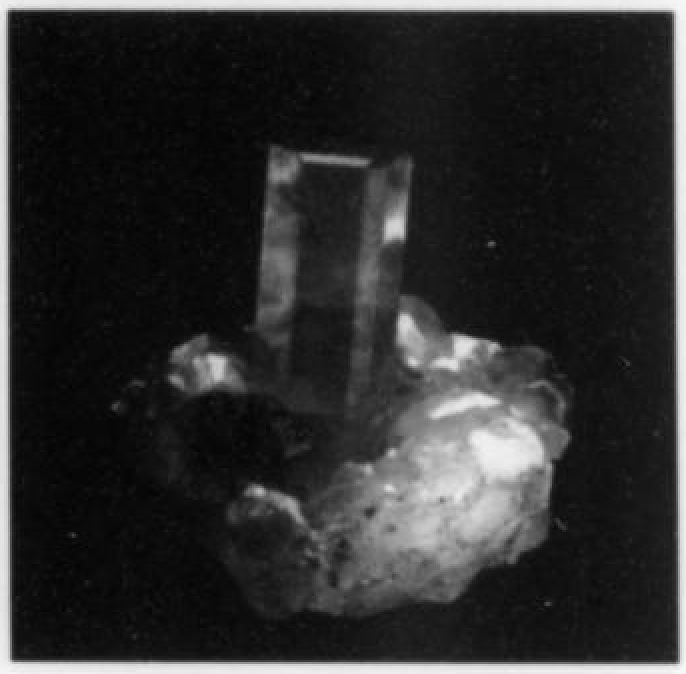
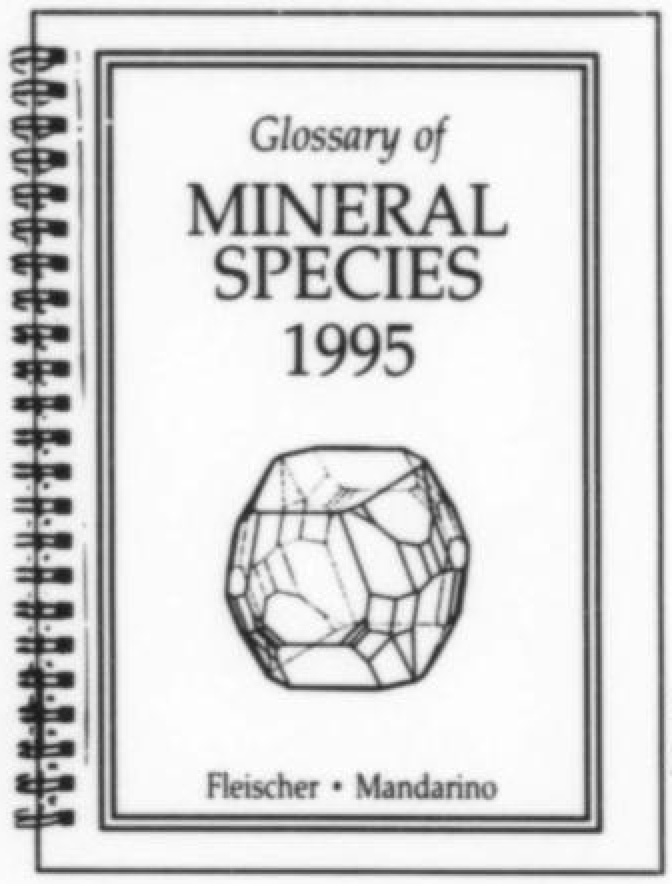




Pyromorphite, Les Farges, France





BLUE QUARTZ

FROM THE ANTEQUERA-OLVERA OPHITE, MÁLAGA, SPAIN

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Attractive "dipyramidal" blue quartz owing its color to aerinite inclusions occurs lining fractures in ophite near Málaga, Spain. Blue quartz of any kind is rather rare, especially in good crystals; this is the only area known to have produced crystals colored by aerinite.

INTRODUCTION

The Triassic rocks between the Antequera and Olvera regions in the Andalusian provinces of Málaga and Cádiz have yielded many interesting, unstudied mineral occurrences in recent years. Three different varieties of quartz are also found in the area: dark smoky quartz ("morion"), green quartz (colored by inclusions of actinolite and chlorite) and an unusual blue quartz apparently colored by inclusions of aerinite, a zeolite-facies hydrothermal silicate-carbonate. The latter occurrence is the subject of this article.

The quartz occurrences are all related to basic volcanic rocks known as *ophites*, a general term for diabases that have retained their ophitic texture (i.e. lath-shaped plagioclase crystals partially or completely included within pyroxene crystals), although the pyroxene has usually been altered to uralite. The ophites in Málaga are found as dikes and sills intruded into an evaporite/clay sequence.

HISTORY

The earliest reference to blue quartz in Spain is found in Calderón (1910), who gives the locality only as the Antequera region. There is no further mention of it in the literature. Recently, however, two geologists from Granada (J. Olivares and R. Marquez, 1985) discovered an interesting outcrop of a green, mineralized volcanic rock near the Olvera-Pruna road, in the province of Cádiz. The rock they found is an ophitic augite diabase with clay-lined fractures containing well-crystallized "dipyramidal" blue quartz. The 5-mm to 1.5-cm "dipyramids" (actually consisting of two rhombohedrons in equal development) are unmodified by any prism faces. The 1-meter block containing the quartz proved to be a detached fragment embedded in a gravitational slide of massive gypsum.

More recently (1988) I and a colleague confirmed the find, and discovered that similar rocks exist near Algodonales, Coripe and El Gastor (Cádiz province) in addition to the known occurrences in the Archidona and Antequera regions (Málaga province).

GEOLOGY

The Triassic Antequera-Olvera region is structurally a part

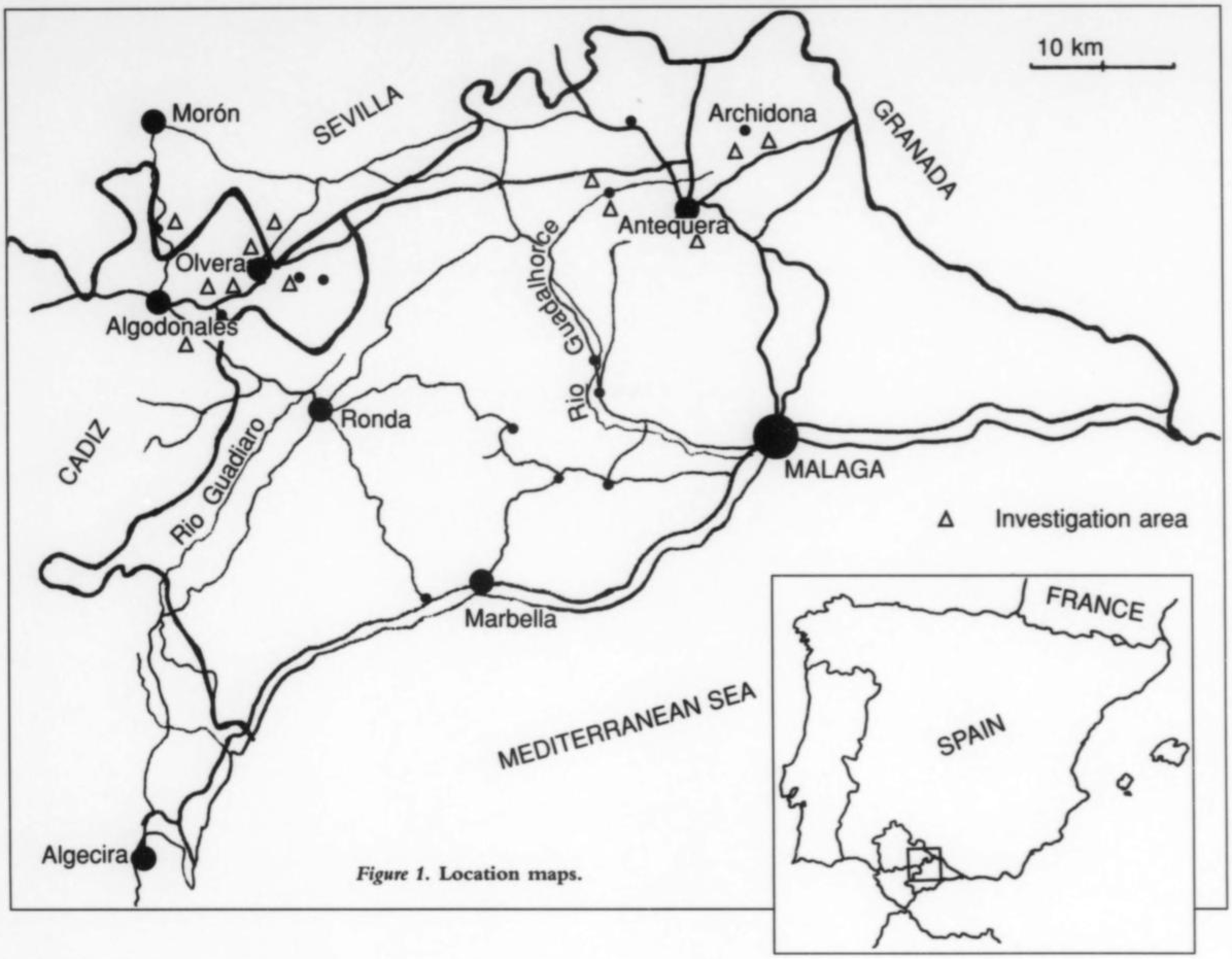


Figure 1. **Location maps.**

of the Spanish Betic Ranges, forming the western end of the Perimediterranean Alpine Orogenic Province which extends from Gibraltar to Asia Minor. Tectonically the Betic Ranges are divided into two zones, the Internal and External; the Triassic rocks are part of the External Zone, and are referred to as the "Triassic Subbetic Unidentified" rocks. An allocthonous origin has been proposed by several authors (including Perconig and Chauve, 1960; and Cruz-Sanjulian, 1974).

The Subbetic Triassic rocks crop out along a narrow north-northeast-trending band as heterogenous, massive and chaotic units forming the base on which the Jurassic Subbetic limestones were deposited. Lithologically they include evaporite sequences (predominantly colored clays, massive gypsum and detrital materials) and also dolomites, limestones and gray dolomitic breccias (see Fig. 3). Tectonic movements have thoroughly deformed these plastic beds resulting in a chaotic appearance.

Ophitic rocks have intruded these layers forming lenticular masses, dikes and sills. Large structureless blocks of this intrusive rock (averaging 2 cubic meters) are commonly found embedded in coarsely chaotic gypsum, accompanied by fragments of sandstone, dolomite, limestone and marl in a cemented breccia.

Microscopic study has revealed the intrusive rock to be an augite diabase consisting primarily of augite and plagioclase $(An_{55}-An_{63})$ plus accessory titanite, albite, epidote, calcite, dolomite, chlorite, hematite, prehnite, actinolite, ilmenite, magnetite, pyrite, dufrenite, deep blue aerinite and blue quartz. The rock ranges from deep green to dull green in color, with a microporfidic to subophitic texture. Cooling and solidification were accompanied by the formation of a dense network of vertical and horizontal joints and fractures resulting in a compartmentalized, box-work appearance (Fig. 2).

Ophite outcrops are relatively common in the Antequera-Olvera region, though varying greatly in local extent. Because of its hardness, ophite has occasionally been mined for road metal in the Archidona area.

MINERALOGY

Aerinite

$Ca_4(Al,Fe^{3+},Mg,Fe^{2+})_{10}Si_{12}O_{35}(OH)_{12}(CO_3)\cdot 12H_2O$

Aerinite was first described from Spain by Lasaulx (1876), based on specimens in the Breslau Museum. A few years later it was found in the Spanish province of Huesca, near a village named Caserras, where it occurred filling fractures in ophite, associated with scolecite and prehnite. It is considered a hydrothermal mineral of the zeolite facies.

Anthony *et al.* (1995) report that it has also been found at Juseu and Estinopiñan in Huesca province, Tartaren in Lerida

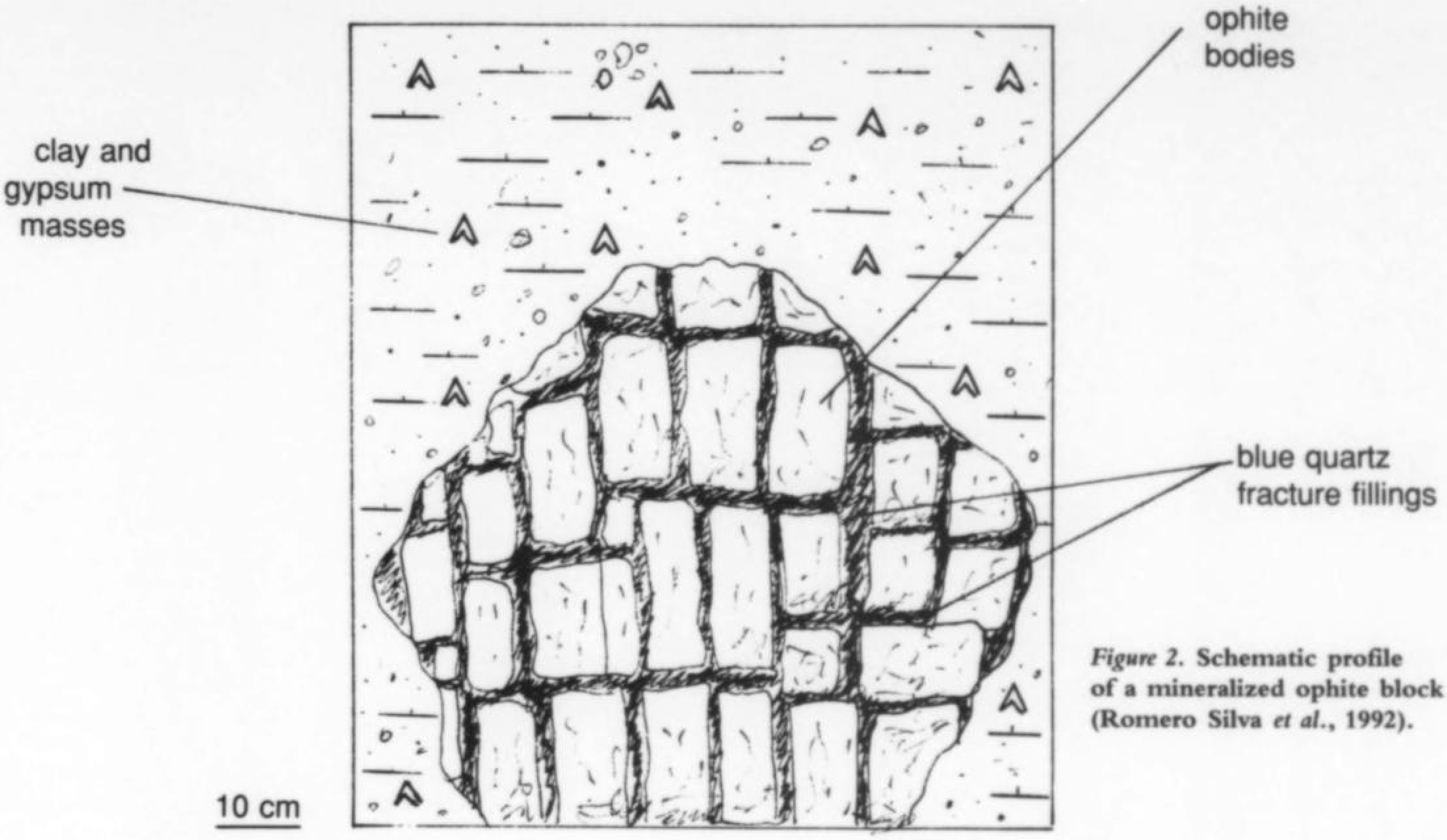


Figure 2. **Schematic profile of a mineralized ophite block (Romero Silva *et al.*, 1992).**

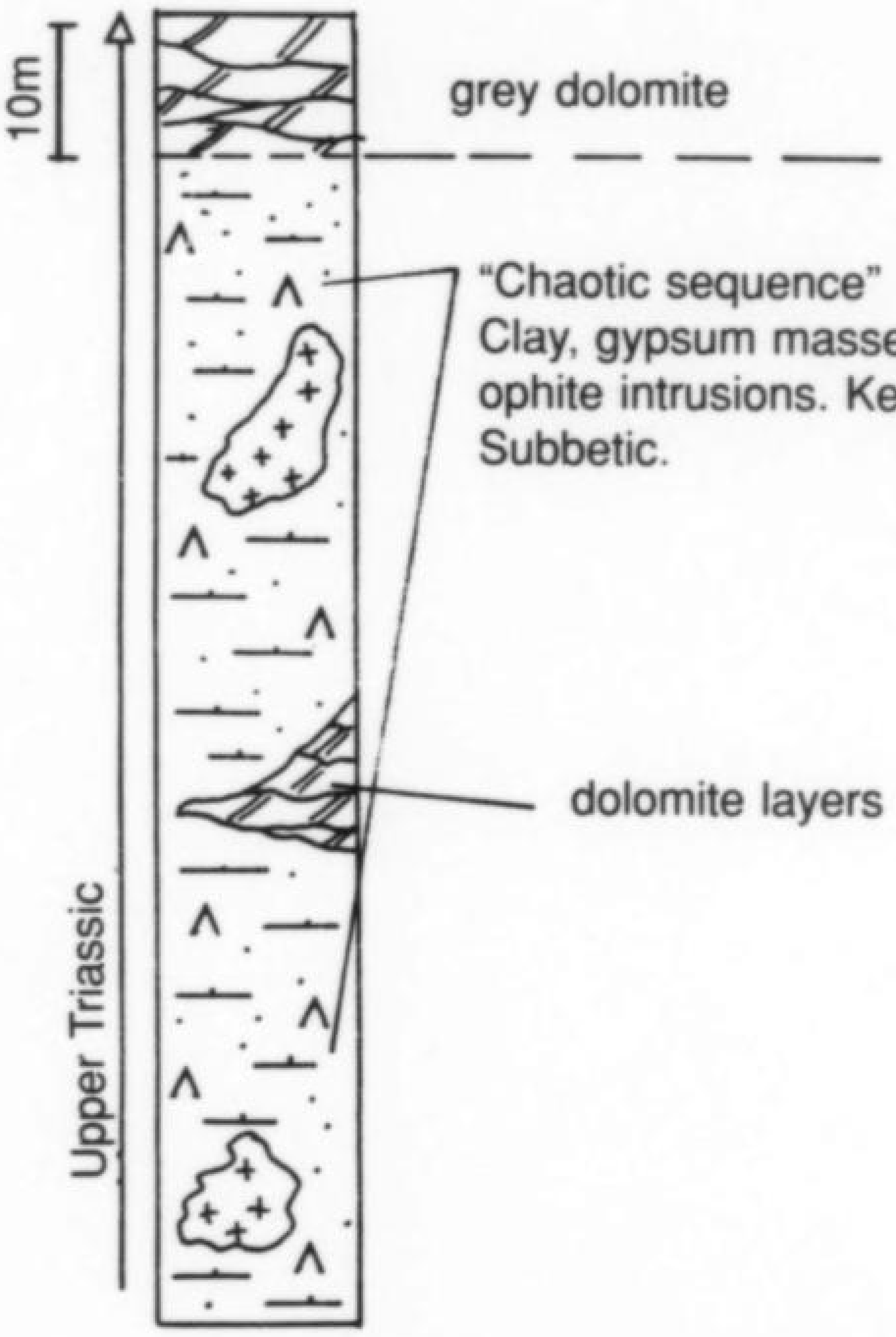


Figure 3. **A simplified geologic column showing the typical arrangement of rock types associated with blue quartz (Romero Silva *et al.*, 1992).**

province, and "other less-well-defined" localities in Spain. In 1982 Besteiro and Lago described specimens from a Pyrenees ophite. Occurrences are also noted at Saint-Pandelon, Landes, France; in Morocco at Ourika; and from the Gunsight Mountains in Arizona. The Saint-Pandelon occurrence was described by Azambre and Monchoux (1988), who gave sufficient new data to persuade the International Mineralogical Association's Commission on New Minerals and Mineral Names to reinstate aerinite as a valid mineral species. (The early descriptions had been regarded as unsatisfactory.) Specimens from Saint-Pandelon consist of blue to blue-green fibers associated with scolecite and prehnite in a tholeiitic dolerite.

The Antequera occurrence described here consists of distinctive, fibrous masses on and in quartz crystals, and as sky-blue coatings to 3 mm thick on fracture surfaces in ophite. Small cavities in the rock may be filled by radial-fibrous aggregates. Laser-ablation mass spectrometric analysis conducted at the University of Arizona gave ratios between Ca, Al, Fe and Si which are consistent with the ideal formula for aerinite, although iron substitution appears somewhat high (1.5 times expected). X-ray powder diffraction analysis confirmed the identification as a high-iron aerinite.

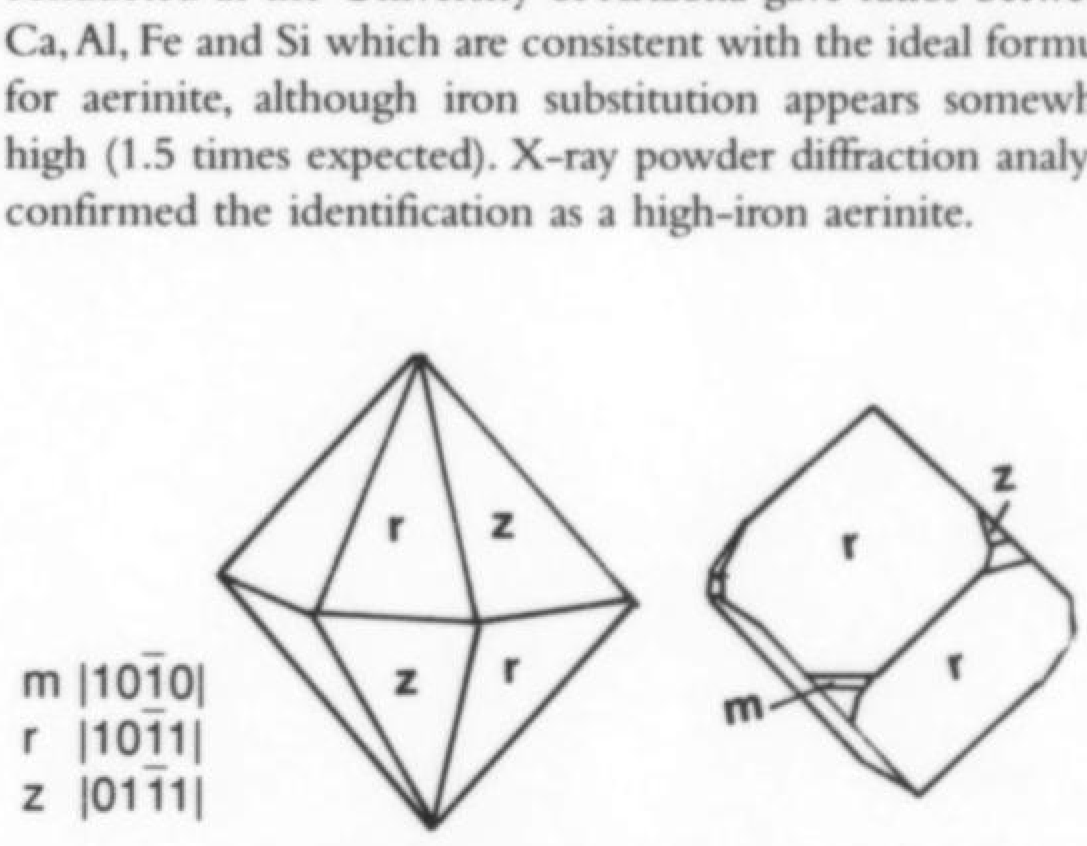
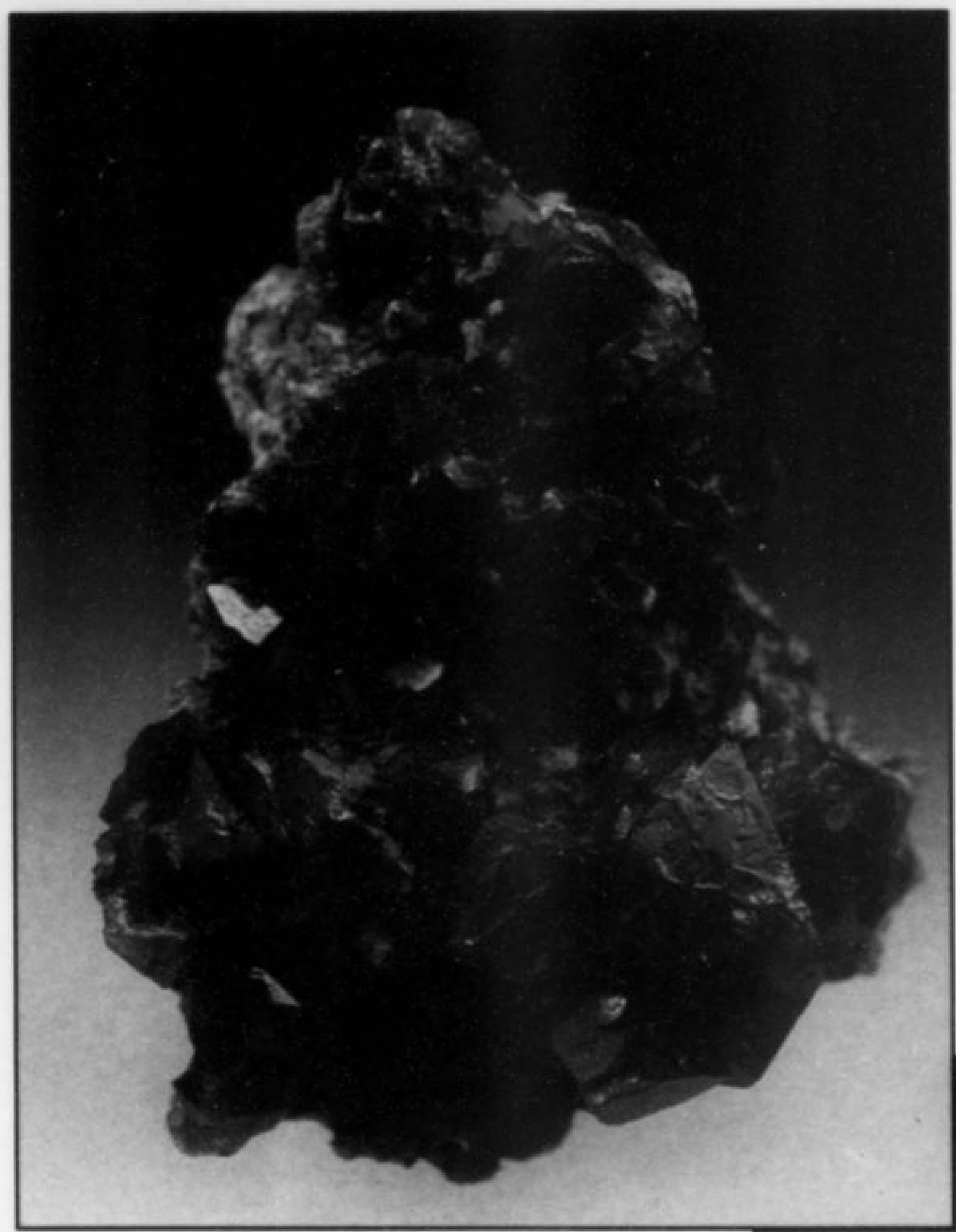


Figure 4. **Crystal drawings showing typical habits of Antequera blue quartz (Romero Silva *et al.*, 1992).**

Quartz SiO_2

Blue aerinite-included quartz crystals consist virtually exclusively of the rhombohedrons $r\{10\bar{1}1\}$ and $z\{01\bar{1}1\}$, resulting in a "hexagonal dipyramidal" aspect. Distorted tabular crystals are also known, as are pseudocubic crystals



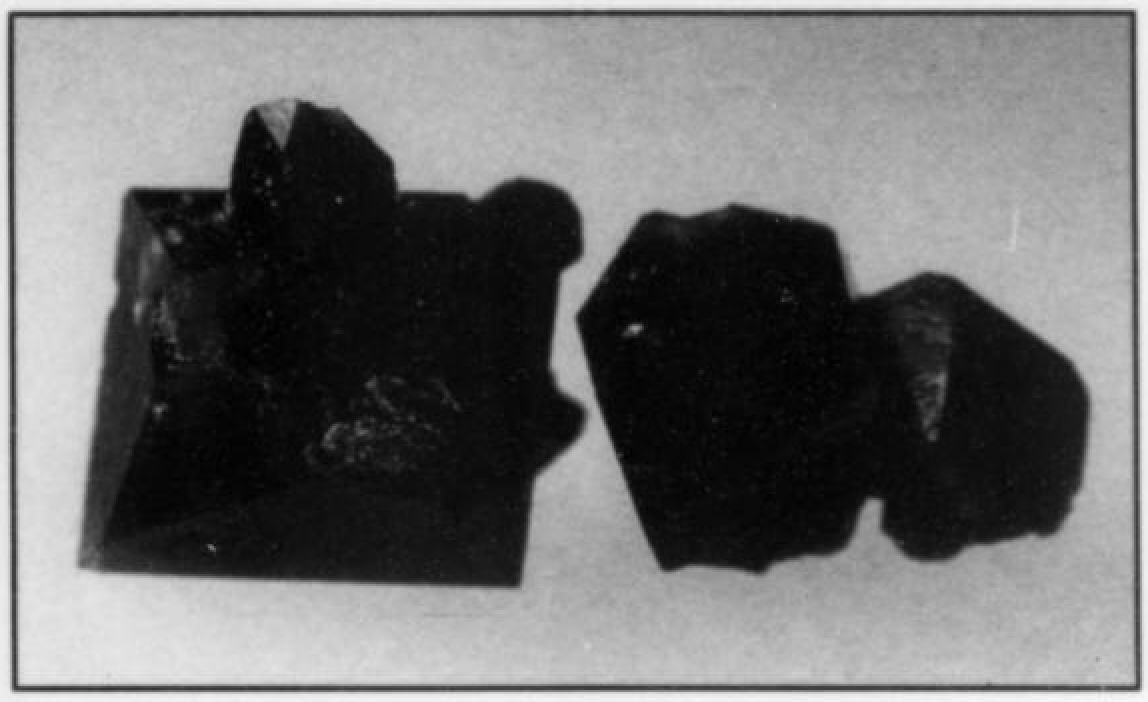


Figure 5. "Dipyramidal" crystals of blue quartz to 7 mm. Wendell Wilson photo.

Figure 6. Groups of blue quartz crystals to 1.4 cm. Note the pseudocubic crystal on the right. Wendell Wilson photo.

Figure 7. Group of blue quartz crystals, 2.3 cm. Wendell Wilson photo.

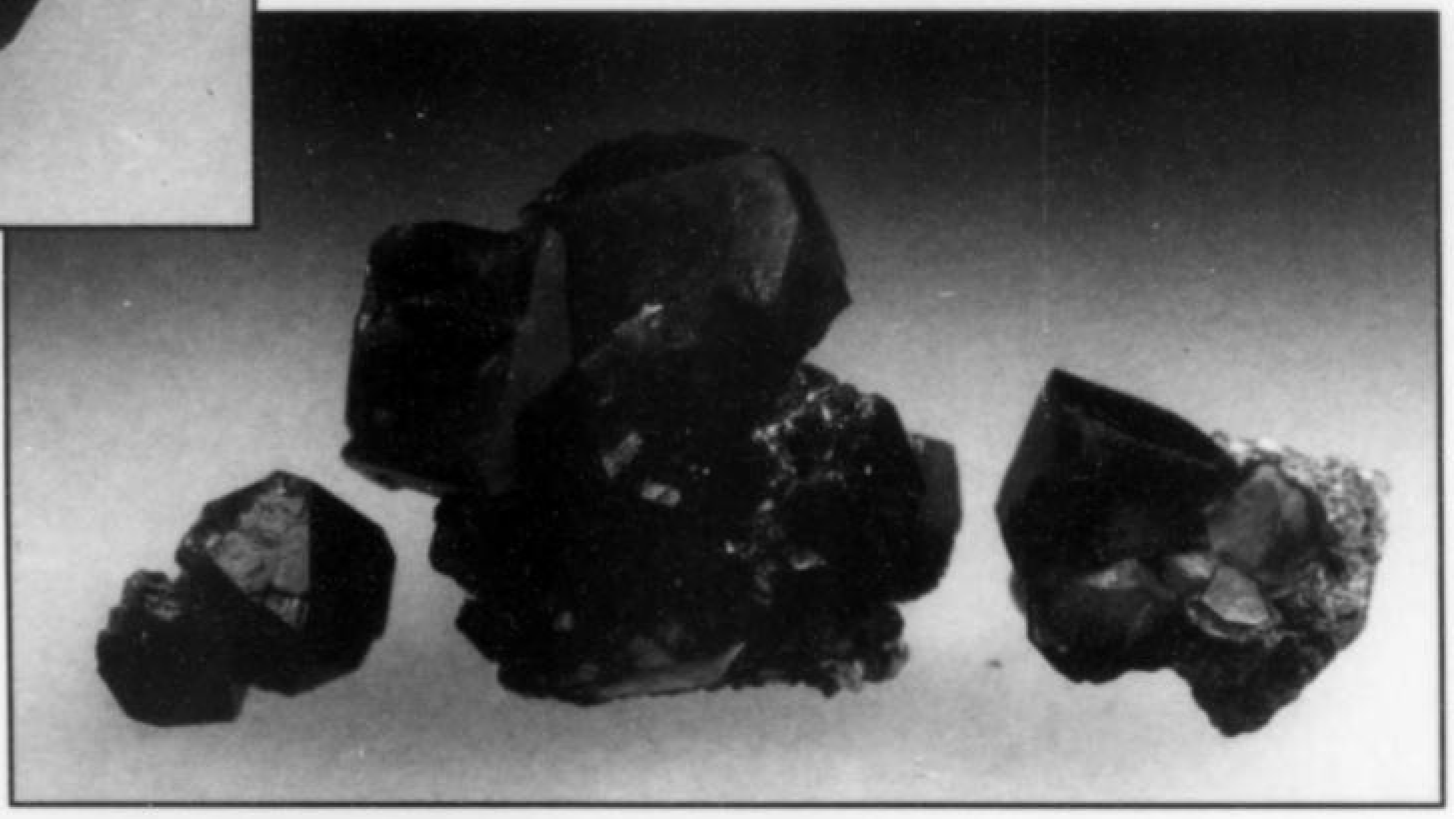
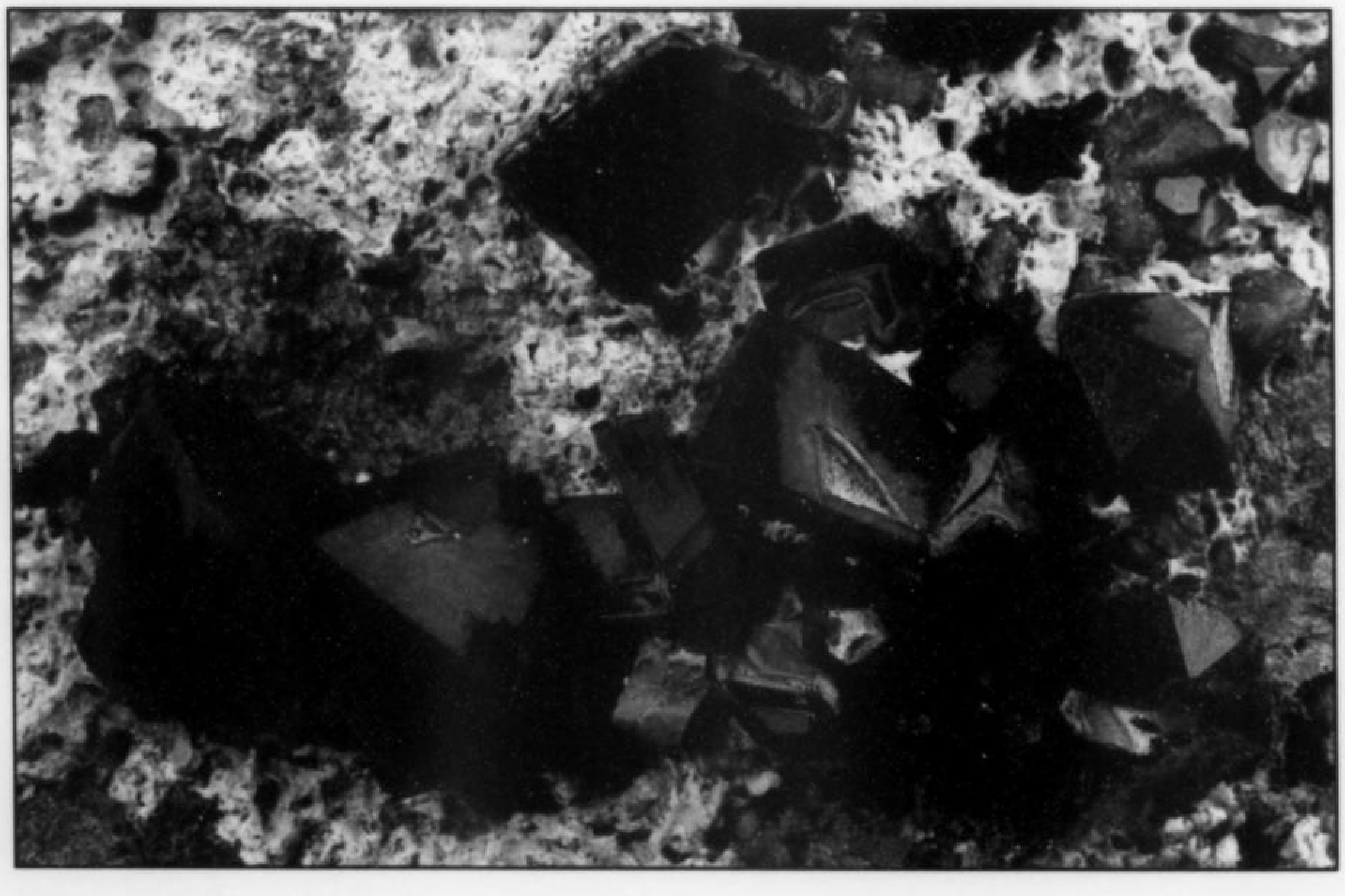


Figure 8. Blue quartz crystals to 5 mm on matrix with carbonates and aerinite. Wendell Wilson photo.



dominated by only the $r\{10\bar{1}1\}$ rhombohedron (in some cases showing minute prism $m\{10\bar{1}0\}$ faces).

The typical crystal size ranges from 5 mm to 1.5 cm; kidney-shaped to botryoidal masses up to 3 cm have also been found in the Olvera region. The color varies from deep blue to sky-blue with typical vitreous luster. Blue quartz occurs strictly as fracture fillings and in small vugs with fibrous aerinite and carbonates.

A close relationship exists between the blue quartz and the ophite intrusions, which seem to be the preferred environment for aerinite formation. Dark smoky quartz, although common in the same general area, occurs outside of the ophite blocks, along the contact zone between Carniolar dolomites and gypsum beds.

Blue-quartz-bearing ophite occurrences range from lenticular or tabular mineralized ophite which is altered and fractured, to mineralized but unconnected "floater" blocks embedded in "chaotic masses" of gypsum. The finest specimens have been found in this latter type of occurrence.

Frondel (1962) discusses blue quartz, but only those examples that are colored blue by sub-microscopic inclusions of rutile (which produce a "Tyndall effect"); in such cases the crystals are bluish in reflected light but pinkish in transmitted light. No rutile has been found in the Málaga occurrences, nor does the blue quartz appear anything but blue in transmitted light.

The "dipyramidal" habit of the Málaga blue quartz might suggest that it formed initially as the "high quartz" or "beta quartz" polymorph, which inverts spontaneously to normal ("low") quartz below 573° C. If this is true, the faces instead represent a true dipyramid $\{10\bar{1}1\}$. The presence of pseudocubic (i.e. unequivocally rhombohedral) crystals, however, mitigates against that interpretation, as does the lack of obvious contact twinning (Frondel, 1962).

Other Minerals

Other species found associated with the aerinite and blue quartz include extremely common calcite and ferruginous dolomite, hematite microcrystals filling fractures with reddish clay, prismatic to acicular epidote crystals, 5-mm pyrite crystals, and accessory titanite.

ACKNOWLEDGMENTS

Our thanks to Dr. Terry Wallace, University of Arizona, Tucson, for analyses confirming the identity of the aerinite. Dr. Wendell E. Wilson provided the specimen photography.

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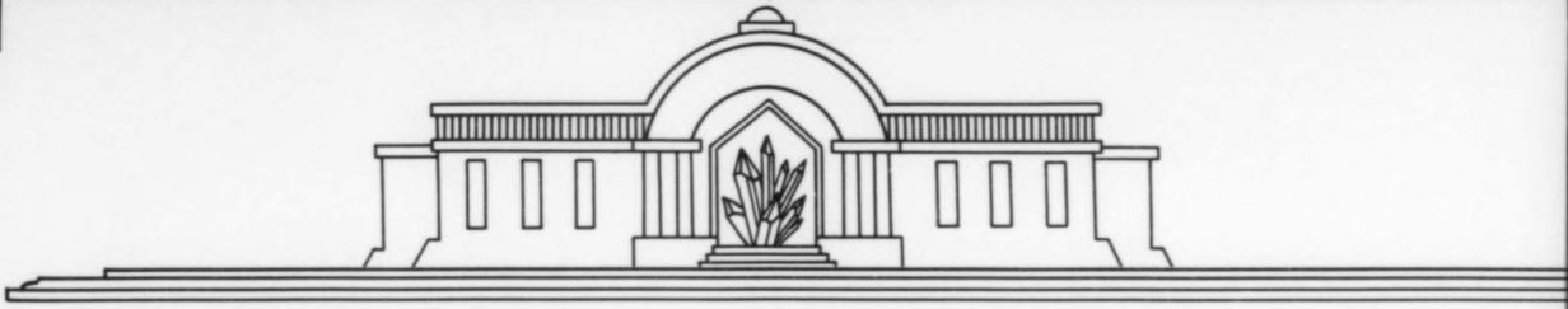

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Afghanite is a member of the cancrinite group first described in 1968 as a new species from the Sar-e-Sang lazurite deposit in Afghanistan. However, specimens of the mineral were first collected more than a century earlier from the Mount Vesuvius area. The material was partially described and named "natrodavyne" in 1910, but was then lost until being recently re-identified.

INTRODUCTION

Afghanite $[(Na,Ca,K)_8(Si,Al)_{12}O_{24}(SO_4,Cl,CO_3,H_2O)_3]$ is a feldspathoid of the cancrinite group. Minerals of this group (see Table 1) are hexagonal silicates having the general formula $A_{6-8}(Si,Al)_{12}O_{24}[(SO_4),(CO_3),Cl,(OH),H_2O]_{2-4}$, where A = Na,Ca and/or K.

Afghanite was officially described as a new species by Bariand *et al.* (1968) based on specimens from the Sar-e-Sang lazurite deposit in Afghanistan. It has since been reported from ten localities worldwide (see Table 2), half of them being volcanic occurrences in Italy. Typical associated minerals include a sodalite-group mineral (sodalite, lazurite, haüyne or nosean), nepheline, diopside, sanidine, pargasite, phlogopite-biotite and calcite. Afghanite is usually associated with sodalite-group minerals that are structurally related to the cancrinite group.

In order to understand why the cancrinite group has historically been so problematical for mineralogists it is necessary to understand something of the structural relationships. Cancrinite-group minerals are framework aluminosilicates built up of six-membered rings of $(Si,Al)O_4$ tetrahedra in planar arrangements. Different stacking sequences can lead to a theoretically infinite number of possible structures (see Fig. 1). A simple AB sequence characterizes five of the cancrinite-group minerals (cancrinite, vishnevite, davyne, microsommite and pitiglianoite).

Davyne, the first member of this group to be described, was discovered at Mount Vesuvius by Monticelli and Covelli (1825). They recognized it as a new species similar to

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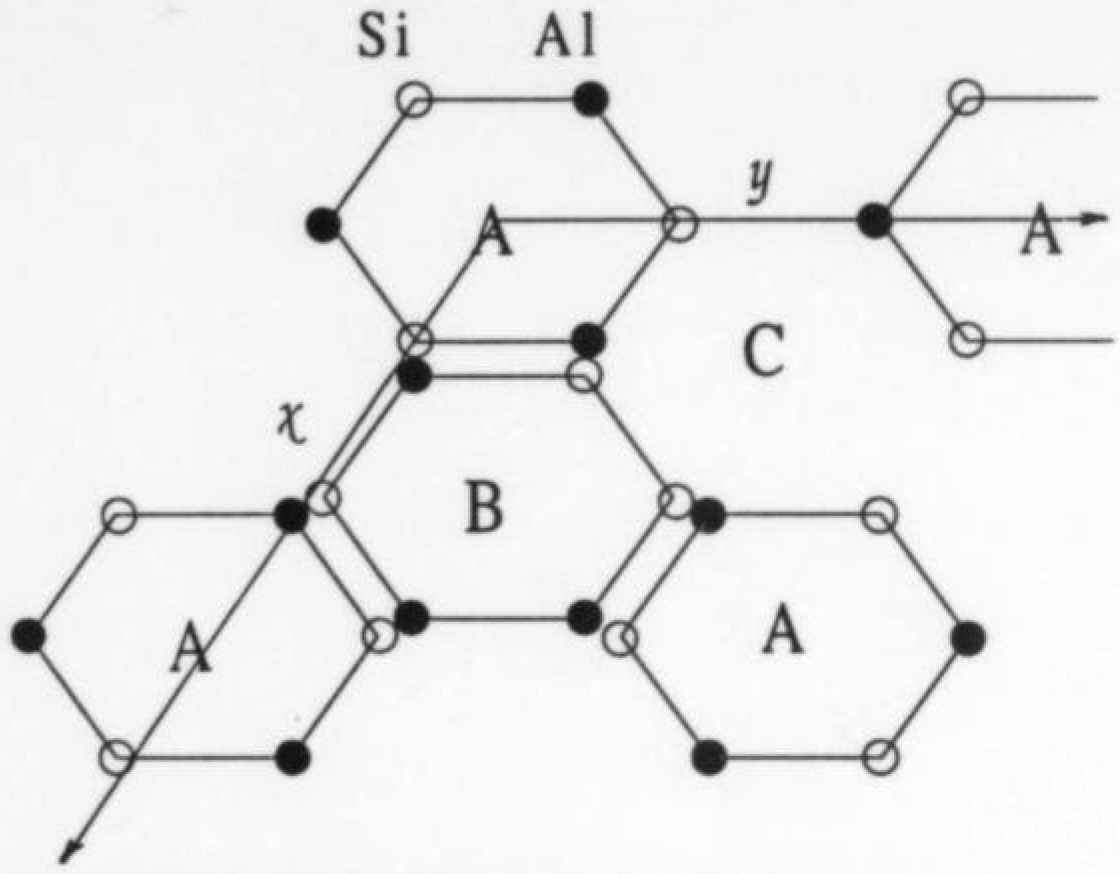

Figure 1. **Schematic drawing of the framework of davyne as seen along the *z* direction.**

nepheline but showing a well-developed prismatic cleavage. Subsequently the Italian mineralogist Arcangelo Scacchi described the related new species microsommite, a mineral similar to nepheline but containing significant Cl,S and Ca, in 1872.

The similarity between davyne, microsommite and nepheline caused considerable confusion and disagreement. As it later turned out, only X-ray diffraction analyses are capable of accurately distinguishing between davyne and microsommite. The cell parameters of davyne are a = 12.705(4) and c = 5.368(3) Å (Bonaccorsi *et al.*, 1991); microsommite shows an identical value for c, and a value for a which (due to cation ordering) is equal to the value for davyne times the square root of 3 (Merlino *et al.*, 1991). Incidentally, a new member of the group, quadridavyne, was described by Bonaccorsi *et al.* in 1994; similar cation ordering has resulted in a value for a which is twice that of davyne. Up until now, only davyne, microsommite and quadridavyne have been reported from the Mount Vesuvius complex (although many other cancrinite-group minerals with complex stacking sequences are known from elsewhere in Italy; Merlino and Mellini, 1976).

Afghanite has an eight-layer structure characterized by an ABABACAC layering sequence (Merlino and Mellini, 1976). The structure was solved recently by Pobedimskaya *et al.* (1991), who found it to belong to space group $P6_3mc$.

THE "LOST" AFGHANITE SPECIMENS

While gathering samples for an extensive investigation of the cancrinite group we came across two intriguing specimens in the collection of the Mineralogical Museum of the University of Rome. Infra-red, X-ray diffraction and chemical analyses have confirmed them both to be afghanite (Ballirano *et al.*, 1994a; Maras and Ballirano, 1994).

Specimen 7640/27 is a single, colorless, transparent crystal showing penetration twinning and small inclusions of pyroxene. Some fluid inclusions may also be present. The crystal measures 4.45 x 8.65 x 9.10 mm.

Specimen 7634/21 is an ejectum fragment composed primarily of phlogopite and calcite with a complex aggregate of well-formed, colorless, transparent afghanite crystals. These crystals show several orders of dipyramids, and are associated with green haüyne crystals (identified by IR, XRD and chemical analyses).

These two specimens have an interesting history. They were apparently collected at Vesuvius by Arcangelo Scacchi,[2] and later given to Lavinio de Medici Spada, a private

Figure 2. **Arcangelo Scacchi (1810–1893).**

collector. Spada's large collection (10,228 specimens) was purchased by Pope Pius IX, who later donated it to the University (Maras and Mottana, 1982). The two afghanite specimens have retained their original labels, handwritten by Spada himself. They read (translated):

> *Davyne no. 7634/21*
> *In this block were found the rare crystals*
> *described bv Scacchi*

[2]Arcangelo Scacchi (1810–1893) was among the greatest European mineralogists of the 19th century. He discovered and described 21 new mineral species, but his scientific production was extremely wide and ranged from zoology to paleontology and volcanology. He was awarded a degree in medicine in 1831 and became, in 1842, the director of the Royal Mineralogical Museum of the University of Naples. Two years later he became professor of mineralogy and geology at the University of Naples. Subsequently he became Dean of the faculty and President of the University of Naples. The compound $MnCl_2$, which was found in the fumarolitic products of the Mount Vesuvius volcanic complex, was named scacchite by G. J. Adam (1869). (From Mottana, 1993.)

Davyne no. 7640/27
Sample donated by Scacchi. This is a crystal described by Scacchi. There exists only one other crystal like it in the Scacchi Collection.

These actual labels are shown below.

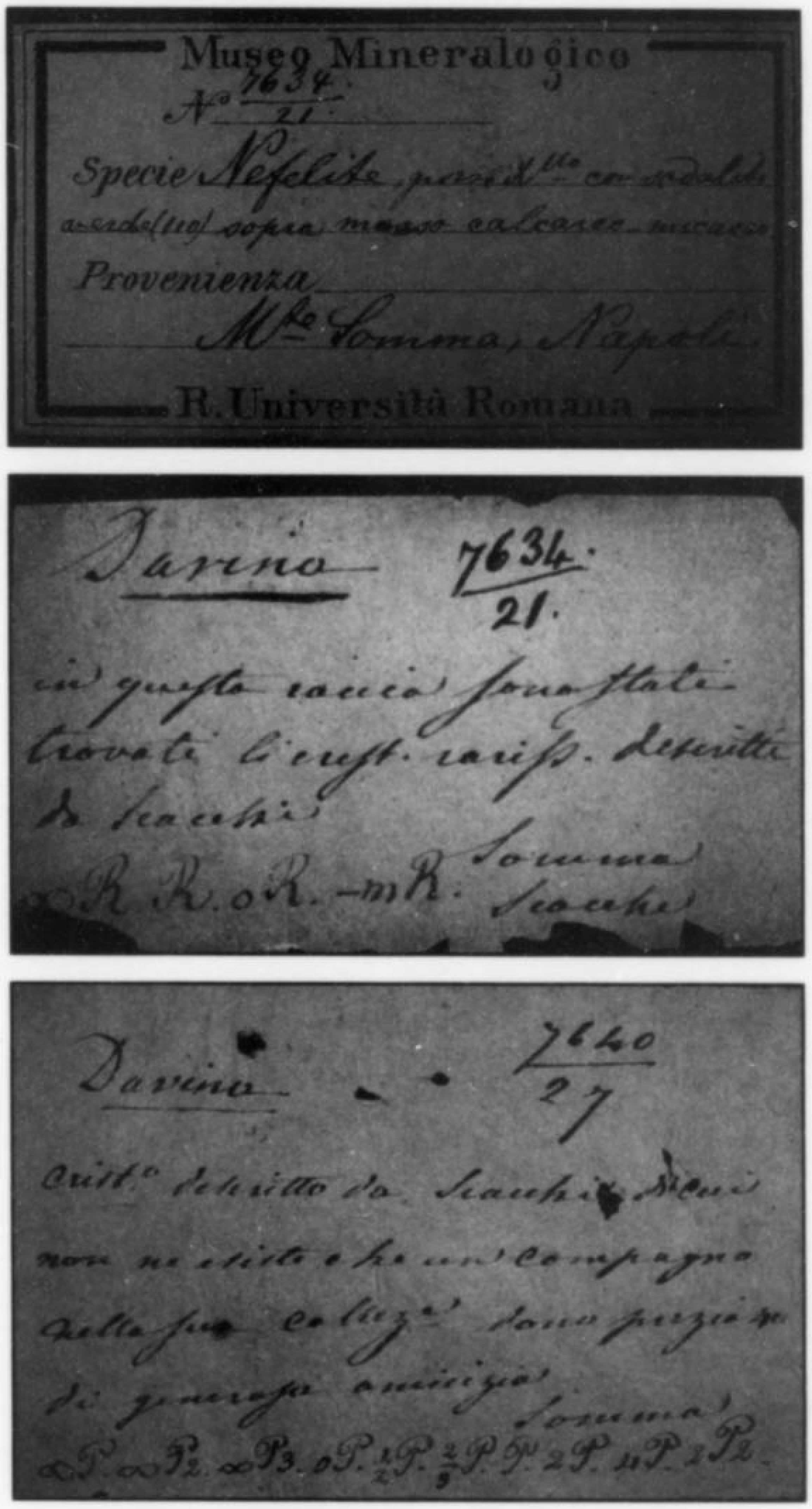

Figure 3. **Original labels accompanying the two samples of afghanite (see text). (Courtesy of S. Fiori)**

A second label (shown above) was appended to specimen no. 7634/21 by Giovanni Struver (1842–1915), professor of mineralogy and director of the Mineralogical Museum from 1872 until his death. It reads (translated):

Nefeline, 7634/21
Large crystal associated with "green sodalite" {110} on mica-calcite ejectum.

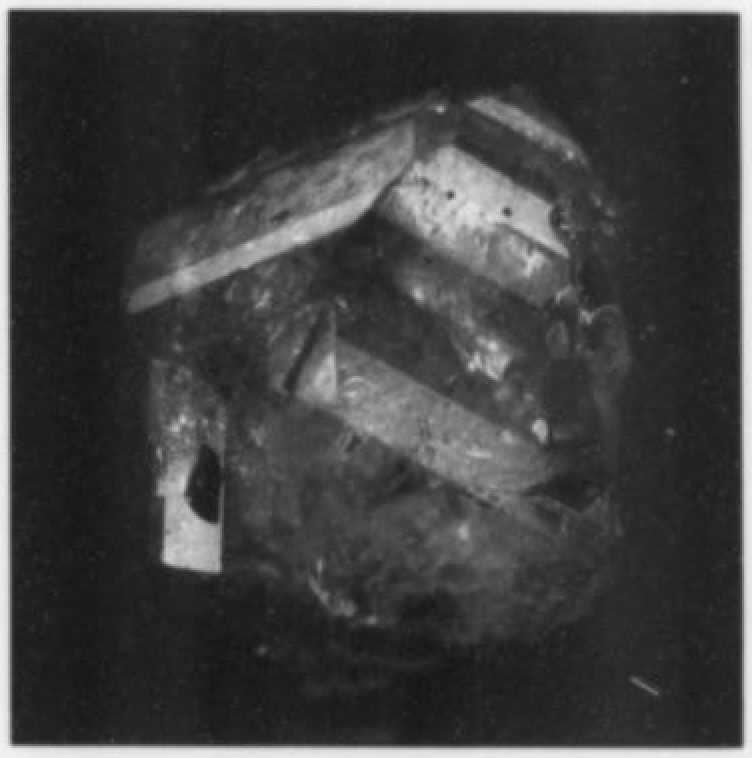

Figure 4. **Drawing of the "squat natrodavyne" (Zambonini, 1910) compared with the two afghanite samples 7634/21 (left) and 7640/27 (below right). (Courtesy of S. Fiori)**

In 1842 Scacchi had described as "nepheline" some crystals (apparently these) showing a combination of many forms and a "fibrous structure." A few years later he described as "davyne" some other crystals, similar to the former but exhibiting many more forms.

Opinions differed among other authors as to the true nature of these crystals. Dana called them all nepheline, whereas Hintze agreed with Scacchi. The specimens were subsequently studied by Zambonini (1910), who decided they were neither nepheline nor davyne but a new species he called "natrodavyne," a member of the "davyne-microsommite series." Utilizing etch figures he determined the crystal class to be dihexagonal dipyramidal (6/mmm), and the axial ratio (*c*/*a*) to be 1.6720.

Zambonini also observed that "natrodavyne" occurs in two different habits: predominantly prismatic (elongated) and predominantly dipyramidal (squat), the latter being the rarer of the two. Specimens 7640/27 and 7634/21 are both extremely similar to the idealized drawing of the squat habit figured by Zambonini in 1910 (Fig. 4).

The name "natrodavyne" did not find widespread use and was forgotten. It has recently been recycled to describe some synthetic material (Edgar and Burley, 1963).

Table 1. **Minerals of the cancrinite group (Fleischer and Mandarino, 1995).**

Afghanite	$(Na,Ca,K)_8(Si,Al)_{12}O_{24}(SO_4,Cl,CO_3)_3 \cdot H_2O$
Bystrite	$Ca(Na,K)_4Si_6Al_6O_{34}(S^{2-})_{1.5} \cdot H_2O$
Cancrinite	$Na_6Ca_2Al_6Si_6O_{24}(CO_3)_2$
Cancrisilite	$Na_7Al_5Si_7O_{24}(CO_3) \cdot 3H_2O$
Davyne	$(Na,Ca,K)_8Al_6Si_6O_{24}(Cl,SO_4,CO_3)_{2-3}$
Franzinite	$(Na,Ca)_7(Si,Al)_{12}O_{24}$-$(SO_4,CO_3,OH,Cl)_3 \cdot H_2O$
Giuseppettite	$(Na,K,Ca)_{7-8}(Si,Al)_{12}O_{24}(SO_4,Cl)_{1-2}$
Hydroxy-cancrinite	$Na_8Al_6Si_6O_{24}(OH)_2 \cdot 2H_2O$
Liottite	$(Ca,Na,K)_8(Si,Al)_{12}O_{24}$-$[(SO_4),(CO_3),Cl,OH]_4 \cdot H_2O$
Microsommite	$(Na,Ca,K)_{7-8}(Si,Al)_{12}O_{24}(Cl,SO_4,CO_3)_{2-3}$
Pitaglianoite	$K_2Na_6Si_6Al_6O_{24}(SO_4) \cdot 2H_2O$
Quadridavyne	$[(Na,K)_6Cl_2](Ca_2,Cl_2)(Si_6Al_6O_{24}$
Sacrofanite	$(Na,Ca,K)_9(Si,Al)_{12}O_{24}$-$[(OH)_2,(SO_4),(CO_3),Cl_2]_3 \cdot nH_2O$
Tounkite	$(Na,Ca,K)_8(Al_6Si_6O_{24})(SO_4)_2Cl \cdot H_2O$
Vishnevite	$(Na,Ca,K)_6(Si,Al)_{12}O_{24}$-$[(SO_4),(CO_3),Cl_2]_{2-4} \cdot nH_2O$
Wenkite (?)	$Ba_4Ca_6(Si,Al)_{20}O_{39}(OH)_2(SO_4)_3 \cdot H_2O$ (?)

DISCUSSION

The afghanite analyses given in Table 3 reveal some interesting features. The relative cationic contents are quite variable, but Na and Ca generally predominate over K. (Only minor quantities of Mg and Fe were detected, probably due to small inclusions of pyroxene.) No simple correlation can be seen between the relative cationic and anionic contents.

Maras and Ballirano (1994) and Ballirano *et al.* (1994b) show that it is possible to define compositional ranges for members of the cancrinite group based on the $Cl:SO_4$ ratio. Afghanite analyses, for example, show a consistent 1:1 ratio, as does liottite (a species not yet found at Mount Vesuvius). Davyne and microsommite have Cl predominating over SO_4 and CO_3, whereas the cancrinite-like species are characterized by predominant SO_4. Afghanite specimens 7640/27 and 7631/21 show $Cl:SO_4$ ratios of 1.09 and 1.12 respectively.

On the basis of the $Cl:SO_4$ ratio it can be hypothesized that sample VII of Zambonini (1910) (described as "davyne") is actually afghanite or liottite. Zambonini's "natrodavyne" (sample NAT) reportedly contained very little SO_4, but the SO_4 was calculated by difference. The Ca content of samples VII and NAT are identical; and the sample VII value for $Na_2O + K_2O$ equals the Na_2O value given for sample NAT. Considering that the chlorine contents are also similar, we may surmise that the two samples may be from the same specimen.

Table 2. **Morphology and occurrences for the known specimens of afghanite.**

Sample	*Locality*	*Habit*	*Associated Minerals*	*References*
1	Sar-e-Sang	Tabular	Sodalite, nepheline, phlogopite, forsterite, pyrite	Bariand *et al.* (1968)
afg		Tabular	Phlogopite, diopside, oligoclase, lazurite	Hogarth (1979)
2	Lake Baikal	Tabular	Lazurite, phlogopite, diopside, calcite	Ivanov and Sapozhnikov (1975)
3	Pamir	Tabular	Lazurite, diopside	Hogarth (1979)
4	Edwards	Rounded grains, tabular	Lazurite, diopside, pargasite, oligoclase	Hogarth (1979)
NA	Baffin Island	Rounded grains	Lazurite, nepheline, diopside	Hogarth (1979)
5	Pitigliano	Well-formed crystals	Vesuvianite, grossular, phlogopite, sanidine	Leoni *et al.* (1979)
NP1		Well-formed crystals	Calcite, andradite, diopside, apatite	Parodi (1982)
NP2		Well-formed crystals	Haüyne, sanidine, biotite, titanite, pyroxenes	Parodi (1982)
24336		Well-formed crystals	Diopside-augite, wollastonite	Maras and Ballirano (1994)
NP3	Vetralla	Well-formed crystals	Nosean, sanidine, damburite, vonsenite, garnet	Parodi (1982)
NP4	Bassano	Microscopic crystals	Sanidine, titanite, apatite, zircon	Parodi (1982)
6	Sacrofano	No habit given	Phlogopite, diopside, sanidine, anorthite	Leoni *et al.* (1979)
NP5		Well-formed crystals	Pyroxenes, haüyne, anorthite, tuscanite	Parodi (1982)
9PAR		Well-formed crystals	Andradite, vesuvianite	Maras and Ballirano (1994)
7634/21	M. Somma	Well-formed crystals	Haüyne, phlogopite, calcite	Ballirano *et al.* (1994)
7640/27		Well-formed crystals	?	Maras and Ballirano (1994)
NAT		Well-formed crystals	Calcite, vesuvianite	Zambonini (1910)
VII		?	?	Zambonini (1910)

Table 3. **Selected chemical analyses and formulae for known afghanite samples.**

	7640/27	*7634/21*	*NAT*	*VII*	*9PAR*	*6*	*24336*	*5*	*afg*	*2*	*3*	*4*
SiO_2	31.63	31.45	31.01	31.40	31.31	31.21	31.58	31.92	31.95	32.10	31.80	32.96
Al_2O_3	26.66	26.41	28.04	27.80	26.15	25.51	26.15	24.55	25.45	27.00	25.20	25.45
Fe_2O_3	nd	nd	—	—	nd	0.05	nd	0.11	—	—	—	—
FeO	—	—	—	—	—	—	—	—	nd	nd	nd	nd
MgO	—	—	—	—	—	0.40	—	0.29	nd	nd	nd	nd
MnO	—	—	—	—	—	—	—	—	—	—	—	—
CaO	11.62	11.83	13.81	13.82	11.10	9.72	12.94	13.12	11.66	12.34	11.70	11.98
K_2O	4.63	4.74	—	6.07	7.57	4.90	3.44	4.89	2.60	0.86	2.20	3.07
Na_2O	11.60	11.87	15.66	9.07	9.78	11.56	11.45	11.33	13.26	12.43	13.30	12.52
SO_3	9.56	9.20	2.14*	8.78	10.88	8.19	10.84	8.33	10.99	9.68	10.50	10.82
F	—	—	—	—	0.17	—	0.05	—	0.04	0.035	—	—
Cl	4.58	4.75	4.81	5.19	3.25	3.75	4.39	2.44	4.35	4.54	3.60	3.98
CO_2	0.50**	0.50**	5.61	—	—**	2.73	—**	1.80	nd	0.76	nd	nd
H_2O	—**	—**	—	—	0.50**	2.81	—**	1.79	nd	2.11	nd	nd
	100.78	100.75	101.08	102.13	100.71	100.83	101.06	100.53	101.43	101.85	98.33	100.78
O=Cl,F	1.03	1.06	1.09	1.17	0.80	0.85	1.01	0.54	1.00	1.05	0.81	0.90
tot	99.75	99.69	99.99	100.96	99.91	99.98	100.05	99.99	100.43	100.80	97.52	99.88

* SO_3 calculated by difference.

** Inferred from IR spectroscopy.

7640/27	$(Na_{17.12}K_{4.48}Ca_{9.48})[Si_{24.08}Al_{23.92}O_{95.44}](SO_4)_{5.44}Cl_{5.92}(CO_3)_{0.48}$
7634/21	$(Na_{17.64}K_{4.64}Ca_{9.72})[Si_{24.12}Al_{23.88}O_{96.04}](SO_4)_{5.32}Cl_{6.16}(CO_3)_{0.48}$
NAT	$(Na_{22.75}Ca_{11.09})[Si_{23.24}Al_{24.76}O_{96.09}](SO_4)_{1.20}Cl_{6.11}(CO_3)_{5.74}$
VII	$(Na_{13.16}K_{5.79}Ca_{11.08})[Si_{23.49}Al_{24.51}O_{96.08}](SO_4)_{4.93}Cl_{6.58}$
9PAR	$(Na_{14.64}K_{7.48}Ca_{9.20})[Si_{24.20}Al_{23.80}O_{95.72}](SO_4)_{6.32}Cl_{4.24}F_{0.40}\cdot 2.00\ H_2O$
6	$(Na_{17.56}Fe_{0.03}Mg_{0.47}K_{4.90}Ca_{8.16})[Si_{24.45}Al_{23.55}O_{96.00}](SO_4)_{4.82}Cl_{4.98}(CO_3)_{2.92}\cdot 7.35\ H_2O$
24336	$(Na_{17.40}K_{3.36}Ca_{10.68})[Si_{24.28}Al_{23.72}O_{96.00}](SO_4)_{6.28}Cl_{5.72}F_{0.12}$
5	$(Na_{17.33}Fe_{0.07}Mg_{0.34}K_{4.92}Ca_{11.08})[Si_{25.18}Al_{22.82}O_{96.00}](SO_4)_{4.993}Cl_{3.21}(CO_3)_{1.92}(OH)_{5.50}\cdot 1.97\ H_2O$
afg	$(Na_{19.50}K_{2.52}Ca_{9.48})[Si_{24.24}Al_{23.76}O_{95.50}](SO_4)_{6.26}Cl_{5.59}$
2	$(Na_{18.10}K_{0.82}Ca_{9.93})[Si_{24.11}Al_{23.89}O_{94.28}](SO_4)_{5.46}Cl_{5.78}(CO_3)_{0.78}F_{0.08}\cdot 5.28\ H_2O$
3	$(Na_{20.13}Mg_{0.04}K_{2.19}Ca_{9.78})[Si_{24.82}Al_{23.18}O_{96.86}](SO_4)_{6.15}Cl_{4.76}$
4	$(Na_{18.51}K_{2.99}Ca_{9.79})[Si_{25.13}Al_{22.87}O_{96.34}](SO_4)_{6.19}Cl_{5.14}$

Our chemical analyses for samples 7634/21 and 7640/27 are quite similar to the values given for samples VII and NAT, except for differences in the relative proportions of the cations. This fact strongly suggests the identity of sample 7640/27 with Zambonini's (1910) original "natrodavyne" specimen. Sample 7634/21, as stated on its label, is a part of the ejectum studied earlier by Scacchi in 1842.

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ABSTRACTS
OF NEW MINERAL DESCRIPTIONS

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INTRODUCTION

Shortly before I retired from the two jobs noted above, I approached Wendell Wilson to see if he would like to publish abstracts of new mineral descriptions in *The Mineralogical Record*. His reaction was positive and the abstracts which appear here are the first of many to follow. During the year after the manuscript of the *Glossary of Mineral Species 1995* was sent to Wendell, about fifty descriptions of new minerals have been published in journals throughout the world and I will continue to send abstracts of these and other new mineral descriptions for publication here.

Most of the data included in these abstracts are taken directly from the descriptions. In some cases, particularly for those descriptions written in Russian and Chinese, I have supplemented the data (which I am unable to read) with data from the original IMA proposal. In some other cases, data which I have calculated from the data given in the descriptions vary from those calculated by the author(s). If the differences are significant, I have presented the results of my calculations. Where the differences are slight, I note that slightly different data are given in the original paper.

Crystal drawings appear in very few of the new descriptions published in the past year. I have reproduced these drawings with the use of Eric Dowty's SHAPE program. Small differences in my selection of distances for the various forms may result in slightly different proportions of the crystal forms in my drawings compared to those in the original drawings. However, every effort has been made to minimize this effect.

The format of the abstracts has evolved over the past few months and I welcome suggestions for any changes which will make the information more useful.

It is a pleasure to acknowledge the assistance of Mr. Andrew C. Roberts of the Geological Survey of Canada, who kindly supplies me with photocopies of descriptions from journals which are not readily available to me.

Abenakiite-(Ce) — Hexagonal (trigonal)

$Na_{26}(Ce,REE)_6(SiO_3)_6(PO_4)_6(CO_3)_6(S^{4+}O_2)O$

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

Occurrence: A single crystal (coated by an unidentified rhabdophane-group mineral) embedded in sodalite in a xenolith of sodalite syenite. Other associated minerals are: aegirine, eudialyte, mangan-neptunite, polylithionite, serandite and steenstrupine-(Ce).

General appearance: An ellipsoidal crystal approximately 2 x 1 mm.

Physical properties: *Luster:* vitreous. *Diaphaneity:* transparent. *Color:* pale brown. *Streak:* white. *Luminescence:* non-fluorescent. *Hardness:* > 4. *Tenacity:* brittle. *Cleavage:* {001} poor. *Fracture:* conchoidal. *Density:* 3.21 g/cm^3 (meas.), 3.27 g/cm^3 (calc.). ***Crystallography:*** Hexagonal (trigonal), $R\bar{3}$, a 16.018, c 19.761 Å, V 4390.9 Å^3, Z 3, c:a = 1.2337. Morphology: no forms given. Twinning: none noted. ***X-ray powder diffraction data:*** 11.414 (75), 8.036 (85), 6.554 (85), 5.066 (60), 4.646 (75), 3.773 (90), 3.591 (80), 3.150 (70), 2.674 (100). ***Optical data:*** Uniaxial (-), ω 1.589, ε 1.586, nonpleochroic. ***Chemical analytical data:*** Means of four sets of electron microprobe data: Na_2O 25.32, SrO 0.12, Ce_2O_3 15.31, La_2O_3 5.94, Nd_2O_3 7.78, Pr_2O_3 2.02, Sm_2O_3 0.74, ThO_2 1.42, SiO_2 13.30, P_2O_5 14.11, SO_2 2.28, CO_2 (8.91), Total 97.24 wt.%. Empirical formula: $Na_{24.22}(Ce_{2.77}Nd_{1.37}La_{1.08}Pr_{0.36}Th_{0.16}Sm_{0.13}Sr_{0.03})_{\Sigma 5.90}Si_{6.56}P_{5.89}C_{6.00}S^{4+}_{1.06}O_{63.00}$. ***Relationship to other species:*** none apparent. ***Name:*** For the Abenaki Indian tribe, which inhabited the area around Mont Saint-Hilaire. ***Comments:*** IMA No. 91-054.

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Alumoklyuchevskite — Monoclinic

$K_3Cu_3AlO_2(SO_4)_4$

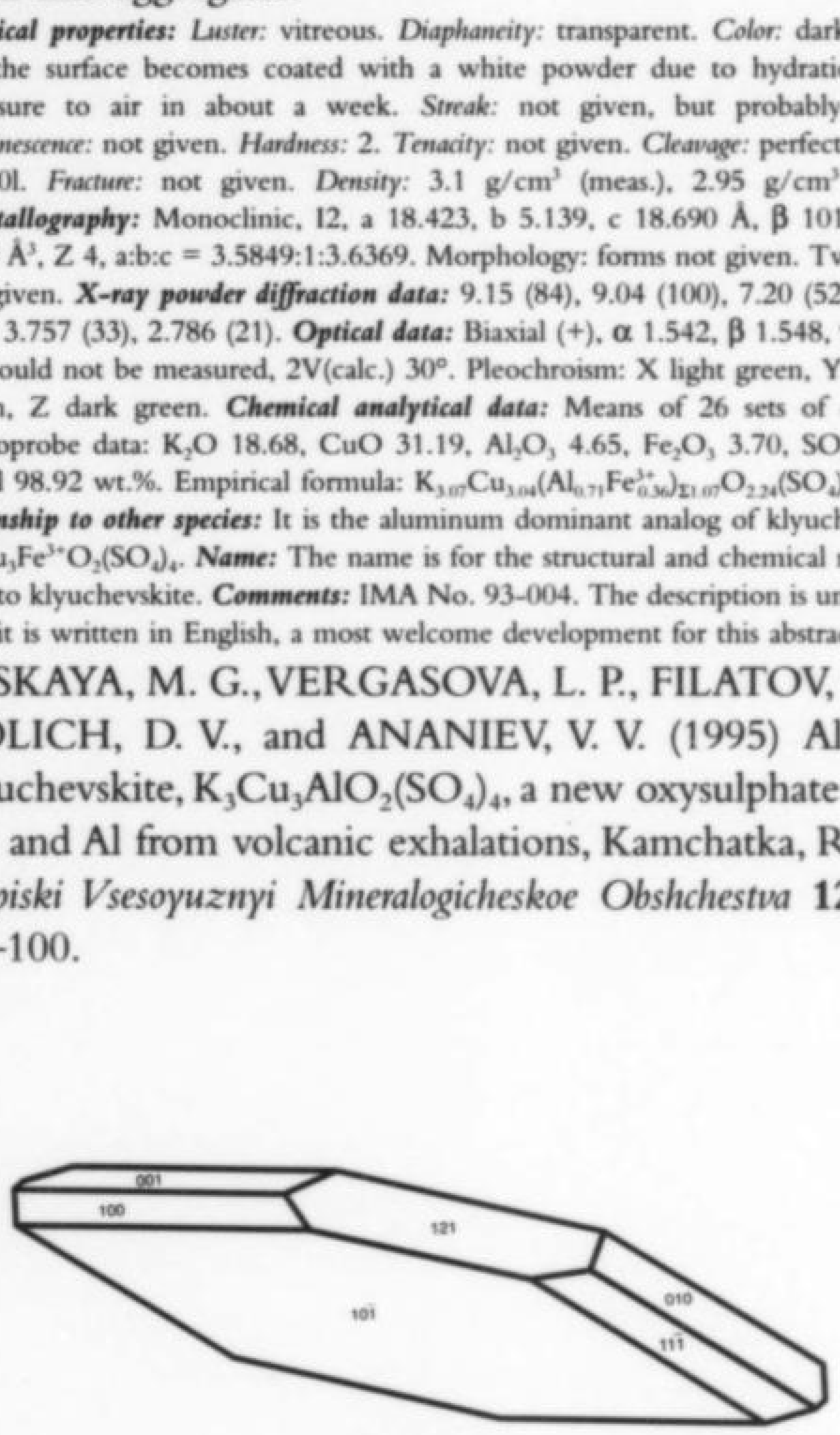
Locality: The 2-nd cone of the Northern Breakthrough of the Main Tolbachik fracture eruption, Kamchatka, Russia.

Occurrence: As volcanic exhalations. Associated minerals: fedotovite, tenorite, langbeinite and lammerite.

General appearance: As long prismatic to needle-like crystals elongated parallel to [010] (up to 1 mm x < 0.1 mm) in sheaf-like aggregates.

Physical properties: *Luster:* vitreous. *Diaphaneity:* transparent. *Color:* dark green, but the surface becomes coated with a white powder due to hydration after exposure to air in about a week. *Streak:* not given, but probably green. *Luminescence:* not given. *Hardness:* 2. *Tenacity:* not given. *Cleavage:* perfect parallel to h0l. *Fracture:* not given. *Density:* 3.1 g/cm^3 (meas.), 2.95 g/cm^3 (calc.). ***Crystallography:*** Monoclinic, I2, a 18.423, b 5.139, c 18.690 Å, β 101.72°, V 1732 Å^3, Z 4, a:b:c = 3.5849:1:3.6369. Morphology: forms not given. Twinning: not given. ***X-ray powder diffraction data:*** 9.15 (84), 9.04 (100), 7.20 (52), 3.781 (37), 3.757 (33), 2.786 (21). ***Optical data:*** Biaxial (+), α 1.542, β 1.548, γ 1.641, 2V could not be measured, 2V(calc.) 30°. Pleochroism: X light green, Y greyish green, Z dark green. ***Chemical analytical data:*** Means of 26 sets of electron microprobe data: K_2O 18.68, CuO 31.19, Al_2O_3 4.65, Fe_2O_3 3.70, SO_3 40.70, Total 98.92 wt.%. Empirical formula: $K_{3.07}Cu_{3.04}(Al_{0.71}Fe^{3+}_{0.36})_{\Sigma 1.07}O_{2.24}(SO_4)_{3.94}$. ***Relationship to other species:*** It is the aluminum dominant analog of klyuchevskite, $K_3Cu_3Fe^{3+}O_2(SO_4)_4$. ***Name:*** The name is for the structural and chemical relationship to klyuchevskite. ***Comments:*** IMA No. 93-004. The description is unusual in that it is written in English, a most welcome development for this abstracter.

GORSKAYA, M. G., VERGASOVA, L. P., FILATOV, S. K., ROLICH, D. V., and ANANIEV, V. V. (1995) Alumoklyuchevskite, $K_3Cu_3AlO_2(SO_4)_4$, a new oxysulphate of K, Cu and Al from volcanic exhalations, Kamchatka, Russia. *Zapiski Vsesoyuznyi Mineralogicheskoe Obshchestva* **124(1)**, 95–100.



Artroeite

Artroeite — Triclinic

$PbAlF_3(OH)_2$

Locality: The Grand Reef mine, near Klondyke, Graham County, Arizona, U.S.A.

Occurrence: In a quartz-lined vug associated with anglesite, fluorite, galena and another new mineral with a formula, $PbCa_2Al(F,OH)_9$.

General appearance: Blades, up to 1 x 0.7 x 0.04 mm.

Physical properties: *Luster:* vitreous. *Diaphaneity:* not given, but presumably transparent. *Color:* colorless. *Streak:* white. *Luminescence:* not given. *Hardness:* 2½. *Tenacity:* brittle. *Cleavage:* {100} perfect, {010} good. *Fracture:* conchoidal. *Density:* 5.36 g/cm^3 (meas.), 5.42 g/cm^3 (calc.). ***Crystallography:*** Triclinic, $P\bar{1}$, a 6.270, b 6.821, c 5.057 Å, α 90.68°, β 107.69°, γ 104.46°, V 198.6 Å^3, Z 2. a:b:c = 0.9192:1:0.7414. Morphology: forms: {100}, {010}, {$10\bar{1}$}, {011}, {$11\bar{1}$}, {121}. Twinning: common by rotation on [010] with composition plane (100). ***X-ray powder diffraction data:*** 4.42 (100), 4.05 (35), 3.267 (35), 3.221 (40), 2.595 (70), 2.190 (65), 2.030 (50), 2.015 (40). ***Optical data:*** Biaxial (-), α 1.629, β 1.682, γ 1.691, 2V(meas.) 41°, 2V(calc.) 44°; dispersion r > v, strong. ***Chemical analytical data:*** Means of ten sets of electron microprobe data: PbO 67.5, Al_2O_3 15.6, F 16.1, H_2O 6.0, sum 105.2, less O = F 6.8, Total 98.4 wt.%. Empirical formula: $Pb_{1.00}Al_{1.01}F_{2.79}(OH)_{2.19}O_{0.02}$. ***Relationship to other species:*** Most closely related to the dimorphs acuminite and tikhonenkovite, $SrAlF_4(OH){\cdot}H_2O$. ***Name:*** For Dr. Arthur (Art) Roe (1912–1993). ***Comments:*** IMA No. 93-031. The calculated density, calculated 2V and empirical formula given here are slightly different from those given in the description. The crystal drawing in the description is in a non-standard orientation, so it has been changed to the normal orientation in this abstract.

KAMPF, A. R., and FOORD, E. E. (1995) Artroeite, $PbAlF_3(OH)_2$, a new mineral from the Grand Reef mine, Graham County, Arizona: Description and crystal structure. *American Mineralogist* **80**, 179–183.

Crerarite — Cubic

$(Pt,Pb)Bi_3(S,Se)_{4-x}$ x ~ 0.7

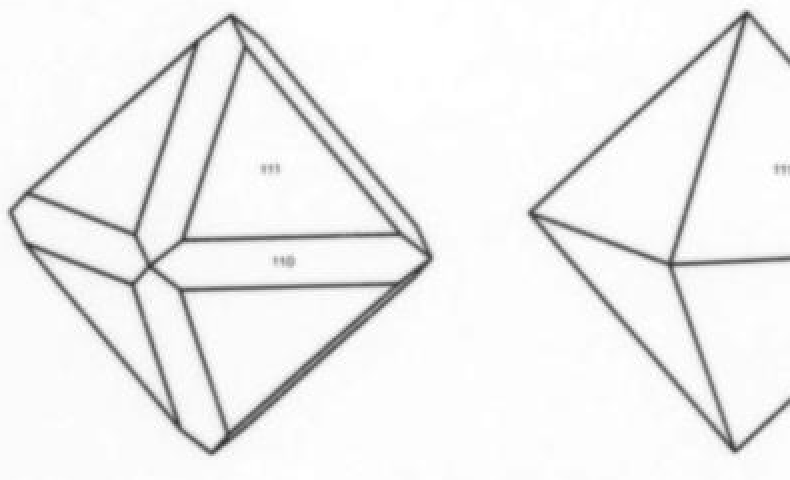
Locality: Lac Sheen, near the village of Belleterre, Guillet Township, Abitibi-Témiscaminque region, Québec, Canada (Lat. 47°30′ N, Long. 78°20′ W).

Occurrence: In amphibolite. Associated minerals are: chalcopyrite, pyrrhotite, pentlandite, sphalerite, galena, actinolite, chlorite and quartz. A single 10 µm grain of michenerite was found also.

General appearance: Small grains (mean diameter 12 mm, only two grains exceeded 50 µm in diameter).

Physical properties: *Luster:* metallic. *Diaphaneity:* opaque. *Color:* megascopic color not observed. *Streak:* black. *Hardness:* could not be determined, but the mineral is softer than chalcopyrite, i.e. less than 3½. *Tenacity:* brittle. *Cleavage:* {100} perfect. *Fracture:* not observed. *Density:* could not be measured, 7.85 g/cm^3 (calc.). ***Crystallography:*** Cubic, Fm3m, a 5.86 Å, V 201.2 Å^3, Z 1. Morphology: no forms observed. Twinning: none observed. ***X-ray powder diffraction data:*** 3.37 (50), 2.94 (100), 2.07 (30), 1.766 (15), 1.687 (15), 1.472 (50), 1.347 (10), 1.311 (8), 1.197 (10). ***Optical data:*** In reflected light: white-grey; no anisotropism, bireflectance or pleochroism. R: (52.7 %) 460nm, (50.3 %) 540nm, (49.8 %) 580nm, (48.9 %) 660nm. ***Chemical analytical data:*** Means of 3 sets of electron microprobe data: Pd 0.03, Pt 10.34 (erroneously given as 10.14), Cu 0.09, Pb 13.85, Ni < 0.05, Fe 0.08, Bi 65.26, Te 0.03, Se 0.86, S 10.55, Total 101.09 (given as 101.11) wt.%. Empirical formula: $(Pt_{0.50}Pb_{0.63}Bi_{2.94})_{\Sigma 4.07}(S_{3.10}Se_{0.10})_{\Sigma 3.20}$. ***Relationship to other species:*** None apparent. ***Name:*** For Prof. David Crerar (1945–1994) of Princeton University. ***Comments:*** IMA No. 94-003. A very small amount of the data given in this abstract were taken from the original IMA proposal.

COOK, N. J., WOOD, S. A., GEBERT, W., BERNHARDT, H-J, and MEDENBACH, O. (1994) Crerarite, a new Pt-Bi-Pb-S mineral from the Cu-Ni-PGE deposit at Lac Sheen, Abitibi-Témiscaminque, Québec, Canada. *Neues Jahrbuch für Mineralogie, Monatshefte* **1994**, 567–575.



Dzharkenite

Dzharkenite — Cubic

$FeSe_2$

Locality: In the Suluchekinskoye Se-U deposit, Dzharkenskaya depression, south eastern Kazakhstan.

Occurrence: In selenium ore associated with ferroselite and goethite.

General appearance: As small (10 to 100 µm in diameter, rarely up to 0.5 mm) octahedra and octahedra modified by dodecahedra.

Physical properties: *Luster:* metallic. *Diaphaneity:* opaque. *Color:* black. *Streak:* black. *Hardness:* 5, VHN_{20} 338 kg/mm^2. *Tenacity:* brittle. *Cleavage:* not known. *Fracture:* uneven. *Density:* 7.34 g/cm^3 (calc.). ***Crystallography:*** Cubic, Pa3, a 5.783, V 193.4 Å^3, Z 4. Morphology: forms: {111}, {110}. Twinning: not observed. ***X-ray powder diffraction data:*** 2.888 (50), 2.588 (100), 2.364 (80), 2.045 (40), 1.743 (50), 1.543 (60), 1.1131 (40). ***Optical data:*** In reflected light: pink-yellow; anisotropism, bireflectance and pleochroism absent. R: (41.7 %) 480nm, (42.6 %) 540nm, (45.1 %) 580nm, (50.2 %) 660nm. ***Chemical analytical data:*** Means of six sets of electron microprobe data: Co 0.01, Cu 0.04, Fe 26.70, Se 73.32, Total 100.07 wt. %. Empirical formula: $Fe_{1.02}Se_{1.98}$. ***Relationship to other species:*** The selenium analog of pyrite. ***Name:*** For the locality. ***Comments:*** IMA No. 93-054.

YASHUNSKY, Yu. V., RYABEVA, E. G., ABRAMOV, M. V., and RASULOVA, S. D. (1995) Dzharkenite $FeSe_2$—the new mineral. *Zapiski Vsesoyuznyi Mineralogicheskoe Obshchestva* **124(1)**, 85–90.

Effenbergerite — Tetragonal

$BaCuSi_4O_{10}$

Locality: Central-eastern orebody of the Wessels mine, Kalahari Manganese Field, Northwestern Cape Province, Republic of South Africa.

Occurrence: In a matrix consisting primarily of braunite, sugilite and hausmannite, cut by pectolite veinlets (0.1–1 mm wide) in which the mineral occurs. Other associated minerals are: native copper, calcite, quartz, clinozoisite and two unidentified species.

General appearance: Subhedral plates up to 8 x 8 x 0.1 mm.

Physical properties: *Luster:* vitreous on cleavage plates, resinous on crystal faces and subvitreous on fracture surfaces. *Diaphaneity:* presumably transparent. *Color:* blue, similar to that of linarite. *Streak:* pale blue. *Luminescence:* non-fluorescent. *Hardness:* 4–5. *Tenacity:* brittle. *Cleavage:* {001} perfect and {110} very poor. *Fracture:* subconchoidal. *Density:* 3.57 g/cm^3 (meas.), 3.52 g/cm^3 (calc.). ***Crystallography:*** Tetragonal, P4/ncc, a 7.442, *c* 16.133 Å, V 893.50 Å^3, Z 4, c:a = 2.168. Morphology: forms: {100}, {110}, {102}, {001}. Twinning: none observed. ***X-ray powder diffraction data:*** 8.0624 (100), 4.0325 (39), 3.5443 (29), 3.1998 (44), 2.6892 (21), 2.3943 (41), 2.0169 (34), 1.9466 (22), 1.4802 (21). ***Optical data:*** Uniaxial (-), ω 1.633, ε 1.593, pleochroism strong: O intense blue, E pale blue to colorless. ***Chemical analytical data:*** Means of 27 sets of electron microprobe data: BaO 32.48, CuO 16.52, SiO_2 50.76, Al_2O_3 0.5, Total 100.26 wt. %. Empirical formula: $Ba_{1.00}Cu_{0.98}(Si_{3.98}Al_{0.05})_{\Sigma 4.03}O_{10.00}$. ***Relationship to other species:*** Isostructural with cuprorivaite ($CaCuSi_4O_{10}$), gillespite ($BaFeSi_4O_{10}$) and some synthetic compounds. ***Name:*** For Dr. Herta S. Effenberger, mineralogist and crystallographer of the University of Vienna. ***Comments:*** IMA No. 93-036.

GIESTER, G., and RIECK, B. (1994) Effenbergerite, $BaCu[Si_4O_{10}]$, a new mineral from the Kalahari Manganese Field, South Africa: description and crystal structure. *Mineralogical Magazine* **58**, 663–670.

Frankhawthorneite — Monoclinic

$Cu_2Te^{6+}O_4(OH)_2$

Locality: The Centennial Eureka mine, Juab County, Utah, U.S.A.

Occurrence: Isolated crystals or groups on drusy quartz. About 2 mg of the mineral is known to exist. Other associated minerals: mcalpineite, pyrite, hematite, acanthite, chrysocolla, connellite, enargite, hinsdalite, svanbergite and an undefined Cu-Zn-Te-mineral. The following Cu-Te secondary minerals also occur at the locality: cesbronite, xocomecatlite, quetzalcoatlite, dugganite, and five minerals under study.

General appearance: Prismatic to stubby bladed crystals up to 0.1 mm elongated on [001], with a length-to-width ratio of about 3:1.

Physical properties: *Luster:* given as vitreous, but the high index of refraction indicates that it should be adamantine. *Diaphaneity:* transparent. *Color:* medium leaf-green. *Streak:* less intense than the color. *Luminescence:* non-fluorescent. *Hardness:* estimated to be 3 to 4. *Tenacity:* brittle. *Cleavage:* not mentioned. *Fracture:* uneven. *Density:* could not be measured, 5.44 g/cm^3 (calc.). ***Crystallography:*** Monoclinic, $P2_1/n$, a 9.095, b 5.206, c 4.604 Å, β 98.69°, V 215.5 Å^3, Z 2, a:b:c = 1.7470:1:0.8844. Morphology: forms: {010}, {100}, {011}. Twinning: not observed. ***X-ray powder diffraction data:*** 4.506 (40), 4.337 (60), 3.838 (50), 2.891 (70), 2.598 (100), 1.834 (40), 1.713 (40), 1.500 (40). ***Optical data:*** In reflected light: pale grey, weakly anisotropic with somber brown rotation tints, weakly bireflectant but not pleochroic. The index of refraction calculated from the reflectance values at 590 nm is 2.00. ***Chemical analytical data:*** Means of five sets of electron microprobe data: CuO 45.20, TeO_3 48.77, H_2O (5.05) calculated, Total (99.02) wt. %. Empirical formula: $Cu_{2.03}Te^{6+}_{0.99}O_{4.00}(OH)_{2.00}$. ***Relationship to other species:*** none apparent. ***Name:*** For Prof. Frank C. Hawthorne, University of Manitoba. ***Comments:*** IMA No. 93-047. Note that the mineral is a tellurate.

ROBERTS, A. C., GRICE, J. D., CRIDDLE, A. J., JENSEN, M. C., HARRIS, D. C., and MOFFATT, E. A. (1995) Frankhawthorneite, $Cu_2Te^{6+}O_4(OH)_2$, a new mineral species from the Centennial Eureka mine, Tintic district, Juab County, Utah. *Canadian Mineralogist* **33**, 641–647 and GRICE, J. D., and ROBERTS, A. C. (1995) Frankhawthorneite, a unique HCP framework structure of a cupric tellurate. *Canadian Mineralogist* **33**, 649–653.

Gaotaiite — Cubic

Ir_3Te_8

Locality: Near the village of Gaotai, about 200 km NNE of Beijing, People's Republic of China.

Occurrence: A constituent of placer deposits and crushed ores of a chromite deposit. Associated minerals: iridium, osmium, ferrian platinum, erlichmanite, iridisite, laurite, chromite, magnetite, gold and shuangfengite.

General appearance: As veinlets 0.05–0.02 mm wide by 0.3–1.0 mm long and as equant granular aggregates with individual grains 0.05–0.2 mm in diameter.

Physical properties: *Luster:* metallic. *Diaphaneity:* opaque. *Color:* steel-black. *Streak:* black. *Hardness:* 3, VHN_{20} 117 kg/mm^2. *Tenacity:* brittle. *Cleavage:* none. *Fracture:* not observed. *Density:* could not be measured, 9.97 g/cm^3 (calc.). ***Crystallography:*** Cubic, Pa3, a 6.413 Å, V 263.7 Å^3, Z 1. Twinning: none. ***X-ray powder diffraction data:*** 2.86 (70), 2.60 (60), 1.93 (100), 1.713 (60), 1.235 (80), 1.190 (60), 1.132 (90), 1.040 (80), 0.9780 (80). ***Optical data:*** In reflected light: bright white with bluish tint; no anisotropism, but sometimes weak with bluish or yellowish tint; bireflectance not observed; pleochroism, not observed. R: (46.6 %) 470nm, (46.3 %) 546nm, (46.3 %) 589nm, (45.6 %) 650nm. ***Chemical analytical data:*** Means of nine sets of electron microprobe data: Cu 0.2, Ir 35.6, Pt 0.1, Te 62.8, S 0.2, Total 98.9 wt. %. Empirical formula: $(Ir_{2.96}Cu_{0.05}Pt_{0.01})_{\Sigma 3.02}(Te_{7.88}S_{0.10})_{\Sigma 7.98}$. ***Name:*** For the locality. ***Comments:*** IMA No. 93-017. The calculated density is given as 10.00 g/cm^3, but the value calculated from the unit cell and empirical formula is 9.97 g/cm^3.

YU ZUXIANG (1995) Gaotaiite—a new iridium telluride. *Acta Mineralogica Sinica* **15(1)**, 1–4.

Mayingite — Cubic

IrBiTe

Locality: Near the village of Maying, about 230 km NNE of Beijing, People's Republic of China.

Occurrence: A constituent of placer concentrates and crushed ores of a chromite deposit. Associated minerals: osmium, ferrian platinum, iridisite, laurite, chromite, magnetite, gold, irarsite and shuangfengite.

General appearance: Massive aggregates 0.02–0.2 mm in diameter and as veinlets 0.1–0.2 mm wide by 1.0 mm long.

Physical properties: *Luster:* metallic. *Diaphaneity:* opaque. *Color:* steel-black. *Streak:* black. *Hardness:* 4, VHN_{50} 178 kg/mm^2. *Tenacity:* brittle. *Cleavage:* none. *Fracture:* none observed. *Density:* could not be measured, 12.72 g/cm^3 (calc.). **Crystallography:** Cubic, Pa3, a 6.502 Å, V 274.9 Å^3, Z 4. **X-ray powder diffraction data:** 2.89 (70), 1.955 (100), 1.735 (80), 1.250 (80), 1.207 (70), 1.148 (70), 1.054 (70), 0.9911 (70). **Optical data:** In reflected light: bright white with yellowish tint; no anisotropism, but some grains moderate with bluish or yellowish tint; no bireflectance or pleochroism. R: (49.5 %) 470nm, (50.8 %) 546nm, (51.6 %) 589nm, (52.2 %) 650nm. **Chemical analytical data:** Means of seven sets of electron microprobe data: Cu 0.1, Te 24.6, Ir 34.6, Pt 1.9, Bi 38.5, Total 99.7 wt. %. Empirical formula: $(Ir_{0.95}Pt_{0.05})_{\Sigma 1.00}Bi_{0.97}Cu_{0.01}Te_{1.02}$. **Name:** For the locality. **Comments:** IMA No. 93-016. The empirical formula and calculated density given in the description are slightly different from those given here.

YU ZUXIANG (1995) Mayingite—a new iridium bismuthide-telluride. *Acta Mineralogica Sinica* **15(1)**, 5–8.

Mcalpineite — Cubic

$Cu_3^{2+}Te^{6+}O_6 \cdot H_2O$

Locality: McAlpine mine, Tuolumne County, California, U.S.A. (Lat. 37°45′58″ N, Long. 120°15′9″ W). Also from the Centennial Eureka mine, West Tintic district, Juab County, Utah, U.S.A. (Lat. 39°56′38″ N, Long. 112°7′18″ W). Most of the following data are for the McAlpine material. Data for the Utah mineral are also given in the paper.

Occurrence: On quartz associated with chromian muscovite. Metallic phases are: pyrite, acanthite, hessite, "electrum," altaite, silver, galena, pyrargyrite, sphalerite and owyheeite. Secondary nonmetallic minerals are: chlorargyrite, choloalite, keystoneite, mimetite, azurite, malachite, annabergite, calcite, goethite, hematite and numerous unidentified phases.

General appearance: Isolated 0.5-mm crusts on white quartz.

Physical properties: *Luster:* adamantine. *Diaphaneity:* transparent to translucent. *Color:* emerald-green. *Streak:* light green. *Luminescence:* non-fluorescent. *Hardness:* could not be determined. *Tenacity:* brittle. *Cleavage:* not observed. *Fracture:* uneven. *Density:* could not be measured, 6.63 g/cm^3 (calc.). **Crystallography:** Cubic, P space group unknown, a 9.555 Å, V 872.4 Å^3, Z 8. Morphology: no forms observed. **X-ray powder diffraction data:** 4.26 (40), 2.763 (100), 2.384 (70), 1.873 (40), 1.689 (80), 1.440 (60). **Optical data:** Isotropic, n 2.01 (from reflectance measurements). In reflected light, R values: (12.8 %) 470nm, (11.6 %) 546nm, (11.2 %) 589nm, (11.0 %) 650nm. **Chemical analytical data:** Means of four sets of electron microprobe data: CuO 50.84, NiO 0.17, PbO 4.68, SiO_2 0.65, TeO_3 39.05, H_2O (4.61), Total (100.00) wt. %. H_2O could not be determined but was confirmed by IR absorption spectroscopy; the value given is by difference from 100. Empirical formula: $(Cu_{2.78}Pb_{0.09}Ni_{0.01})_{\Sigma 2.88}(Te^{6+}_{0.97}Si_{0.05})_{\Sigma 1.02}O_{5.88} \cdot 1.12H_2O$. **Relationship to other species:** It is unrelated to any of the other six copper tellurite or tellurate minerals (balyakinite, cesbronite, graemite, rajite, teineite and xocomecatlite). **Name:** For the mine at the type locality. **Comments:** IMA No. 92-025. The calculated value for H_2O is given as 4.51 wt. % in the description, but this is a typographical error for 4.61; it has been corrected here. The calculated density is given as 6.65 g/cm^3 in the paper, but the empirical formula and unit cell give 6.63 g/cm^3.

ROBERTS, A. C., ERCIT, T. S., CRIDDLE, A. J., JONES, G. C., WILLIAMS, R. S., CURETON, F. F., and JENSEN, M. C. (1994) Mcalpineite, $Cu_3TeO_6 \cdot H_2O$, a new mineral from the McAlpine mine, Tuolumne County, California, and from the Centennial Eureka mine, Juab County, Utah. *Mineralogical Magazine* **58**, 417–424.

Mccrillisite — Tetragonal

$NaCs(Be,Li)Zr_2(PO_4)_4 \cdot 1\text{–}2H_2O$

Locality: Mount Mica granite pegmatite, South Paris, Oxford County, Maine, U.S.A.

Occurrence: Found in a large (1 x 1.2 x 1.6 m) piece of rock mined in 1977–1978, which was covered and then re-exposed in 1988. It occurs in open cavities up to several centimeters across and formed as a result of late-stage hydrothermal alteration of earlier-formed Zr-bearing minerals. Associated minerals: albite, quartz, manganoan almandine, muscovite, siderite, fluorapatite, elbaite, lepidolite, beryl, montebrasite, rhodochrosite, cassiterite, manganocolumbite, uraninite, löllingite, zircon, eosphorite, moraesite, ferroan roscherite and kosnarite.

General appearance: Bipyramidal crystals up to 1.2 mm in maximum dimension.

Physical properties: *Luster:* vitreous. *Diaphaneity:* transparent to translucent. *Color:* colorless. *Streak:* white. *Luminescence:* non-fluorescent. *Hardness:* 4 to 4½. *Tenacity:* not given. *Cleavage:* none observed. *Fracture:* conchoidal. *Density:* 3.125 g/cm^3 (meas.), 3.30 g/cm^3 (calc.). **Crystallography:** Tetragonal, $I4_1/amd$, a 6.573, c 17.28 Å, V 746.6 Å^3, Z 2, c:a 2.6289. Morphology: forms: {111}, {001}. Twinning: not mentioned. **X-ray powder diffraction data:** 6.159 (90), 4.326 (80), 4.099 (40), 3.281 (80), 3.060 (100), 2.896 (30), 1.849 (30). **Optical data:** Uniaxial (+), ω 1.634, ε 1.645. Some grains anomalously biaxial with 2V up to 5°. **Chemical analytical data:** Means of five sets of data from electron microprobe, laser-ablation and inductively coupled plasma-mass spectroscopy data: Li_2O 0.6, Na_2O 4.2, K_2O 0.3, Rb_2O < 0.1, Cs_2O 15.3, BeO 2.9, MgO 0.1, CaO < 0.1, MnO < 0.1, FeO < 0.1, ZnO 0.5, SrO 0.2, Al_2O_3 < 0.1, SiO_2 0.1, ZrO_2 31.6, HfO_2 2.5, P_2O_5 38.3, H_2O 3.0, F 0.5, sum 100.1, less O = F 0.21, Total 99.89 wt. %. The empirical formula is: $Na_{1.00}(Cs_{0.80}Li_{0.18}K_{0.05})_{\Sigma 1.03}(Be_{0.86}Li_{0.12}Mg_{0.02})_{\Sigma 1.00}(Zr_{1.90}Hf_{0.09}Zn_{0.05})_{\Sigma 2.04}(P_{4.00}Si_{0.01})_{\Sigma 4.01}(O_{15.8}F_{0.2})_{\Sigma 16.0} \cdot 1.23H_2O$. **Relationship to other species:** It is the cesium-analog of gainesite, $Na(Na)(Be,Li)Zr_2(PO_4)_4 \cdot 1\text{–}2H_2O$. **Name:** In honor of the McCrillis family, particularly the late Dean McCrillis and his son, Philip McCrillis, of Oxford County, Maine, for their more than 90 years spent working the granitic pegmatites of Maine. **Comments:** IMA No. 91-023. The empirical formula and density calculated by the abstracter are very slightly different from those given by the authors.

FOORD, E. E., BROWNFIELD, M. E., LICHTE, F. E., DAVIS, A. M., and SUTLEY, S. J. (1994) Mccrillisite, $NaCs(Be,Li)Zr_2(PO_4)_4 \cdot 1\text{–}2H_2O$, a new mineral species from Mount Mica, Oxford County, Maine, and new data for gainesite. *Canadian Mineralogist* **32**, 839–842.

Nierite — Hexagonal (Trigonal)

Si_3N_4

Locality: In perchloric acid-resistant residues of three ordinary chondrite meteorites (Adrar 003 [LL3.2], Inman [L3.4] and Tieschitz [H3.6]) and one enstatite chondrite meteorite (Indarch [EH4]).

Occurrence: The grains in Indarch probably formed by exsolution of Si and N from kamacite, perryite and schreibersite during parent-body metamorphism. The origin of the mineral in the other meteorites is not known, but formation during exsolution is possible. Other minerals in the residues are: spinel, chromite, hibonite, rutile, a Na-Cr silicate, diamond, silicon carbide and β-Si_3N_4, the hexagonal ($P6_3/m$) polymorph of nierite (α-Si_3N_4).

General appearance: Very small (~ 2 x 0.4 mm) lath-shaped grains.

Physical properties: *Luster:* probably adamantine. *Diaphaneity:* transparent. *Color:* colorless. *Streak:* probably white. *Luminescence:* unknown. *Hardness:* 9. *Tenacity:* probably brittle. *Cleavage:* unknown. *Fracture:* unknown. *Density:* 3.17–3.18 g/cm^3 (meas.), 3.11 g/cm^3 (calc.). **Crystallography:** Hexagonal (trigonal), P31c, a 7.74, c 5.61 Å, V 291.1 Å^3, Z 4, c:a 0.7248. Twinning: unknown. **Selected area electron diffraction (SAED) data:** 6.59, 2.90, 2.64, 2.17, 1.76, 1.45, 1.41. **Optical data:** Uniaxial (-), ω 2.03, ε 2.02. **Chemical analytical data:** Because of the small grains, ordinary electron microprobe analysis was not possible. The data given here were determined with an analytical STEM (scanning transmission electron microscope). Means of eight sets of data: N 43, Si 57, Total 100 wt. %. Empirical formula:

$Si_{2.79}N_{4.21}$. ***Name:*** For A. O. Nier (1912–1994), who was responsible for the now accepted measurement of the atmospheric N-isotopic composition. He was one of the founding fathers of mass spectrometry. ***Comments:*** IMA No. 94-032. Because of the very small size of the grains, many properties could not be determined. Many of the properties listed here are for the synthetic material.

LEE, M. R., RUSSELL, S. S., ARDEN, J. W., and PELLINGER, C. T. (1995) Nierite (Si_3N_4), a new mineral from ordinary and enstatite chondrites. *Meteoritics* **30**, 387–398.

Owensite — Cubic

$(Ba,Pb)_6(Cu,Fe,Ni)_{25}S_{27}$

Locality: The Wellgreen Cu-Ni-Pt-Pd deposit, Kluane District, Yukon Territory, Canada.

Occurrence: In pyrrhotite which occurs in peridotite and chilled gabbro-pegmatite gabbro. Other associated minerals: magnetite. chalcopyrite, pentlandite, pyrite, cobaltite-gersdorffite series, arsenopyrite, ullmannite, violarite, chromite, ilmenite, sphalerite, covellite, argentopentlandite, breithauptite, marcasite, nickeline, galena, rutile, barite, hessite, Au-Ag alloys, sperrylite, moncheite, sudburyite, testibiopalladite, kotulskite, mertieite-II, stibiopalladinite, geversite, melonite and four undefined minerals.

General appearance: Small anhedral grains 6 x 12 µm up to a maximum of 43 x 110 mm.

Physical properties: *Luster:* metallic. *Diaphaneity:* opaque. *Color:* observed only in polished section, so the megascopic color is unknown. *Streak:* black. *Hardness:* 3½, VHN_{10} 137 kg/mm^2. *Tenacity:* unknown. *Cleavage:* unknown. *Fracture:* unknown. *Density:* could not be measured, 4.78 g/cm^3 (calc.). ***Crystallography:*** Cubic, Pm3m, a 10.349 Å, V 1108.4 Å^3, Z 1. ***X-ray powder diffraction data:*** 3.460 (40), 3.281 (40), 2.996 (90), 2.378 (90), 1.835 (100), 1.779 (40). ***Optical data:*** In reflected light: pale brownish grey; anisotropism, bireflectance and pleochroism not discernible. R: (22.0 %) 470nm, (24.9 %) 546nm, (26.2 %) 589nm, (27.55 %) 650nm. ***Chemical analytical data:*** Means of nine sets of electron microprobe data: Ba 23.04, Cu 25.33, Pb 3.58, Fe 20.24, Ni 0.25, S 27.11, Total 99.55 wt. %. Empirical formula: $(Ba_{5.42}Pb_{0.56})_{\Sigma 5.98}(Cu_{12.87}Fe_{11.70}Ni_{0.14})_{\Sigma 24.71}S_{27.31}$. ***Relationship to other species:*** Closely related to djerfisherite. ***Name:*** For DeAlton R. Owens (1934–), Canada Centre for Mineral and Energy Technology. ***Comments:*** IMA No. 93-061. This is the first barium sulfide mineral.

LAFLAMME, J. H. G., ROBERTS, A. C., CRIDDLE, A. J., and CABRI, L. J. (1995) Owensite, $(Ba,Pb)_6(Cu,Fe,Ni)_{25}S_{27}$, a new mineral species from the Wellgreen Cu-Ni-Pt-Pd deposit, Yukon. *Canadian Mineralogist* **33**, 665–670 and SZYMAŃSKI, J. T. (1995) The crystal structure of owensite, $(Ba,Pb)_6(Cu,Fe,Ni)_{25}S_{27}$, a new member of the djerfisherite group. *Canadian Mineralogist* **33**, 671–677.

Peterbaylissite — Orthorhombic

$Hg_3^{1+}(CO_3)(OH)\cdot 2H_2O$

Locality: A small prospect pit near the long-abandoned Clear Creek mercury mines, New Idria district, San Benito County, California, U.S.A. (Lat. 36°22′59″ N, Long. 120°43′58″ W).

Occurrence: On altered serpentinite consisting of quartz, chalcedony, opal, magnesite, goethite, ferroan magnesiochromite, chlorite and dolomite. Associated mercury-bearing minerals are: cinnabar, metacinnabar and native mercury.

General appearance: As isolated or clustered subhedral to euhedral crystals (20 mm to 0.2 mm; average size about 0.1 mm long).

Physical properties: *Luster:* submetallic to adamantine. *Diaphaneity:* opaque. *Color:* black to very dark red-brown. *Streak:* dark brown-black. *Luminescence:* non-fluorescent. *Hardness:* less than 5. *Tenacity:* brittle. *Cleavage:* none observed. *Fracture:* irregular. *Density:* could not be measured, 7.14 g/cm^3 (calc.). ***Crystallography:*** Orthorhombic, Pcab (pseudotetragonal), a 11.130, b 11.139, c 10.725 Å, V 1330 Å^3, Z 8, a:b:c = 0.9992:1:0.9628. Morphology: no obvious forms were observed. Twinning: none observed. ***X-ray powder diffraction data:*** 4.84 (50), 2.969 (70), 2.786 (70), 2.648 (100), 2.419 (60), 1.580 (50). ***Optical data:*** Average n 2.10. In reflected light: grey with s slight blue tinge; anisotropism, weak in dull and dark grey and brown rotation tints; bireflectance, weak to moderate; nonpleochroic. R_{min} & R_{max}: (11.4, 12.15 %) 470nm, (10.95, 11.6 %) 546nm, (10.9, 11.5 %) 589nm, (10.7, 11.2 %) 650nm. ***Chemical analytical data:*** Means of two sets of electron microprobe data: Hg_2O 87.4 wt. %. CO_2 and H_2O could not be determined due to a dearth of material, but crystal structure determination confirmed the ideal formula, $Hg_3^{1+}(CO_3)$-$(OH)\cdot 2H_2O$, which requires Hg_2O 87.54, CO_2 6.16, H_2O 6.30, Total 100.00 wt. %. ***Relationship to other species:*** none apparent. ***Name:*** For Dr. Peter Bayliss, Prof. Emeritus of Mineralogy, Department of Geology and Geophysics, University of Calgary, Calgary, Alberta, Canada. ***Comments:*** IMA No. 93-041.

ROBERTS, A. C., ERCIT, T. S., GROAT, L. A., CRIDDLE, A. J., ERD, R. C., and WILLIAMS, R. S. (1995) Peterbaylissite, $Hg_3^{1+}(CO_3)(OH)\cdot 2H_2O$, a new mineral species from the Clear Creek claim, San Benito County, California. *Canadian Mineralogist* **33**, 47–53.

Pingguite — Orthorhombic

$Bi_6^{3+}Te_2^{4+}O_{13}$

Locality: At Yangjiava, Pinggu County, near Beijing, People's Republic of China.

Occurrence: In the oxidation zone of a small gold deposit. Associated minerals are: "limonite," malachite, pyromorphite, bismutite, gold, "electrum," quartz, calcite and scheelite.

General appearance: Rounded granular aggregates (0.005–0.5 mm in diameter) of crystals (grain size 0.3–0.6 µm).

Physical properties: *Luster:* vitreous to adamantine. *Diaphaneity:* transparent. *Color:* yellowish-green. *Streak:* light yellow green. *Luminescence:* non-fluorescent. *Hardness:* VHN_{50} = 510 kg/mm^2, Mohs 5–6. *Tenacity:* brittle. *Cleavage:* not observed. *Fracture:* not observed. *Density:* 8.44 g/cm^3 (meas.), 8.64 g/cm^3 (calc.). ***Crystallography:*** Orthorhombic, space group unknown, a 5.689, b 10.791, c 5.308 Å, V 325.8 Å^3, Z 1, a:b:c = 0.5272:1:0.4919. Morphology: crystals are columnar in outline. Twinning: not observed. ***X-ray powder diffraction data:*** 3.146 (100), 2.841 (80), 2.694 (20), 2.651 (9), 1.956 (10), 1.891 (8), 1.695 (20), 1.631 (10), 1.575 (8). ***Optical data:*** Biaxial, n > 2. R: (14.84 %) 470nm, (13.03 %) 546nm, (13.25 %) 589nm, (13.64 %) 650nm. ***Chemical analytical data:*** Means of 15 sets of electron microprobe data: Bi_2O_3 79.56, TeO_2 20.17, Total 99.73 wt. %. Empirical formula: $Bi_{5.80}Te_{2.15}O_{13.00}$. ***Relationship to other species:*** It is a bismuth tellurite. ***Name:*** For the locality. ***Comments:*** IMA No. 93-019. Some of the data given in this abstract were taken from the original IMA proposal.

SUN ZHIFU, LUO KEDING, TAN FALAN, and ZHANG JINGYI (1994) Pingguite—a new bismuth tellurite mineral. *Acta Mineralogica Sinica* **14(4)**, 315–321.

Schwertmannite — Tetragonal

$Fe_{16}O_{16}(OH)_{12}(SO_4)_2$

Locality: Pyhäsalmi sulphide mine, Province of Oulu, Finland (Lat. 63°39.6′ N, Long. 26°2′ E). It has been identified from over 40 different localities in Europe, North America and Australia.

Occurrence: As a secondary precipitate forming crusts on material inundated by acidic (pH 3.2) drainage water. Other minerals at the type locality are pyrite, sphalerite, chalcopyrite, pyrrhotite, galena and arsenopyrite. Associated minerals at other localities may include jarosite, natrojarosite, goethite and ferrihydrite.

General appearance: Very fine-grained, ochreous crusts.

Physical properties: *Luster:* earthy. *Diaphaneity:* opaque. *Color:* brownish yellow. *Streak:* not given, but probably close to the color. *Luminescence:* non-fluorescent. *Hardness:* could not be determined. *Tenacity:* not given. *Cleavage:* not given. *Fracture:* not given. *Density:* could not be measured; 3.77 to 3.99 g/cm^3 (calc.). **Crystallography:** Tetragonal, probably P4/m, a 10.66, c 6.04 Å, V 686 Å^3, Z 1. c:a = 0.5660. Morphology: aggregates of very fine needles; forms could not be identified. **X-ray powder diffraction data:** 4.86 (37), 3.39 (46), 2.55 (100), 2.28 (23), 1.66 (21), 1.51 (24). **Optical data:** could not be determined. **Chemical analytical data:** Wet chemical analysis gave: Fe_2O_3 62.6, SO_3 12.7, CO_2 1.5, H_2O^- 10.2, H_2O^+ 12.9, Total 99.9 wt. %. The most general simplified formula is given as: $Fe_{16}O_{16}(OH)_y(SO_4)_z \cdot nH_2O$, where 16 - y = 2z and z varies between 2.0 and 3.5; the value of *n* is not given. **Relationship to other species:** probably related to akaganéite and hollandite. **Name:** In honor of Udo Schwertmann (1927–), Professor of soil science at the University of Munich. **Comments:** IMA No. 90-006.

BIGHAM, J. M., CARLSON, L., and MURAD, E. (1994) Schwertmannite, a new iron oxyhydroxysulphate from Pyhäsalmi, Finland, and other localities. *Mineralogical Magazine* **58**, 641–648.

Selwynite — Tetragonal

$NaK(Be,Al)Zr_2(PO_4)_4 \cdot 2H_2O$

Locality: A granite quarry near Wycheproof, northwestern Victoria, Australia (Lat. 36°05′ S, Long. 143°14′ E).

Occurrence: In pegmatite cavities. The pegmatite consists mainly of quartz, orthoclase, albite, muscovite and schorl. Associated minerals in the cavities are: wardite, eosphorite, cyrilovite, a kidwellite-like mineral, rockbridgeite, leucophosphite, saleeite and montmorillonite. Other zirconium-bearing species at the locality are: kosnarite and wycheproofite, $NaAlZr(PO_4)_2(OH)_2?H_2O$.

General appearance: Irregular fillings of cavities. These consist of intergrowths of indistinct radiating crystals.

Physical properties: *Luster:* vitreous. *Diaphaneity:* transparent. *Color:* deep purplish blue. *Streak:* pale lavender. *Luminescence:* non-fluorescent. *Hardness:* 4. *Tenacity:* not given. *Cleavage:* none observed. *Fracture:* semiconchoidal. *Density:* 2.94 g/cm^3 (meas.), 3.08 g/cm^3 (calc.). **Crystallography:** Tetragonal, $I4_1$/amd. a 6.570, c 17.142 Å, V 739.9 Å^3, Z 2, c:a = 2.6091. Morphology: no forms observed. Twinning: not mentioned. **X-ray powder diffraction data:** 6.161 (100), 4.291 (25), 3.286 (50), 3.039 (30), 2.895 (20), 2.609 (5), 2.431 (5), 2.169 (5), 1.847 (5), 1.828 (5). **Optical data:** Uniaxial (+), ω 1.624, ε 1.636. Pleochroism distinct: O medium bluish lavender, E very pale bluish lavender. **Chemical analytical data:** Means of 9 sets of electron microprobe data (H_2O by CHN analyzer, Rb and Be by ICP): Na_2O 4.77, K_2O 6.26, Rb_2O 0.20, Cs_2O 0.70, BeO 1.43, MgO 0.15, CaO 0.98, MnO 0.99, FeO 0.49, SrO 0.16, BaO 0.16, Al_2O_3 1.04, Ce_2O_3 0.03, SiO_2 0.49, P_2O_5 40.90, ZrO_2 33.76, HfO_2 1.17, H_2O 5.4, F 0.37, sum 99.45, less O = F 0.16, Total 99.29 wt. %. Empirical formula: $Na_{1.00}(K_{0.92}Na_{0.06}Cs_{0.03}Rb_{0.02})_{\Sigma1.03}$-$(Be_{0.40}Al_{0.14}Ca_{0.12}Mn_{0.10}Fe_{0.05}Mg_{0.03}Sr_{0.01}Ba_{0.01})_{\Sigma0.86}(Zr_{1.89}Hf_{0.04})_{\Sigma1.93}(P_{3.98}Si_{0.06})_{\Sigma4.04}$-$O_{15.80}F_{0.13} \cdot 2.07H_2O$. **Relationship to other species:** It is the potassium analog of gainesite, $NaNa(Be,Li)Zr_2(PO_4)_4 \cdot 1\text{–}2H_2O$ and mccrillisite, $NaCs(Be,Li)Zr_2(PO_4)_4 \cdot 1\text{–}2H_2O$. **Name:** For A. R. C. Selwyn (1824–1902), founding director of the Geological Survey of Victoria, Australia. **Comments:** IMA No. 93-037.

BIRCH, W. D., PRING, A., and FOORD, E. E. (1995) Selwynite, $NaK(Be,Al)Zr_2(PO_4)_4 \cdot 2H_2O$, a new gainesite-like mineral from Wycheproof, Victoria, Australia. *Canadian Mineralogist* **33**, 55–58.

Shuangfengite — Hexagonal (trigonal)

$IrTe_2$

Locality: Near the village of Shuangfeng about 190 km NNE of Beijing, People's Republic of China.

Occurrence: Placer concentrates and crushed ores of a chromite deposit. Associated minerals are: iridium, osmium, ferrian platinum, erlichmanite, iridisite, chromite, magnetite, ilmenite, gold, irarsite and gaotaiite.

General appearance: As massive aggregates 0.5–0.2 mm in diameter and as veinlets 0.05–0.10 mm wide and 0.5–1.0 mm long.

Physical properties: *Luster:* metallic. *Diaphaneity:* opaque. *Color:* black. *Streak:* black. *Hardness:* VHN_{20} 108, Mohs 3. *Tenacity:* brittle. *Cleavage:* {001} perfect. *Fracture:* none observed. *Density:* could not be measured, 10.14 g/cm^3 (calc.). **Crystallography:** Hexagonal (trigonal), P3m1, a 3.933, c 5.390 Å, V 72.2 Å^3, Z 1, c:a = 1.3705. Morphology: no forms observed. Twinning: none observed. **X-ray powder diffraction data:** 2.85 (100), 2.10 (80), 1.95 (60), 1.580 (70), 1.435 (50), 1.250 (50), 1.160 (60), 1.0276 (50). **Optical data:** In reflected light: bright yellowish white with bluish tint; anisotropism, moderate with bluish or yellowish tint; bireflectance and pleochroism not observed. $R_{E'}$ & R_O: (45.5, 41.8 %) 470nm, (45.4, 41.8 %) 550nm, (45.5, 42.2 %) 590nm, (46.0, 42.9 %) 650nm. **Chemical analytical data:** Means of 9 sets of electron microprobe data: Ir 40.3, Pt 1.2, Os 0.1, Rh 0.0, Cu 0.2, Pb 0.0, Ni 0.0, Fe 0.0, Sb 0.0, As 0.0, Bi 0.4, Te 56.7, S 0.3, Total 99.2 wt. %. Empirical formula: $(Ir_{0.93}Pt_{0.03}Cu_{0.01}Bi_{0.01})_{\Sigma0.98}(Te_{1.97}S_{0.04})_{2.01}$. **Relationship to other species:** It is isostructural with synthetic $PtTe_2$. **Name:** For the locality. **Comments:** IMA No. 93-018. Some of the data given in this abstract were taken from the original IMA proposal.

YU ZUXIANG (1994) Shuangfengite—a new iridium bitelluride. *Acta Mineralogica Sinica* **14(4)**, 322–326.

Vanadomalayaite — Monoclinic

$CaVOSiO_4$

Locality: Gambatesa mine, near Reppia, Val Graveglia, northern Apennines, Italy.

Occurrence: Associated with calcite, quartz and haradaite in a small vein cutting ophiolitic metacherts.

General appearance: As subhedral, isolated crystals up to 0.4 mm.

Physical properties: *Luster:* adamantine. *Diaphaneity:* transparent. *Color:* deep red. *Streak:* red. *Luminescence:* non-fluorescent. *Hardness:* not given. *Tenacity:* not given, but probably brittle. *Cleavage:* {110}, good. *Fracture:* not given. *Density:* 3.60g/cm^3 (meas.), 3.61 g/cm^3 (calc.). **Crystallography:** Monoclinic, C2/c, a 6.526, b 8.691, c 7.032 Å, β 113.88°, V 364.7 Å^3, Z 4, a:b:c = 0.7509:1:0.8091. No forms were reported. No twinning was observed. **X-ray powder diffraction data:** 4.90 (W), 3.22 (VS), 2.97 (M), 2.59 (S), 2.271 (W), 2.057 (W), 1.702 (W), 1.641 (W), 1.557 (W), 1.493 (W), 1.415 (W). **Optical data:** Biaxial (sign not given), α about 1.95, β unknown, γ 2.105, 2V unknown, dispersion strong. pleochroic: X ≈ Y = brownish red-orange, Z = deep greenish-blue. **Chemical analytical data:** Means of twenty-five sets of electron microprobe data: CaO 28.33, MnO 0.07, Al_2O_3 0.27, Fe_2O_3 0.46, SiO_2 30.47, TiO_2 10.51, VO_2 29.86, Total 99.97 wt. %. Empirical formula: $Ca_{1.00}(V_{0.72}Ti_{0.26}Al_{0.01}Fe_{0.01})_{\Sigma1.00}OSi_{1.01}O_{4.00}$. **Relationship to other species:** the vanadium analogue of malayaite and titanite. **Name:** To show the chemical relationship to malayaite. **Comments:** IMA No. 93-032.

BASSO, R., LUCCHETTI, G., ZEFIRO, L., and PALENZONA, A. (1994) Vanadomalayaite, $CaVOSiO_4$, a new mineral vanadium analog of titanite and malayaite. *Neues Jahrbuch für Mineralogie, Monatshefte* **1994**, 489–498.

The Lac Nicolet Antimony Mine, South Ham, Québec

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First discovered in 1863, the Lac Nicolet antimony deposit has been known as an important source of kermesite for well over a century. Recent collecting has resulted in the discovery of fine specimens of kermesite, valentinite and native antimony, in addition to the first Canadian occurrences of metastibnite and schafarzikite. Confusing locality descriptions for the occurrence underscore the value and need for complete and accurate locality documentation.

INTRODUCTION

The locality described herein has been variously referred to as "Ham Sud," "South Ham," "Québec Antimony mine" or "Lac Nicolet" antimony mine by different people at different times. The first of these is simply the French equivalent of the second, and refers to the township within which the locality is situated. The Québec Antimony mine derives its name from a small exploration company that evaluated the property in the early 1970's. Interestingly, the last of these names, which has less historical validity, but is derived from the mine's proximity to Lac Nicolet (and possibly also from the Lac Nicolet Asbestos Mines company which conducted exploration work there), has become the one in common use today.

Further confusion exists with respect to its precise location within South Ham township. Older references locate the mine in Range 1, lot 28, whereas more recent authors cite lot 56 as containing the mine. Both are correct, depending upon which map is used. The pre-1900 cadastral subdivisions in the township were apparently twice as large as the ones in present usage. In spite of a number of names and locality descriptors, there is only one principal occurrence, which is situated on the south side of a hill, approximately 500 meters south-southeast of the village of St-Martyrs-Canadiens, South Ham Township, Wolfe County, Québec, Canada. Its precise location is at 45°51′09″ N. latitude, 71°32′00″ W. longitude (Warwick topographic sheet 21 E/13, Dept. Energy Mines & Resources, Canada, 1971).

HISTORY

Discovered in 1863, the mine was first operated by Willis Russell, of Québec City (Willimot, 1883; Obalski, 1890). Mr. Russell worked the deposit from two shafts which were

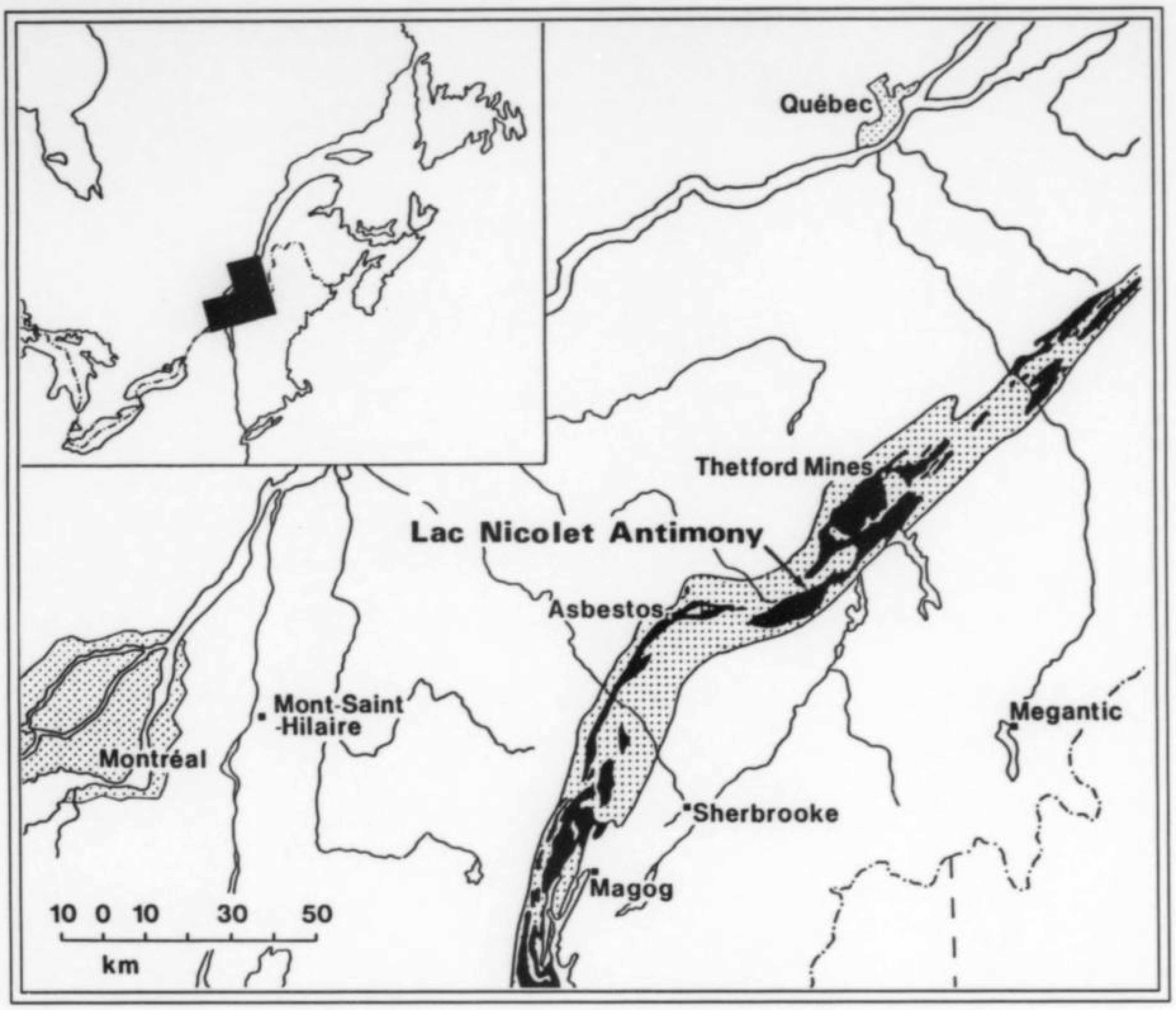


Figure 1. **Location map showing ultramafic complexes (black) and serpentine belt (modified after Grice and Williams, 1979).**

sunk directly on the vein and, by 1880, 79 tons of ore had been recovered. For the next five years the mine was operated by A. H. Elliott, who built a steam-powered stamp mill on the site to concentrate the ore. A contemporary account of the operation was given by Willimot (1883), who visited there in August 1882:

> Some preliminary work was being done by a small gang of men, who were employed removing detached pieces of rock from the bottom of the shaft, which had caved in through unskillful working, having caused the timbers to give way. It is the intention of the owner to sink 10 fathoms deeper. 15 yards off, a double shaft has been sunk to a depth of 100 feet. . . . Two or three levels have been driven short distances, but with what result I was unable to ascertain; judging from what had been excavated, none of the ore would average more than 5 percent, exclusive of some very rich pockets said to have been extracted. . . . The bedded material averages 5 percent, and has to be concentrated to 8 percent before it is marketable. This is accomplished by first passing the ore through a set of stamps; a stream of water then carries the crushed material on to a rubber belt about four feet wide, revolving at a slight inclination, by which the heavier particles are carried under, to the receiving trough, whilst the lighter portions pass off with the water. I have no doubt that a great deal of the oxide must be lost, and also portions of the native metal. On examining some of the slime numerous shining particles of antimony could be seen. A large commodious building has been erected, wherein is stationed an 18-horse power engine.

In 1886, the property was taken over by Dr. J. Reed, who drove a 94-meter drainage adit through the hillside to intersect the bottom of the 30-meter shaft. By the following year, a quantity of ore had been shipped to Portland and smelted at the Bartlett Smelting Works, with favorable results. However, the lack of a market, inefficient concentration, uncertain ore reserves and competition from antimony deposits in Nova Scotia and New Brunswick soon took their toll, effectively shutting down operations by 1889. Obalski (1890) described the occurrence:

> The different [antimony] species are noticeable in bluish quartz veins cropping out at the surface. The main vein . . . sometimes showing a thickness of two feet . . . has been traced for a distance of half a mile, and portions are visibly mineralized even on the surface in thicknesses of 3 to 4 inches. The thickness and richness of the vein varies as you descend, the quartz sometimes being permeated with the acicular crystals of the sulfides and the mineral at others being bunched or concentrated in rich pockets, some of which, struck in shafts 1 and 2 of the old workings, showed—it is said—as much as 2-1/2 feet in thickness.

Figure 2. **Northwest view of the mine and main collecting area as it appeared in May, 1991. Photo by C. Normand.**

The recent works appear to us to have established the fact that, at a depth of 100 feet, the quartz vein has a thickness of 6 feet. . . . The workings consist of two shafts of 60 and 100 feet respectively, located at a distance of 40 feet from each other and connected at the bottom by a drift, which has been prolonged for 70 feet along the vein. . . . It is said that from the old workings, 180 tons of the mineral were extracted and shipped. Since then no regular work has been done, apart from driving the adit just referred to, and only a few men have been employed to keep the mine in order.

Except for perhaps an occasional visit by mineral collectors, the mine appears to have lain idle for the next half century. In 1940, Reed Realties, Ltd. of Montréal, cleared the adit and did some exploratory work in the underground workings, but did not develop the mine. A decade later in 1951, Lac Nicolet Asbestos Mines, Ltd. conducted a small scale diamond drilling program, as did Sullico Mines, Ltd. in 1964, and Québec Antimony Mines, Ltd., who estimated a 75,000-ton ore reserve at 2.5% Sb in 1970–1972. Mr. Maxwell Juby of Montréal staked the property in 1985–1986 to sample for precious metals, but nothing of economic interest was found. In the summer of 1986, the Canadian Museum of Nature mapped the occurrence and collected specimens. Additional specimens were collected by both the museum and by Grenville Minerals the following summer, and numerous collectors have visited the locality since then. The most recent studies of the deposit were by Wight (1985), Gauthier *et al.* (1989), Robinson (1991), Normand *et al.* (1991, 1994) and Normand (1993).

Today, virtually all the old dumps, the adit and buildings have been obliterated by the development of gravel pits near the mine site. It is still possible to collect from the surface exposure of the vein a few meters east of the shafts and, although large, high-quality cabinet specimens are rarely found, fairly good smaller specimens and excellent micromounts of most of the minerals described here can still be obtained. The mining rights to the property are presently under claim by Mr. Bertrand Brassard of Coleraine, Québec, while the local municipality of St-Martyrs-Canadiens controls surface access. With prior permission, casual surface collecting by hobbyists is permitted, but commercial collecting and collecting from the underground workings is forbidden. In addition, the gravel pits that surround the principal occurrence are frequently used for target shooting, further necessitating the need for advance visitation arrangements.

GEOLOGY

The Lac Nicolet antimony mine is located in the Caldwell Group of metasedimentary and igneous rocks that form a portion of the Appalachian geological province. These rocks are upper Cambrian to lower Ordovician in age and have been regionally metamorphosed to greenschist facies (Riordon, 1954; St-Julien, 1972; Harron, 1976). The metasedimentary rocks consist chiefly of slates, phyllites and quartzites, and the

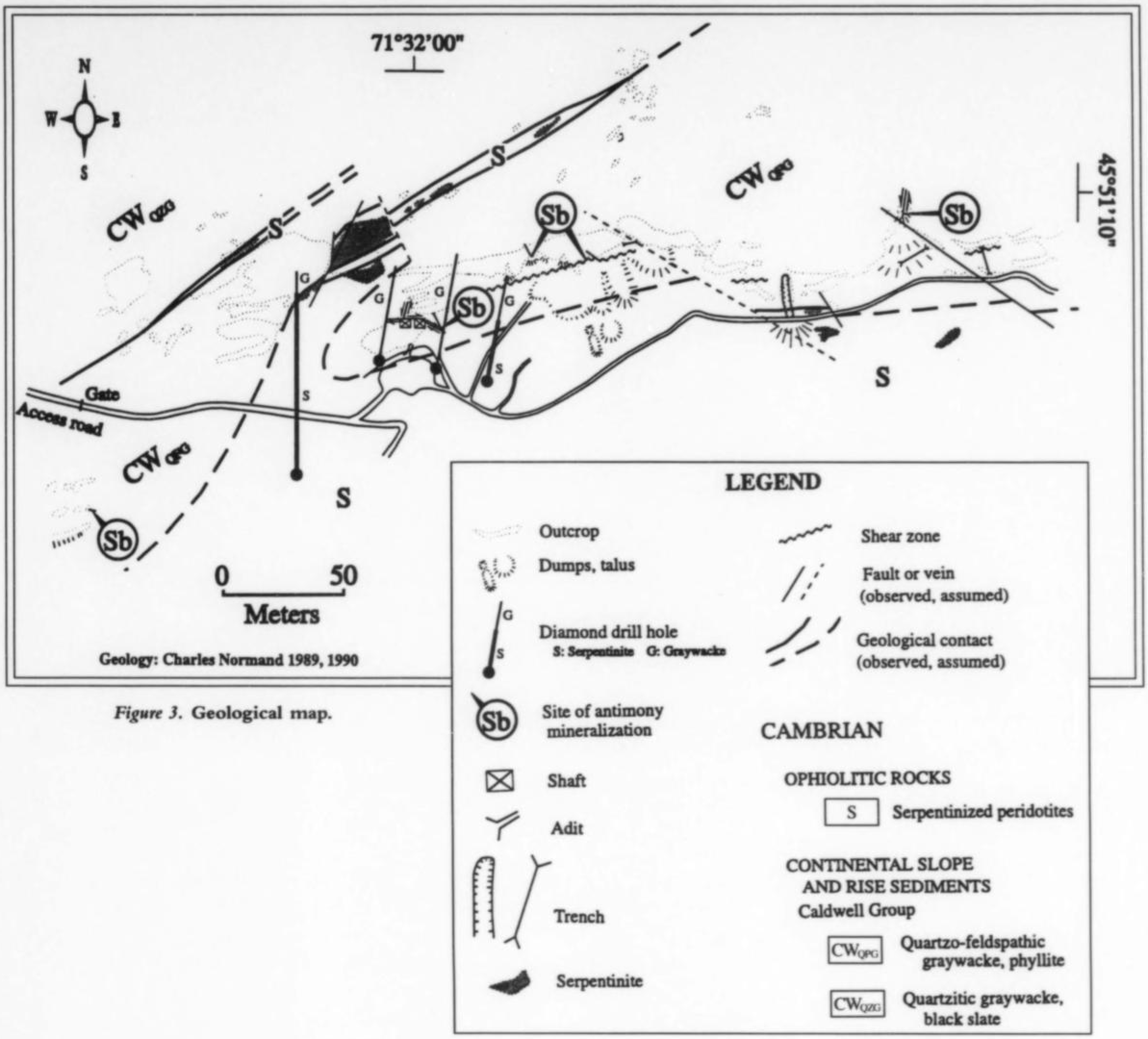


Figure 3. **Geological map.**

igneous rocks have been heavily serpentinized. It is believed that in mid-to-late Ordovician time the Ascot-Weedon island arcs and late Precambrian-Cambrian Chain Lakes massif collided obliquely with the North American continent (Doolan *et al.*, 1982; Gauthier *et al.*, 1989). Major offset and reverse faulting probably caused secondary shearing and tension fractures to develop in adjacent competent rocks, which in turn acted as channels for hydrothermal quartz-metal vein emplacement in Acadian time.

The antimony mineralization observed at Lac Nicolet probably originated in such a manner. The mine itself is situated in a siliceous phyllitic unit, very near a major fault contact with serpentinized peridotite (Fig. 3). In the underground workings most of the vein has either been removed by mining or is presently inaccessible due to caving and seasonal flooding. What little is left is poorly exposed, and shows a pinch-and-swell pattern. The rock in proximity to the vein is noticeably sheared and silicified. Even the vein itself is locally sheared and brecciated, indicating movement during and after its emplacement. Stages of mineralization and faulting were probably pulsating, as evidenced by mylonitized fragments of early dark-colored quartz in later sheared native antimony, drag-folding in the schistosity of the rocks at their contact with the main vein, and the presence of slickensides on vein-parallel fault planes.

Older descriptions (Willimot, 1883; Obalski, 1890; Dresser, 1914; etc.) state that the vein is traceable for about a kilometer on strike, and mention additional workings east of the main shafts. The authors were able to locate two small prospect pits with minor antimony mineralization: one approximately 100 meters northeast of the main workings and another approximately 300 meters to the east. Diamond-drilling logs from both the Sullico and Québec Antimony projects were unable to prove a continuous extension of the vein, and the best estimate of reserves is probably that of Québec Antimony Mines, Ltd., at 68,025 tons at 2.5% Sb (or 181,400 tons at 1.7% Sb).

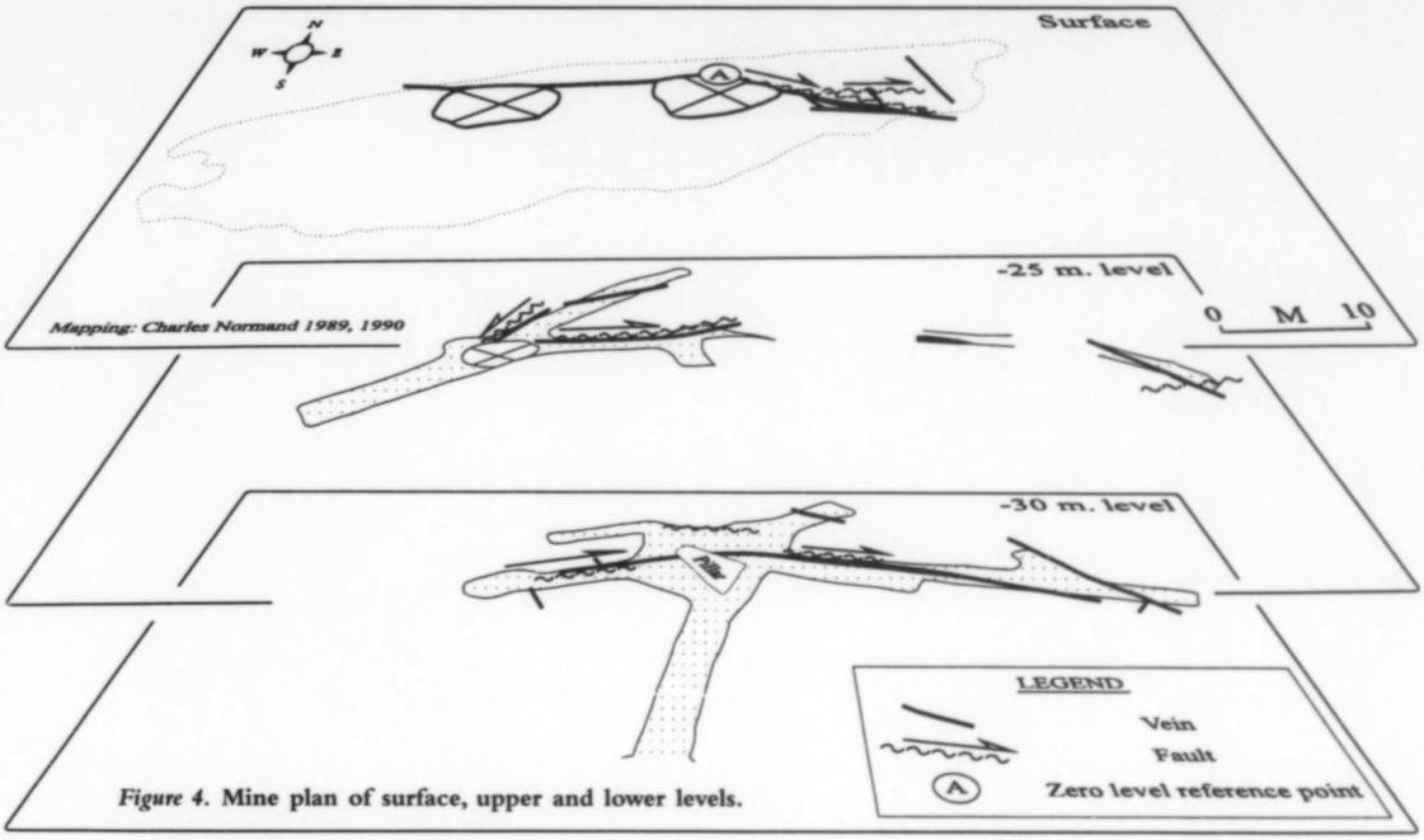


Figure 4. **Mine plan of surface, upper and lower levels.**

MINERALOGY

Antimony mineralization at the Lac Nicolet mine may be divided into three general types, based on their occurrence and dominant mineral assemblages: (1) isolated grains in the country rock, (2) a gudmundite-albite-dolomite assemblage, and (3) quartz-stibnite-antimony veins. The predominance of stibnite or native antimony in the latter veins was probably controlled by local activities of sulfur, oxygen and hydrogen during vein formation. A number of secondary species, such as aragonite and gypsum, have also been identified from the deposit. These probably formed by weathering, and are unrelated to the antimony mineralization. Table 1 summarizes the occurrence of these minerals. Unless otherwise noted, the identity of all the species has been verified by X-ray and/or microprobe analysis.

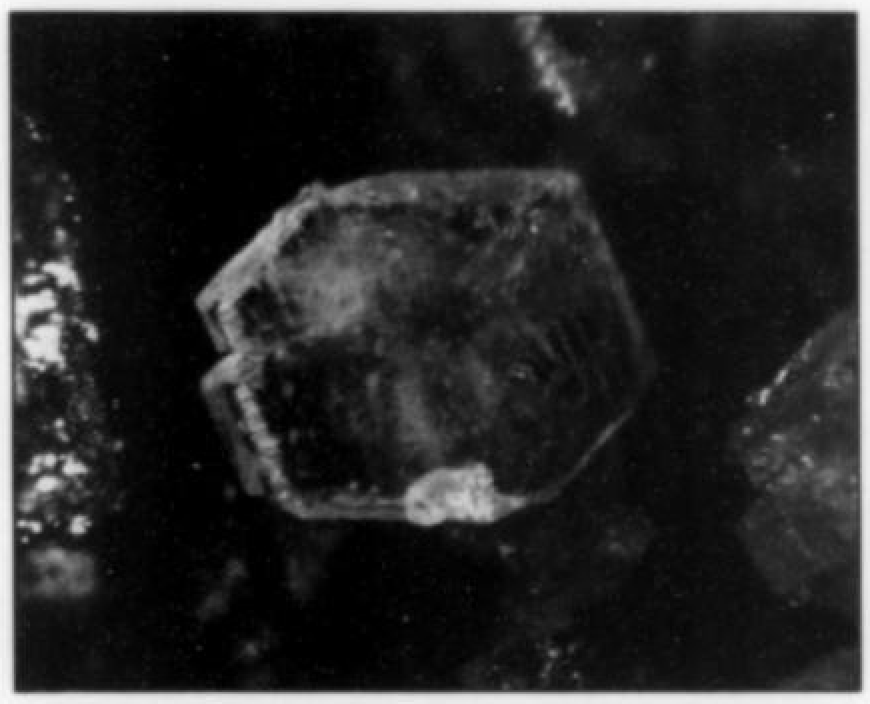


Figure 5. **Albite on gudmundite, 50X. Q. Wight specimen and photo.**

Albite $NaAlSi_3O_8$

Albite is an abundant accessory mineral in the gudmundite-albite-dolomite assemblage. In cavities it forms glassy, colorless, milky to transparent, tabular crystals up to 7 mm, twinned on the albite law. It is nearly always associated with abundant quartz, gudmundite and dolomite, often with stibnite, and occasionally with pyrrhotite or berthierite.

Antimony   Sb

One of the primary ore minerals, native antimony occurs most commonly as pure, massive vein sections up to 15 cm wide. Most vein sections vary in color from bright, tin-white to dull gray, and show a somewhat granular to cataclastic texture on freshly broken surfaces. Abundant shards of quartz are apparent when viewed under the microscope. Occasionally, some of the massive antimony contains small cavities lined with brilliant, silvery, microscopic crystals, but these are rare. SEM examination of such specimens reveals the crystals to be aggregates of intergrown rhombohedra. Antimony also occurs sparingly in cavities in the gudmundite-albite-dolomite assemblage as microscopic, occasionally iridescent, granular to spongy masses.

Aragonite $CaCO_3$

Aragonite has been identified on a single specimen of limonite collected from a surface exposure of the main vein, directly below and east of the two mine shafts. The crystals occur as white to colorless prismatic individuals and radial aggregates up to 1 mm, and are likely the product of near-surface weathering.

Berthierite $FeSb_2S_4$

Berthierite occurs both as rich black masses and more sparingly as iridescent, prismatic, microcrystals in the gudmundite-albite-dolomite assemblage. It has also been identified as granular black masses associated with stibnite, schafarzikite and metastibnite, and rarely as prismatic crystals to 2 cm in the quartz-stibnite-antimony veins. In both

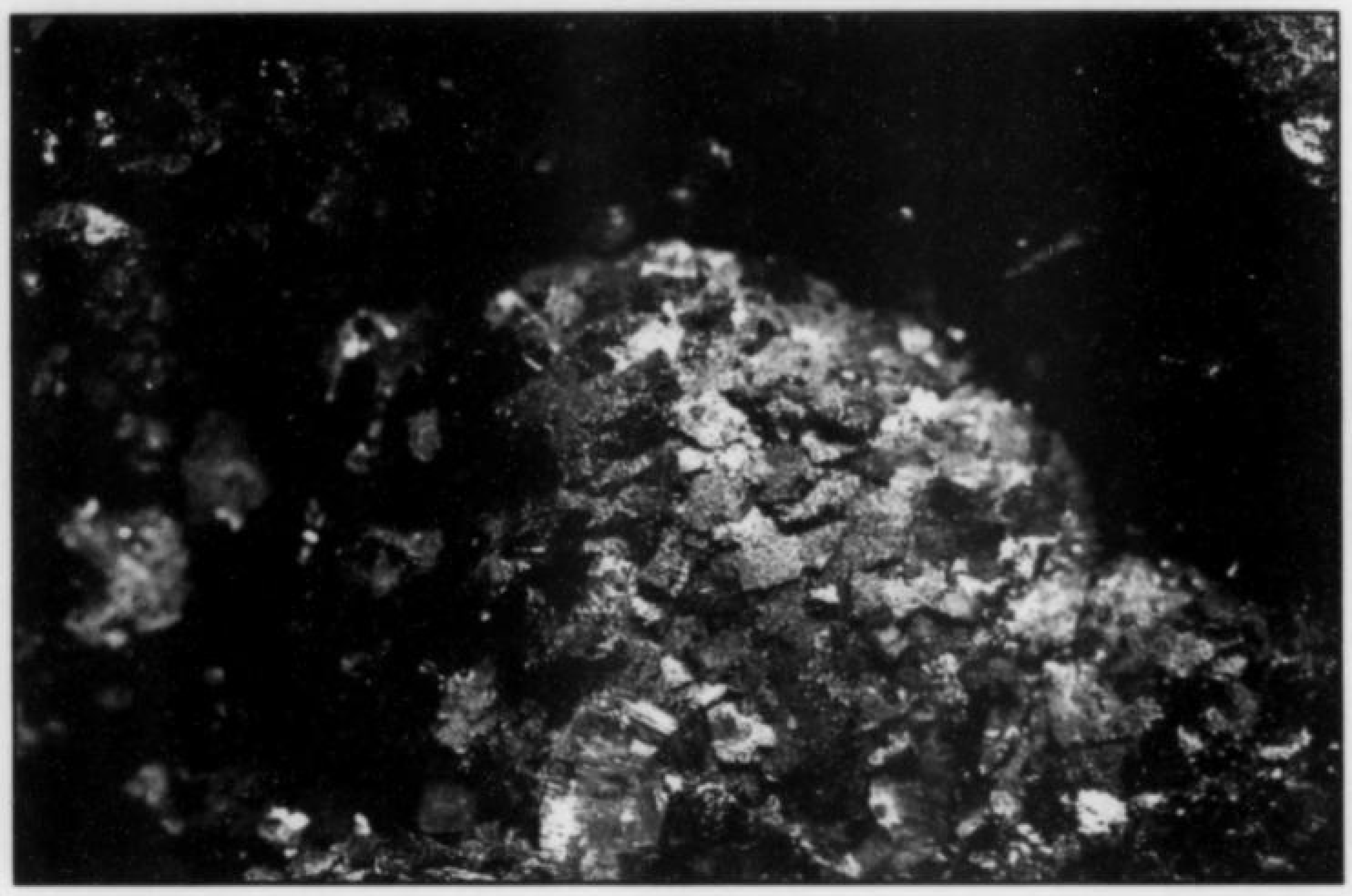


Figure 6. (left) **Native antimony and stibnite, 2 x 2.5 cm. Canadian Museum of Nature specimen #53544; photo by G. Robinson.**

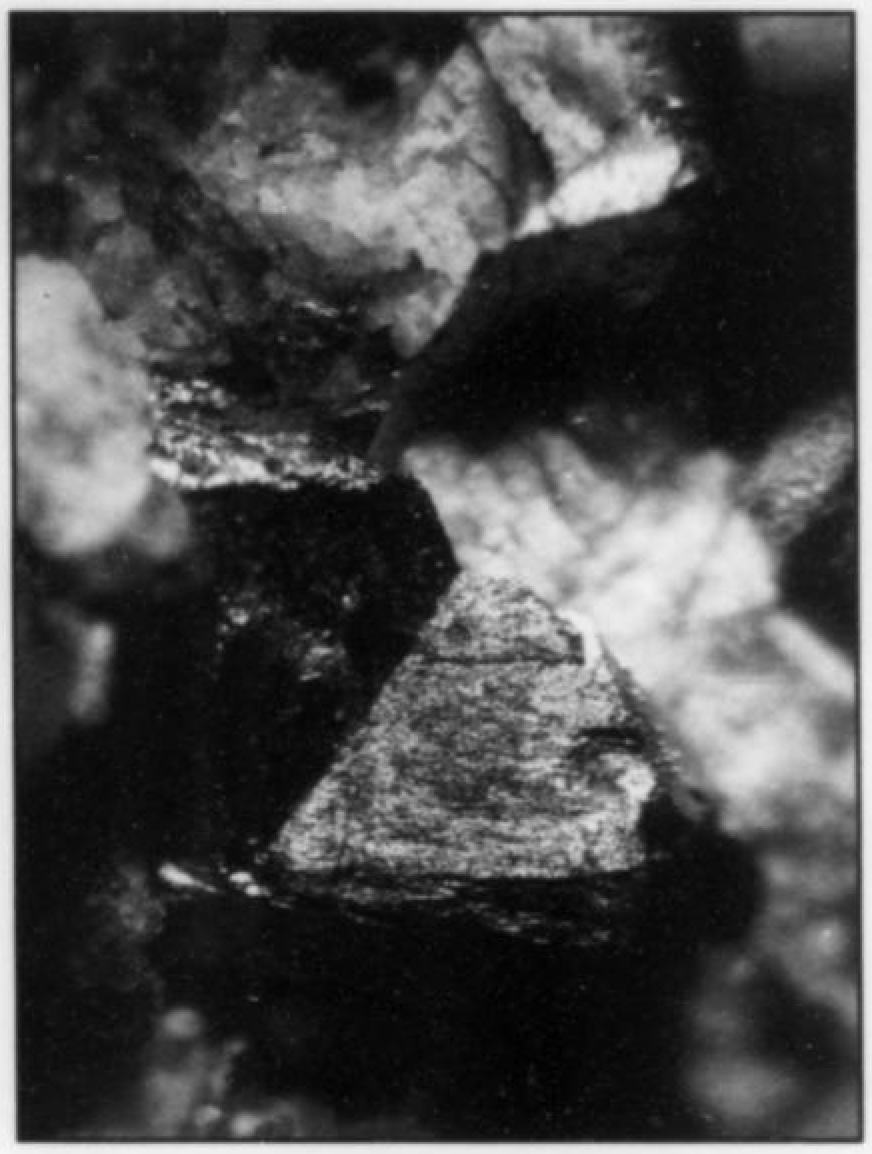


Figure 7. (right) **Twinned gudmundite crystal in dolomite and quartz, 1 mm. Canadian Museum of Nature specimen #81523; photomicrograph by Q. Wight.**

associations, berthierite is virtually indistinguishable from stibnite without employing optical, X-ray or microprobe techniques. Berthierite is not as common as stibnite, and many specimens labeled as berthierite, when X-rayed, have proven to be stibnite.

Calcite $CaCO_3$

Calcite has been collected from a single occurrence in the upper level of the underground workings near the westernmost shaft, where it forms gray-white cleavage masses up to 3 cm in a breccia vein. The calcite fluoresces a moderate purplish red in both longwave and shortwave ultraviolet light. No other species is associated.

Chlorite group $(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$

Aggregates of microscopic, micaceous, velvety, green-brown spheres are occasionally observed in cavities in both the quartz-stibnite-antimony veins and the gudmundite-albite-dolomite assemblage. X-ray patterns obtained from these spheroidal aggregates show them to be members of the chlorite group, and their EDS spectra indicate they are predominantly Mg-Fe aluminosilicates, suggesting they are most likely intermediate in composition between clinochlore and chamosite.

Dolomite $CaMg(CO_3)_2$

Dolomite appears to occur exclusively in the gudmundite-albite-dolomite assemblage. It commonly forms sharp rhombohedral crystals up to 2 mm, associated with quartz, albite, stibnite and gudmundite. Semiquantitative EDS microprobe analysis shows this dolomite to be enriched in iron, and is thus a ferroan dolomite. While most crystals are translucent to opaque and pale yellow-brown in color, some may appear nearly colorless and pseudo-octahedral in habit, due to nearly equal development of rhomb and pinacoid faces. Such crystals have often been mistaken for senarmontite. However, the two minerals are easily differentiated, since the senarmontite is typically more lustrous, gray to colorless, isotropic, lacks rhombohedral cleavage, has a higher specific gravity, and is virtually absent from the gudmundite-albite-dolomite assemblage.

Galena PbS

Galena is very rare at the Lac Nicolet deposit, and has been identified on only a very few specimens collected from the dumps. It has been observed as tiny, 1-mm cleavages associated with resinous, pale brown sphalerite and minor gudmundite in quartz, as microscopic inclusions in gudmundite, and as a granular gray mass replacing stibnite on one specimen.

Goethite $Fe^{3+}O(OH)$

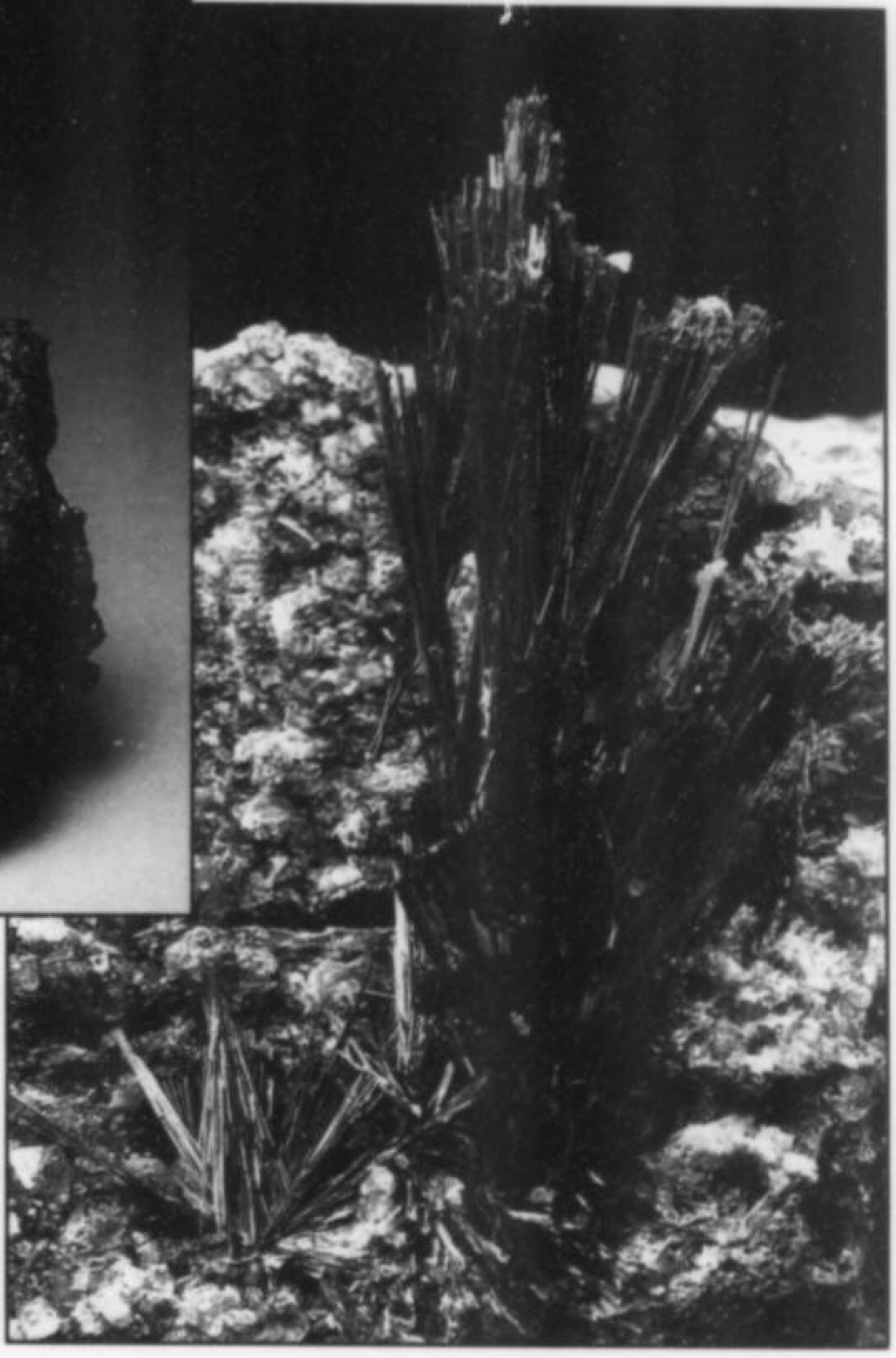
Goethite occurs abundantly as rusty brown coatings on many of the rocks and joint surfaces in the general vicinity of the mine, as the result of chemical weathering of iron-bearing minerals. It has also been observed replacing tabular hexagonal prisms of pyrrhotite in the gudmundite-albite-dolomite assemblage.

Gudmundite FeSbS

Worldwide, gudmundite is a relatively uncommon mineral, but it occurs fairly abundantly at the Lac Nicolet mine as 1–2 mm prismatic crystals generally resembling marcasite. An examination of heavy mineral separates indicates that gudmundite (at 85 volume %) is the most abundant ore mineral in the deposit (Mathieu and Bruce, 1973). Well-formed crystals of gudmundite occur almost exclusively in the gudmundite-albite-dolomite assemblage, and are frequently associated with minor stibnite and quartz. Occasionally, small isolated crystals can be observed in the host rock in

Figure 8. (above) **Kermesite with senarmontite and valentinite on stibnite, 6 x 7.5 cm. Canadian Museum of Nature specimen #51854; photo by G. Robinson.**

Figure 9. (below) **Kermesite on quartz, 4-cm spray. Canadian Museum of Nature specimen #52615; photo by G. Robinson.**



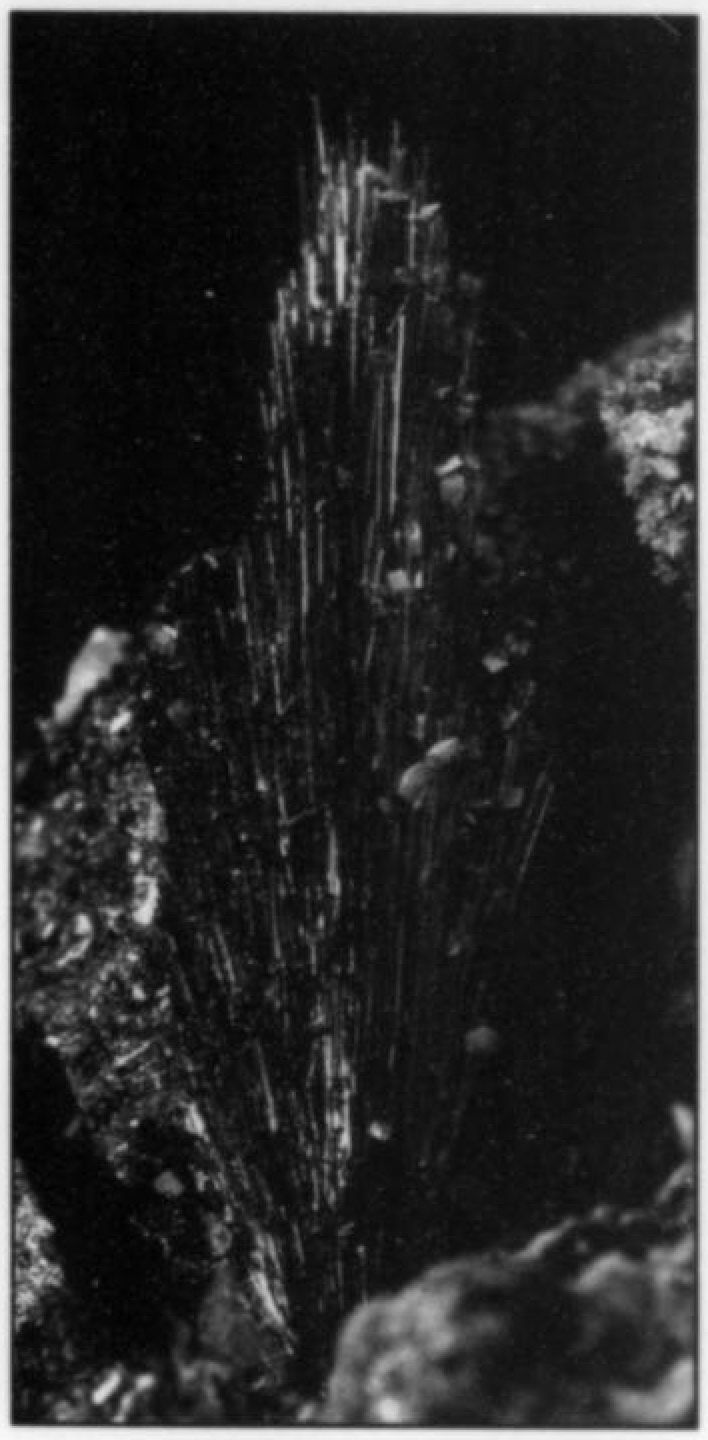


Figure 10. **Kermesite with valentinite, 3-cm spray. Canadian Museum of Nature specimen #53482; photo by G. Robinson.**

the general vicinity of the mine and the small prospect 100 meters to the northeast, but the best specimens have been collected from what remains of the early-mined dump material. Most of the gudmundite has a tarnished brassy brown color, but is bright tin-white on freshly broken surfaces. Electron microprobe analyses indicate the gudmundite is essentially pure FeSbS.

Gypsum $CaSO_4 \cdot 2H_2O$

Colorless crystals of gypsum up to 2 mm were collected from the dumps by Hamilton Stitt, circa 1968. The crystals form transparent stellate groups several millimeters across on goethite-coated phyllite, and may be of post-mining origin. The only two specimens known to us are preserved in the collections of Quintin Wight and Peter Tarassoff.

Halloysite $Al_2Si_2O_5(OH)_4$

Halloysite occurs as microscopic cream-white balls and desiccated masses lining fractures and cavities in some of the quartz-stibnite-antimony veins. It is not common.

Kermesite Sb_2S_2O

Of all the minerals found at the Lac Nicolet mine, the most famous and visually attractive is probably kermesite. This mineral occurs in a variety of habits and colors ranging from powdery red coatings on fracture surfaces to purplish red acicular crystals to 5 cm, crimson-red tufts of microcrystals and purplish red velvety crystal masses several centimeters across. Micromounts of kermesite associated with stibnite, valentinite and quartz exist in abundance, and are perhaps the best known specimens from this locality. Unfortunately, large, high-quality specimens have been preserved in relatively few collections. To our knowledge, the best are probably those in the Canadian Museum of Nature (Ottawa) and the Lucius Hubbard collection at the A. E. Seaman Mineralogical Museum in Houghton, Michigan. The fact that similar specimens were probably lost to the mill and smelter due to general disinterest is indeed a tragedy, for those that have been preserved rank with the world's best for the species.

While kermesite is relatively abundant in the quartz-stibnite-antimony veins, it is virtually absent in the gudmundite-albite-dolomite assemblage. In some specimens kermesite replaces stibnite, and may itself be replaced by stibiconite. Other specimens, however, show no evidence of stibnite replacement. Kermesite formation may be regulated by local changes in the chemical activities of various sulfur species, oxygen and hydrogen, and possibly other factors such as temperature (Krupp, 1988).

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

Malachite has been identified on a single specimen collected from the surface exposure of the main vein directly above the underground workings, where it forms a powdery green stain on and in stibiconite.

Metastibnite Sb_2S_3

Metastibnite occurs abundantly as a red powder, coating other minerals and joint surfaces in the immediate vicinity of the quartz-stibnite-antimony veins. As far as we can determine, this is the first reported occurrence of metastibnite in Canada. While metastibnite is rather common at the Lac Nicolet mine, its identity eluded the authors for quite some time. Metastibnite typically appears more red than kermesite, but it is difficult to distinguish from that mineral unless a simultaneous comparison is made. Thus, initially we assumed the mineral was just fine-grained kermesite. However, X-ray powder patterns showed senarmontite (Sb_2O_3) as the only mineral present! Confusing the issue further, subsequent microprobe investigation of the same samples showed them to be Sb_2S_3, or stibnite. Since neither senarmontite nor stibnite is known as a red powdery mineral, more samples were analyzed, which only confirmed the previous results. Finally, a rather large, 2-cm piece of the material was prepared for SEM examination, which revealed the presence of two phases: submicroscopic octahedrons of senarmontite along with a globular, somewhat botryoidal phase with Sb:S = 2:3. Since metastibnite is amorphous, its presence could not be detected by X-ray analysis, nor could the presence of oxygen in the senarmontite be detected by the EDS microprobe technique in use.

Microcline $KAlSi_3O_8$

A single 5-mm crystal of white microcline was found in a specimen collected from a rubble pile in the lower underground workings of the mine. Abundant quartz, stibnite, kermesite and stibiconite as associated species suggests it is from one of the quartz-stibnite-antimony veins.

Montmorillonite $(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$

Several specimens of microscopic, tan-to-beige spheroids extracted from various cavities in quartz-stibnite-antimony veins gave X-ray patterns similar to that of montmorillonite. Qualitative EDS microprobe analysis showed these samples to be essentially aluminum silicate, often mixed with minor amounts of iron and antimony minerals.

Orthoclase $KAlSi_3O_8$

Microscopic white crystals of orthoclase have been noted on two specimens. The first of these was collected from a sheared quartz vein adjacent to a native antimony vein in the upper level of the underground workings, and the second came from dump material. The crystals on both specimens show the typical "adularia" habit, and average 0.5–2.0 mm in maximum dimension. Associated species are quartz and minor kermesite, stibnite and chlorite.

Pyrrhotite $Fe_{1-x}S$

Pyrrhotite is regularly observed as a minor accessory mineral in the gudmundite-albite-dolomite assemblage, where it forms tabular, hexagonal plates up to 2 mm across, frequently replaced by goethite. Pyrrhotite also occurs as an abundant but minor accessory mineral in the metasedimentary rocks near the principal vein.

Quartz SiO_2

While quartz is one of the most common species at Lac Nicolet, and may be observed on almost any specimen, it seldom occurs in collector-quality crystals. Undoubtedly the most aesthetic specimens are the tiny, Herkimer diamond-like crystals that occur in both the gudmundite-albite-dolomite assemblage and the quartz-stibnite-antimony veins, associated with kermesite, stibnite and valentinite as micromount specimens. Larger crystals are typically etched and cloudy, and seldom exceed a centimeter across. One notable exception, however, is a doubly terminated, 2.5-cm crystal with stibnite (?) inclusions in the collection of Charles Normand.

Schafarzikite $Fe^{2+}Sb_2^{3+}O_4$

In the course of identifying the myriad red powdery minerals observed on fracture surfaces at Lac Nicolet, the rare mineral schafarzikite was identified by X-ray diffraction, and confirmed by semiquantitative EDS microprobe analysis. So far it has been identified on only a few specimens, and is virtually indistinguishable in hand specimens from the metastibnite and powdery kermesite with which it is associated. Berthierite is also present on the specimen, and the schafarzikite may have been formed by alteration of that mineral. Like metastibnite, we believe this to be the first reported occurrence of schafarzikite in Canada.

Senarmontite Sb_2O_3

Senarmontite occurs rather abundantly in some of the cavities in the quartz-stibnite-antimony veins, where it forms colorless-to-gray transparent octahedrons that average a millimeter across. Crystals larger than 1–2 millimeters are very rare, though a unique 8-millimeter single crystal resembling those from Hamimat, Constantine, Algeria, is preserved in the Hubbard collection at the A. E. Seaman Museum.

Sphalerite ZnS

Like galena, sphalerite is very rare at the Lac Nicolet deposit, having been confirmed in only a very few specimens

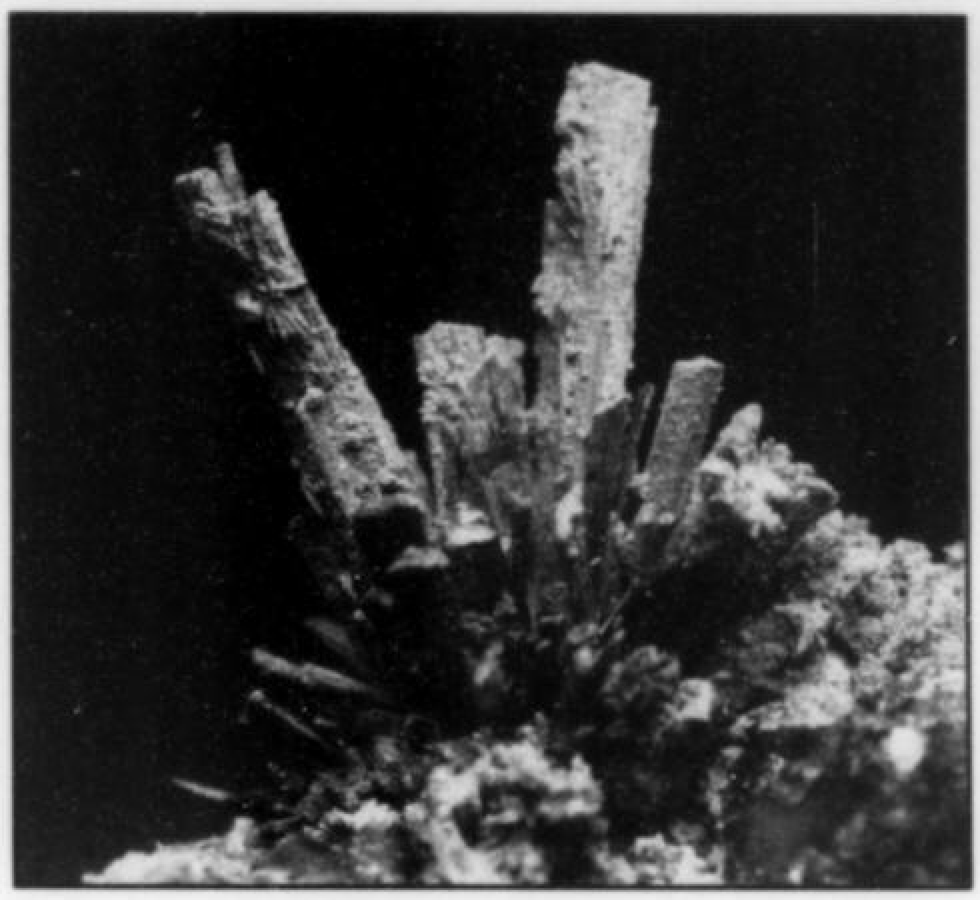


Figure 11. **Stibiconite pseudomorph after stibnite, 1.5 cm. Canadian Museum of Nature specimen #81652; photo by G. Robinson.**

as tiny brown grains and cleavages up to 3–4 mm in quartz associated with either galena or gudmundite.

Stibiconite $Sb^{3+}Sb_2^{5+}O_6(OH)$

Stibiconite is an abundant alteration product at Lac Nicolet, particularly in the quartz-stibnite-antimony veins. It appears late in the paragenesis of these veins, and forms powdery coatings on virtually all earlier-formed antimony minerals. The coatings may be pure white, ivory, beige, yellow, or orange-brown in color, and vary in thickness from 3 cm to a faint dusting that is barely perceivable. Stibiconite frequently replaces both stibnite and kermesite, forming pseudomorphs after these minerals.

Stibnite Sb_2S_3

Along with gudmundite and native antimony, stibnite was one of the primary ore minerals mined from this deposit. It occurs as densely packed, interlocking, millimeter-sized cleavages in veins, as silvery-gray, metallic, terminated crystals 1–2 cm long in cavities (first generation crystals), as radiating (occasionally iridescent) black tufts of microcrystals (second generation crystals), and as thin, silvery sheets resembling aluminum foil coating fractures in the host rock adjacent to some of the quartz-stibnite-antimony veins. Radiating, silvery black microcrystals are common in some cavities in the gudmundite-albite-dolomite assemblage. It is reported that a crystal 15 cm long was found by a worker with the Québec Antimony Mine diamond drilling project in the early 1970's, but the whereabouts of the specimen both then and now is unknown (Quintin Wight, personal communication).

Stibnite has also been observed replacing pyrrhotite crystals in both hand specimens and polished sections. The former are relatively uncommon, and generally resemble graphite. X-ray and microprobe analyses of these pseudomorphs confirm the original hexagonal mineral as pyrrhotite.

Tetrahedrite $(Cu,Fe)_{12}Sb_4S_{13}$

Lustrous, black, tristetrahedral crystals of tetrahedrite, some of them modified by deltohedron faces, were found on a single specimen collected from rubble in the upper level of the underground workings. The crystals are generally less than 0.5 mm across, and are associated with stibnite, quartz and granular brown microcrystals of senarmontite in cavities in quartz. The assemblage is otherwise typical of the quartz-stibnite-antimony vein mineralization. Tetrahedrite also has been identified as sparse, black masses to 2 mm in dense, gray quartz in a second specimen collected from the underground workings, and silver-bearing tetrahedrite occurs as a trace constitute in the altered metasedimentary rocks with pyrrhotite, chalcopyrite and ullmannite.

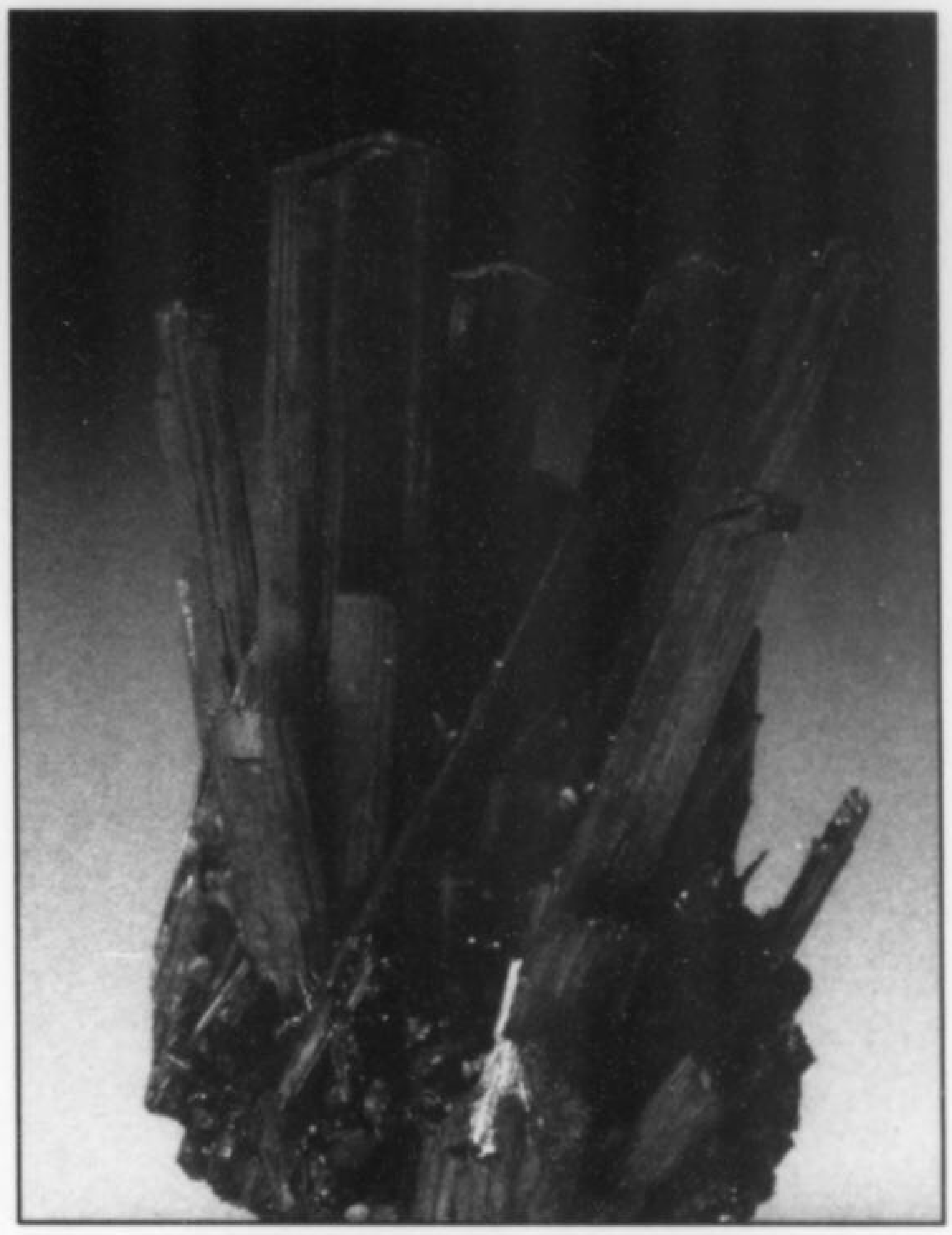


Figure 12. **Stibnite crystal group, 3.5 x 1.7 cm. Simon Morneau specimen; photo by G. Robinson.**

Valentinite Sb_2O_3

Crystals of valentinite occur in at least six different habits, and are frequently encountered in the quartz-stibnite-antimony veins. The most commonly associated species are quartz, stibnite, native antimony, kermesite and senarmontite. The valentinite is always well-crystallized, and is most commonly white or grayish white, though some of the larger crystals may appear beige to caramel-yellow, or rarely even red due to associated metastibnite. The largest crystals approach a centimeter in length, but these are rare. Usually, they are much smaller, averaging 1 to 3 mm; but from a crystallographic standpoint, they are perhaps the most interesting of all the minerals to be found at the locality.

There are at least six different habits of valentinite at the Lac Nicolet mine. Miller indices for the various forms were obtained by optical goniometry from crystals whose orientation was first established by X-ray precession photographs.

Figure 13. **Second generation stibnite on kermesite, 0.3 mm. Canadian Museum of Nature specimen #53549; photomicrograph by Q. Wight.**

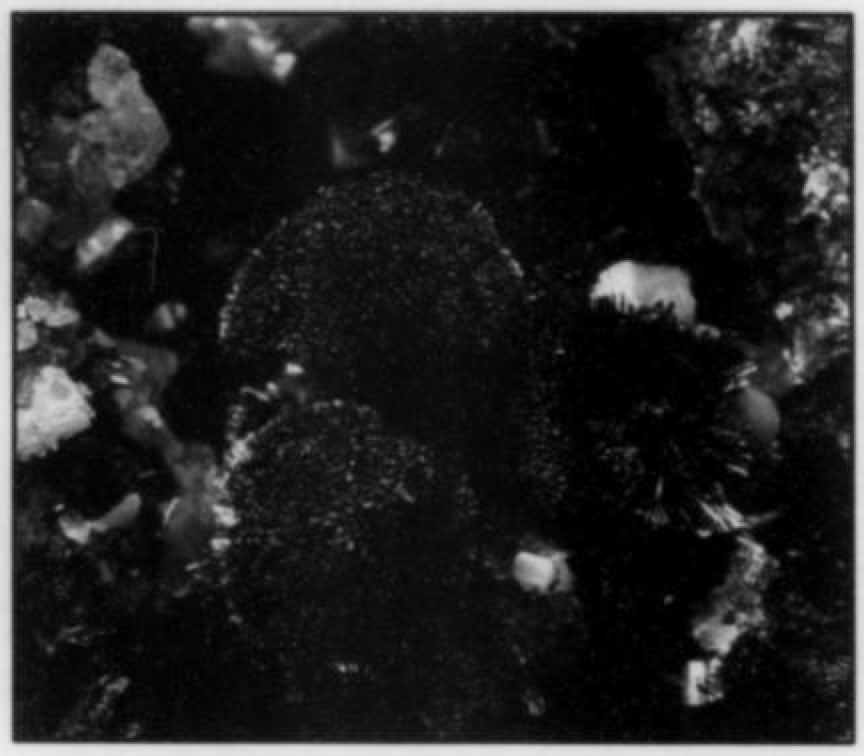


Figure 14. **Second-generation stibnite, 4-mm balls. Canadian Museum of Nature specimen #53481; photo by G. Robinson.**

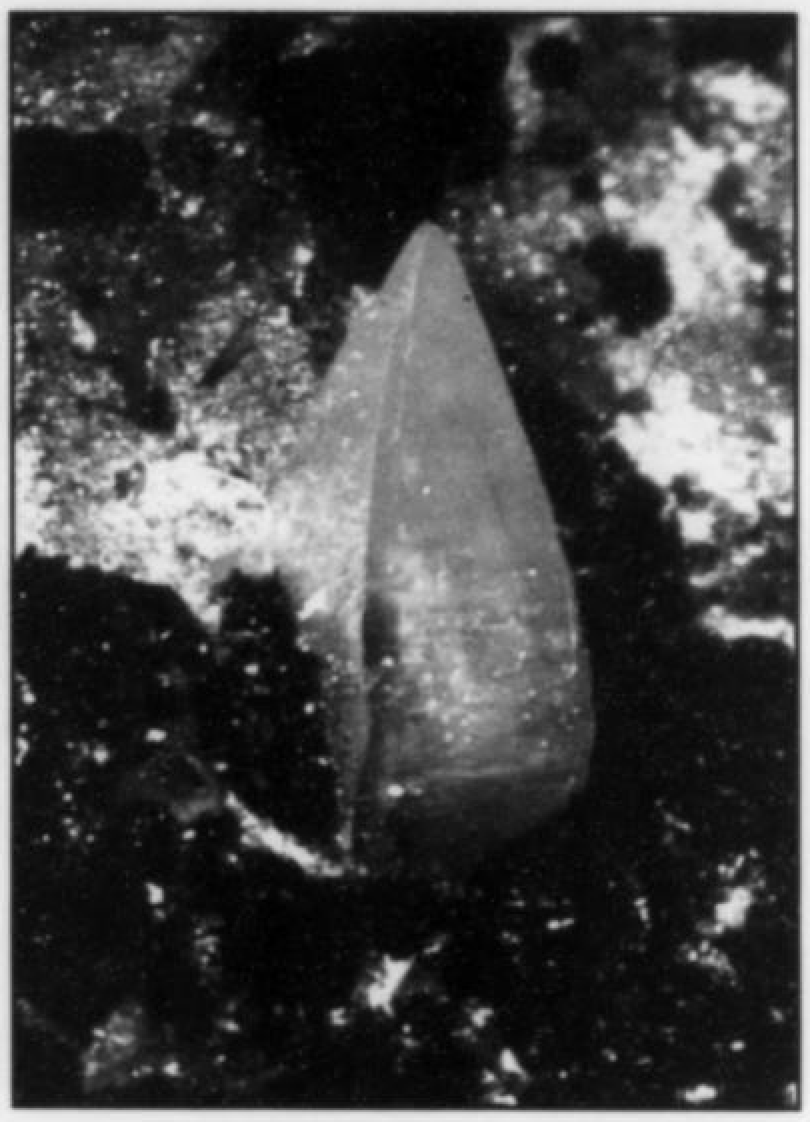


Figure 15. **Valentinite crystal (habit 1) with stibnite and native antimony, 2-mm crystal. Canadian Museum of Nature specimen #53544; photomicrograph by Q. Wight.**

Figure 16. **Stibnite with kermesite, quartz and valentinite, 1.5 x 2-cm area (note two generations of stibnite). Canadian Museum of Nature specimen #52638; photo by G. Robinson.**

Figure 17. **Valentinite crystals (habit 5/6) on stibnite, 0.5 mm crystals. Canadian Museum of Nature specimen #MOC3646; photomicrograph by G. Robinson.**

The first three habits are encountered with about equal frequency, whereas the latter three are relatively uncommon. Variations of these and additional habits have been observed, but only rarely, and usually only with the aid of SEM magnification. Under a regular binocular microscope, most such specimens appear as crusts of microscopic, acicular, white crystals. Because they are of minimal significance, they will not be described.

Crystals of habit 1 resemble pseudotetragonal dipyramids, especially when observed growing from the matrix along [010]. This is due to nearly equal development of forms {011} and {110} and, if viewed under the microscope, the true orthorhombic symmetry of these crystals is readily apparent. The {110} faces are typically smooth and lustrous, and, of course, parallel to the {110} cleavage planes. Small {100}, {010} and {001} pinacoids may also be present. The {011} faces are duller and typically rounded, which makes

Figure 18. **Valentinite with kermesite, quartz and stibnite, 1 x 1.5 cm area. Canadian Museum of Nature specimen #53560; photo by G. Robinson.**

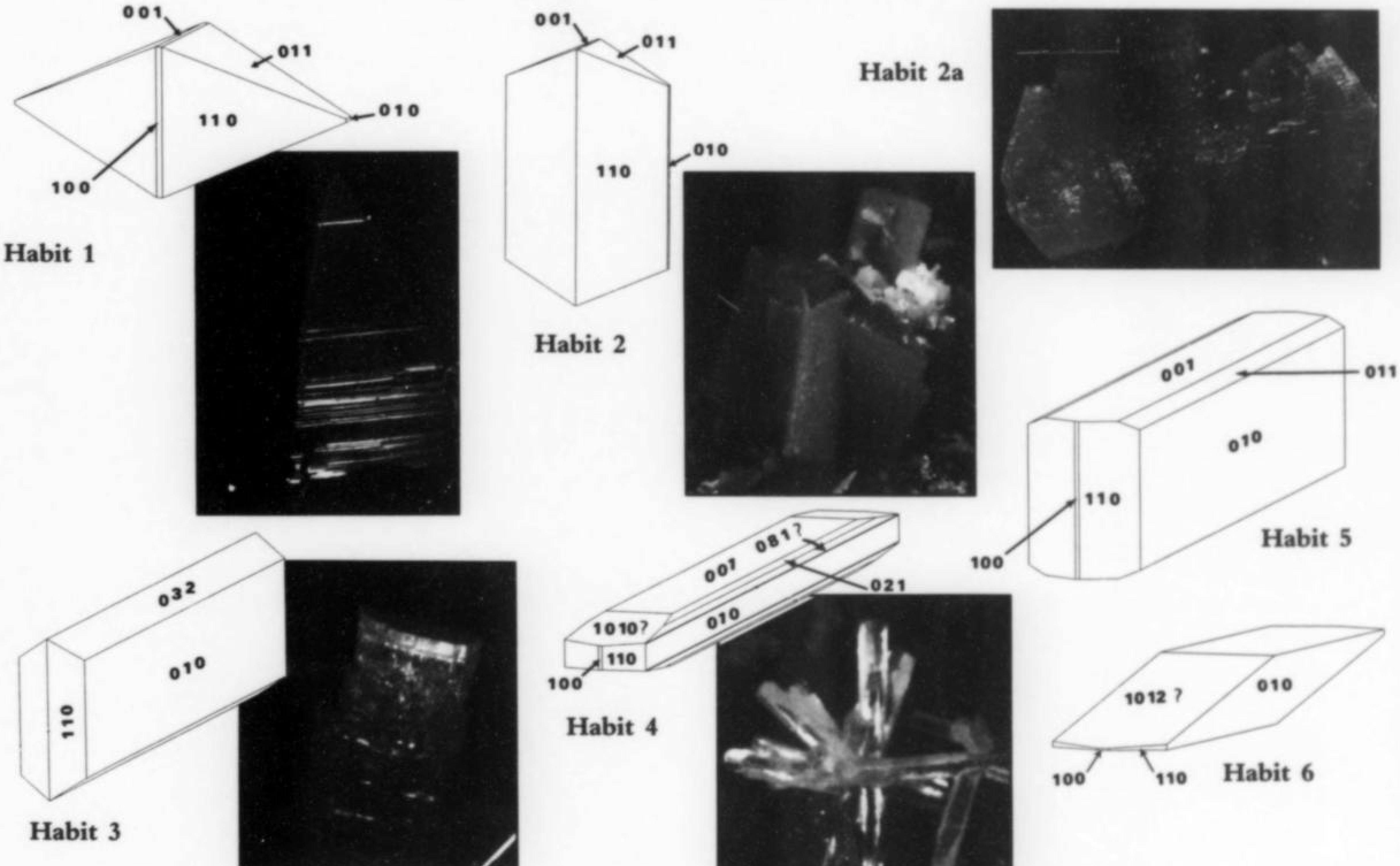


Figure 19. **Valentinite crystal habits. All specimens from the Canadian Museum of Nature (#53476 habit 1, #53559 habit 2, #51400 habit 2a, #53560 habit 3, #MOC3647 habit 4); photomicrographs by Q. Wight (habits 1, 3, 4) and G. Robinson (habits 2 and 2a).**

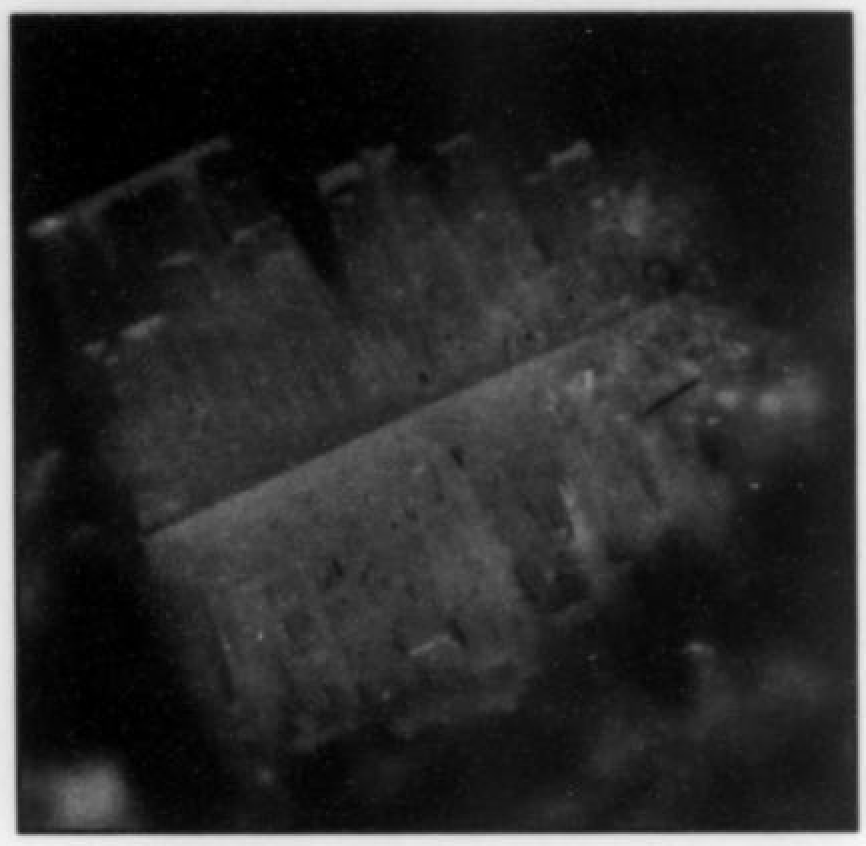


Figure 20. **Valentinite showing habit 5/6. Canadian Museum of Nature [MOC3646] specimen; photo by Q. Wight.**

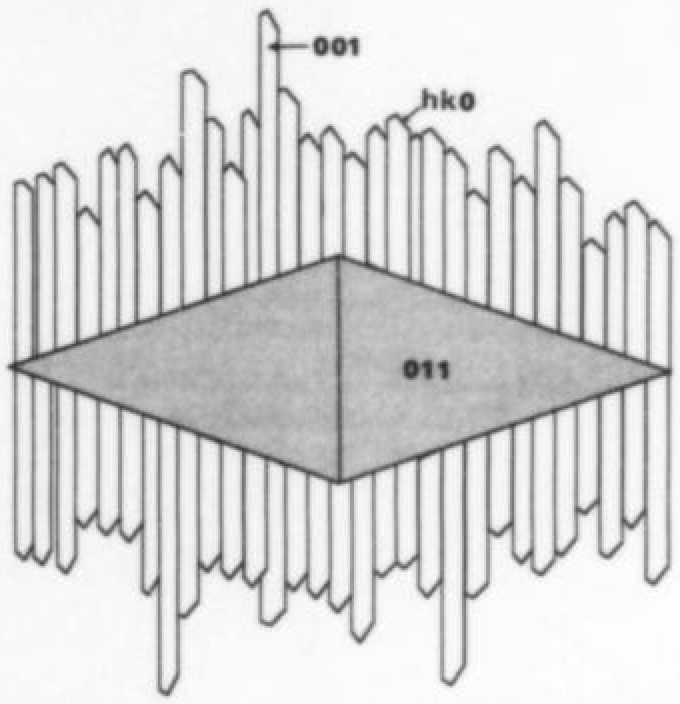


Figure 21. **Valentinite crystal showing habit 5 overgrown on habit 2.**

their identification by optical goniometry somewhat tenuous. Reflections corresponding to the following forms have been observed as oscillatory growths on these faces: {012}, {013}, {014}?, {0.16.1}?, {102}?, {103}, {104}? and {506}. Crystals of habit 2 have the same forms as those of habit 1, but are either elongate or stacked in parallel growth along [001], resulting in bluntly terminated prisms and wheat sheaf-like growths.

The third habit is characterized by large {010} pinacoids bounded by {110} and {032} prisms. Crystals of this habit are nearly always elongate on [100], and often slightly divergent along [001]. Crystals of habit 4 are also elongated on [100], but have large, tabular {001} pinacoids. Other forms on these crystals include {100} and {010} pinacoids, and prisms {110}, {1.0.10}?, {021} and {081}?.

Crystals of the last two habits are perhaps the most interesting of all, and certainly the least common, having been observed on only about a half dozen specimens. Both form spiky oriented overgrowths projecting in parallel position from the {110} faces of crystals of habit 2. Both are elongate on [100], but differ with respect to the forms present. Habit 5 crystals have relatively large {010} and {001} pinacoids, with smaller {110}, {011} and {100} faces, and show oscillatory growth between {001} and unidentified {hk0} or {hk1} faces, giving a false impression of twinning. A small {h01} prism also is occasionally present. Habit 6 is similar, except the {001} and {011} forms are replaced by steep {h01} prisms that yield reflections approximating {1.0.12} and give a distinct sawtooth appearance when viewed along [010] in parallel growths. The sharp boundaries between these overgrowths and their template crystals suggest they probably formed as a second generation of valentinite rather than by dissolution.

Other Species

During the course of this study, several other minerals were noted while examining polished sections by electron microprobe. A number of these were found in only a single section and all occur as singular microscopic grains or inclusions in other minerals. None is of collector quality, and none exists in sufficient size or quantity to permit X-ray analysis. Among these minerals are **arsenopyrite** and **chalcostibite**, both of which occur sparingly as isolated euhedral crystals in some of the massive native antimony; **jamesonite**, which was noted as an inclusion in a single grain of gudmundite; and rare, scattered grains of **pyrite** and **chalcopyrite**. Microscopic grains of **zircon**, **rutile**, **ilmenite**, **xenotime-(Y)** and **monazite-(Ce)** are frequently observed in some of the metasedimentary rocks near the main showing, along with less frequent grains of argentiferous **tetrahedrite**, **ullmannite**, **sphalerite** and **chalcopyrite** in altered zones. Disseminated grains of **chromite** and **pentlandite** are present in the serpentinized peridotite approximately 50 meters to the north. Rarely **glaucodot** (?), and **breithauptite** occur as inclusions in some of the pentlandite grains. Backscattered electron images of some of the pentlandite and associated minerals show chemical alteration along fractures and grain boundaries. Electron microprobe analyses of these alteration products typically give variable amounts of Ni, Fe, Co, Mg, Ca, Si, As, Sb and S, and variable analytic sums, suggesting they are probably mixtures. **Clinozoisite**, **epidote**, **prehnite** and **jarosite** also have been reported from the occurrence (Gauthier *et al.*, 1989; Sabina, 1967), but have not been observed by the authors.

PARAGENESIS

Microscopic examination of numerous polished sections and over 1000 hand specimens has established the paragenetic trends diagrammed in Figure 20. In the gudmundite-albite-dolomite assemblage, quartz, albite, pyrrhotite and dolomite appear to be the earliest minerals to have formed, followed by berthierite, gudmundite, stibnite and adularia (?), then by minor native antimony and chlorite. In the quartz-stibnite-antimony veins, quartz was the first mineral to crystallize, followed in succession by berthierite, stibnite, native antimony, a second generation of stibnite, kermesite, valentinite (+ minor senarmontite), chlorite and senarmontite. Locally, a second generation of valentinite and kermesite as well as a third generation of stibnite appear to have crystallized under equilibrium conditions with the main generation of senarmontite. Metastibnite, schafarzikite, stibiconite and very minor senarmontite appear late in the paragenetic sequence, and may be either very late hypogene or supergene minerals.

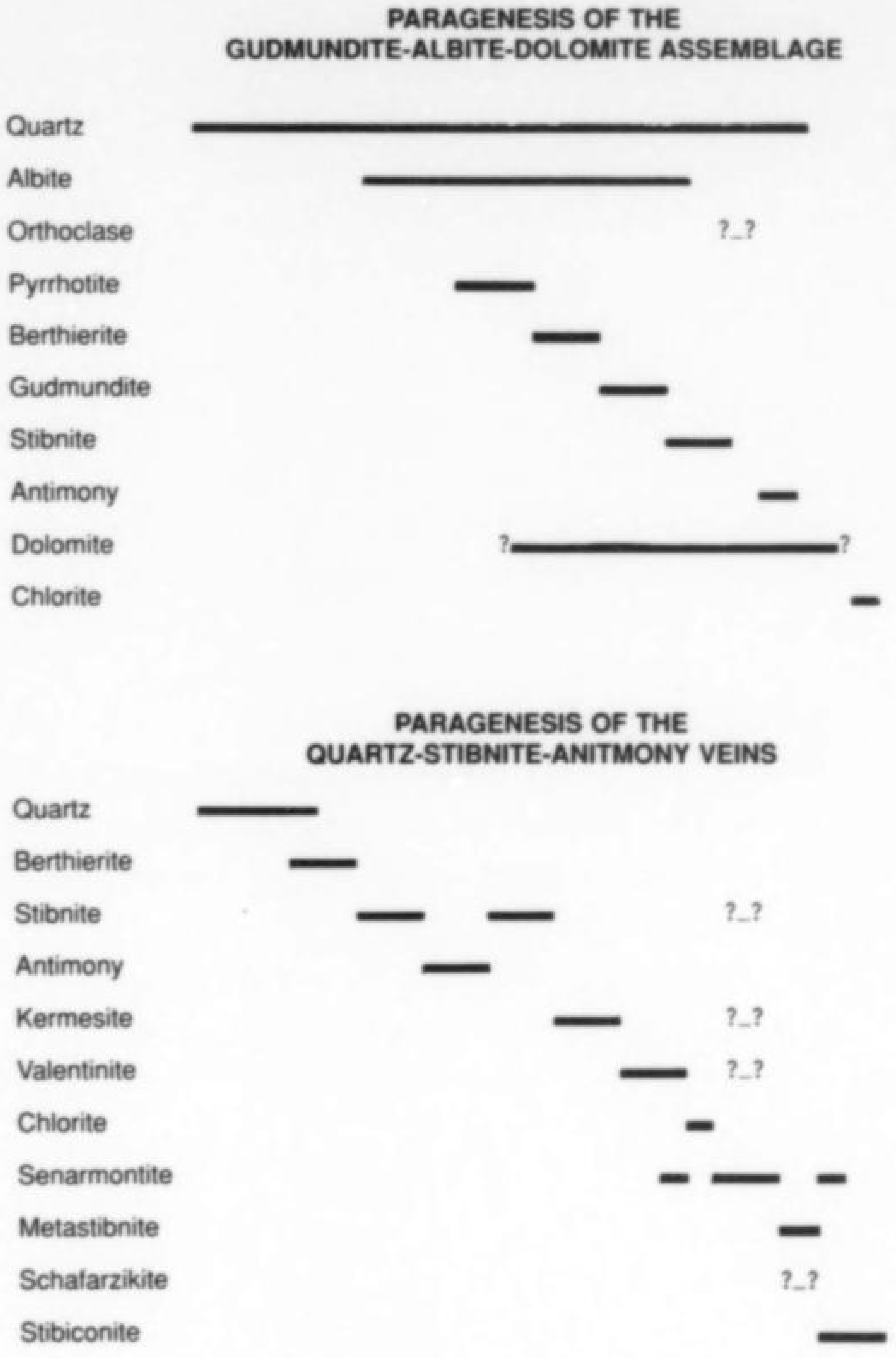


Figure 22. **Paragenesis diagrams.**

Table 1. **Distribution of Species.**

Country Rock or Isolated	*Gudmundite-Albite-Dolomite Assemblage*	*Quartz-Stibnite Antimony Veins*	*Weathering Products*
Albite	Albite	Antimony	Aragonite
Breithauptite	Antimony	Arsenopyrite	Goethite
Calcite	Berthierite	Berthierite	Gypsum
Chalcopyrite	Chlorite	Chalcostibite	Malachite
Chlorite	Dolomite	Chlorite	Metastibnite ?
Chromite	Galena	Galena	Schafarzikite ?
Dolomite	Gudmundite	Halloysite	Senarmontite ?
Galena	Jamesonite	Kermesite	Stibiconite ?
Glaucodot (?)	Orthoclase	Metastibnite	
Gudmundite	Pyrrhotite	Microcline	
Ilmenite	Quartz	Montmorillonite	
Pyrite	Stibnite	Orthoclase	
Microcline		Quartz	
Monazite-(Ce)		Schafarzikite	
Pentlandite		Senarmontite	
Pyrrhotite		Sphalerite	
Quartz		Stibiconite	
Rutile		Stibnite	
Serpentine		Tetrahedrite	
Sphalerite		Valentinite	
Tetrahedrite			
Ullmanite			
Xenotime-(Y)			
Zircon			

Preliminary microthermometric measurements of fluid inclusions in quartz suggest crystallization temperatures between 200–250°C. This temperature range is consistent with the maximum thermal stability limit for gudmundite of ~280°C (Clark, 1966) and the berthierite-pyrrhotite assemblage which is stable about 160°C (Seal *et al.*, 1992). Microcryometric and gas-chromatographic data indicate the presence of CH_4-N_2-rich and CO_2-poor fluids with low salinity (Normand *et al.*, in preparation). Homogenization behavior of monophase CH_4-rich inclusions suggests that pressures at least above 400–500 bars prevailed.

The paragenetic trends described above for the vug minerals suggest a history of increasing oxygen fugacity, decreasing temperature and locally variable, but generally decreasing sulfur fugacity. The reducing conditions required for the main stage of ore mineralization may have been maintained by fluid/rock interaction and/or mixing with fluids derived from the nearby serpentinites (Normand *et al.*, 1995?). A progressive increase in oxidizing conditions is confirmed by the sequential increase in the valence of antimony, from 0 in native antimony to 3+ in stibnite, kermesite, valentinite and senarmontite, to 5+ in the stibiconite. The presence of $(OH)^-$ in the stibiconite further suggests either an increase in pH and/or a drop in temperature, consistent with a geological model of typical oxide zone development as erosion of overlying rock exposed the sheared and brecciated metal-bearing veins to oxygenated groundwater.

ACKNOWLEDGMENTS

Thanks must be given to Maxwell Juby, Bertrand Brassard and Jeanine Evers, who facilitated our visits to the mine, to Stanley Dyl for providing information on the Hubbard collection, to Simon Morneau for lending his stibnite specimen for photography, to Michel Picard, Reinhard Wegner, Brad Wilson and Darryl MacFarlane for their assistance in the field, to Peter Tarassoff for his help researching the history of the deposit, to Quintin Wight for his photomicrographs and assistance with the crystal drawings, and to Jerry Van Velthuizen who provided the X-ray diffraction analyses. Funding for this project was in part made possible through a Canadian Museum of Nature RAC grant (ENPE 100) to GWR.

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What's New

in Minerals

Munich Show 1995 by Michael P. Cooper

[October 27–29]

The dwindling state of the pound sterling against the Deutschmark would be enough to give anyone from the UK pause when contemplating a trip to Germany, but when the Munich Show's special exhibits are worldwide **fluorites**, *and* the history of **crystal models**, such considerations pale somewhat. It's only money. So I went, and I did not regret it; Munich is always a good place just to *look* at minerals, and you don't have to buy anything (I told myself, and then spent more on minerals than I should have). To allow a better chance than usual to get around the show I went a day earlier and arrived in Munich on Wednesday night. This gave me Thursday's set-up and the relative quiet of dealer-day-Friday to get easily around the aisles of the show and see and talk to a lot more people than usual. This was a good idea—attendance was up some 4,000 on last year, for a grand total of 32,000 visitors. However, since I had to get back to London on Sunday afternoon I still didn't have enough time to get around to everything (and I still didn't get to talk to everyone I should—sorry!). But I did see a heck of a lot of fine minerals. I also met roving mineral photographer Jeff Scovil at the show, and I thank him for his notes on what he saw and for the excellent photographs included here.

The most exciting thing at the show, for me anyway, was the special exhibits. In the summer I had met show organizer Johannes Keilman behind the scenes at London's Natural History Museum and seen which specimens he had marked as suitable for the exhibit of British fluorites. If those from other collections and fluorite-producing regions were as good this was going to be something special indeed! And it was, featuring hundreds of specimens from private and institutional collections around the world. Some concentrated on one country's products; others showed a range of material from various sites; and some were the fruits of a lone

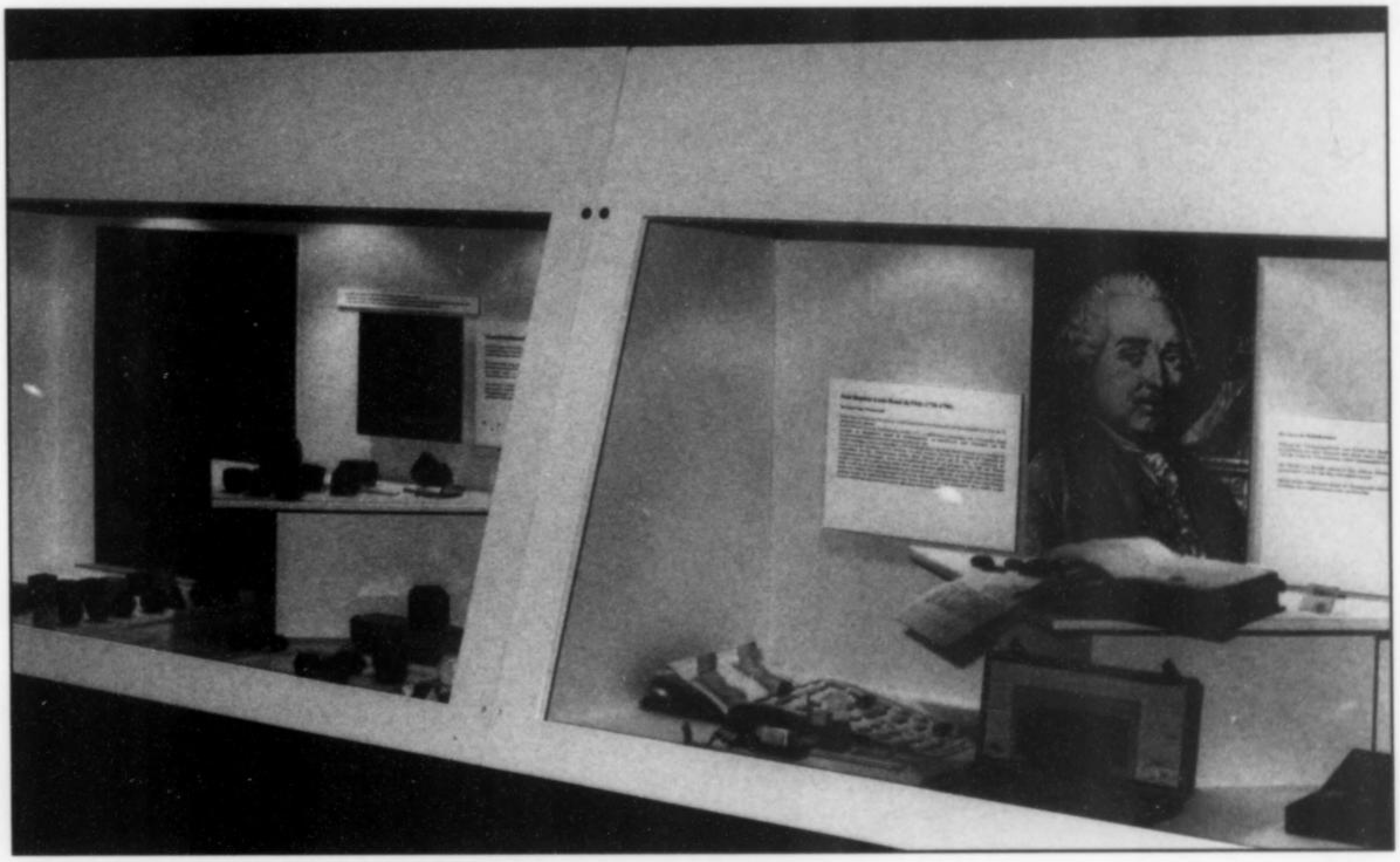


Figure 1. **Two cases from the special exhibit on "200 Years of Crystal Models" by Lydie Touret and Uli Burchard.**

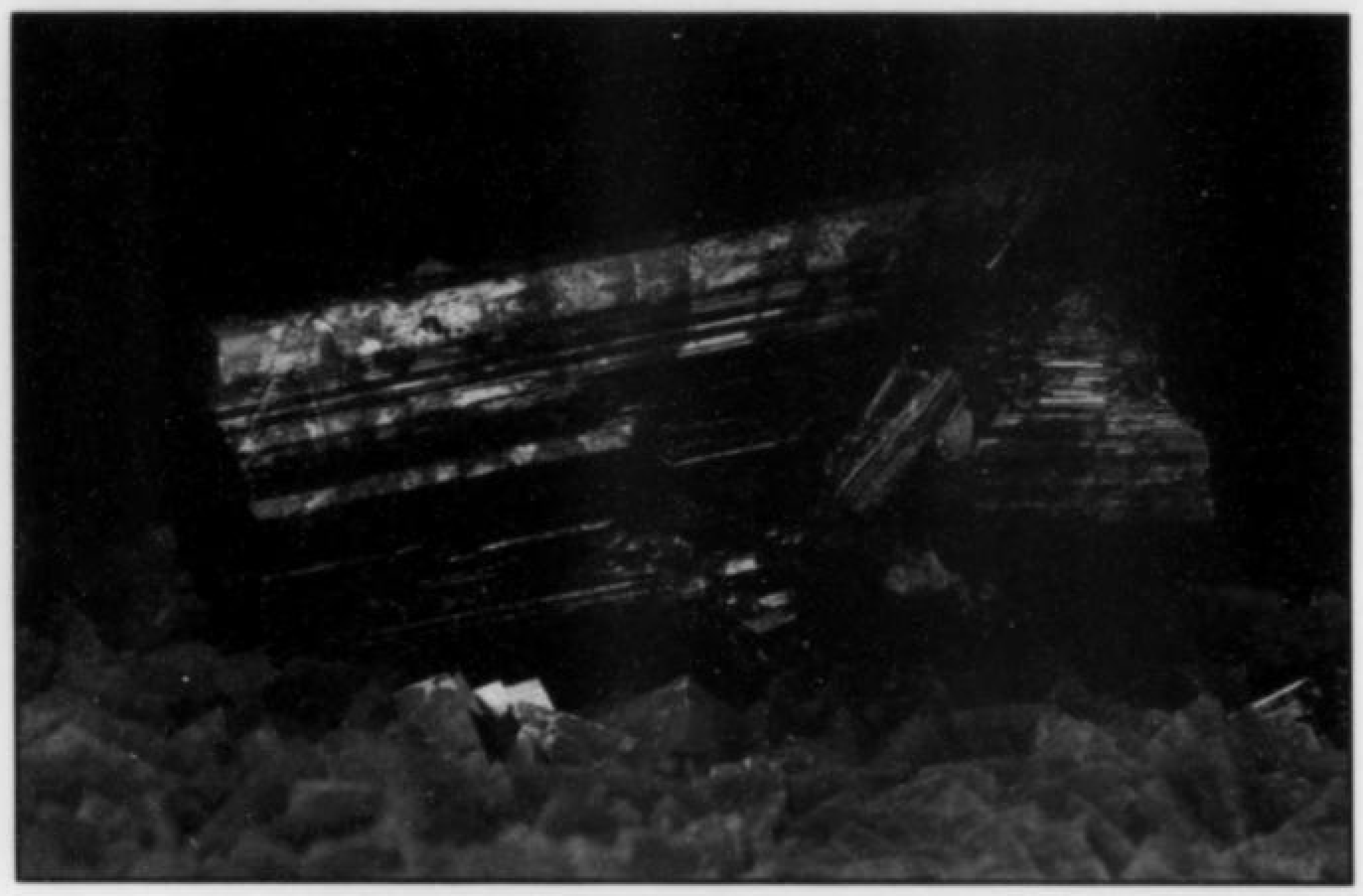
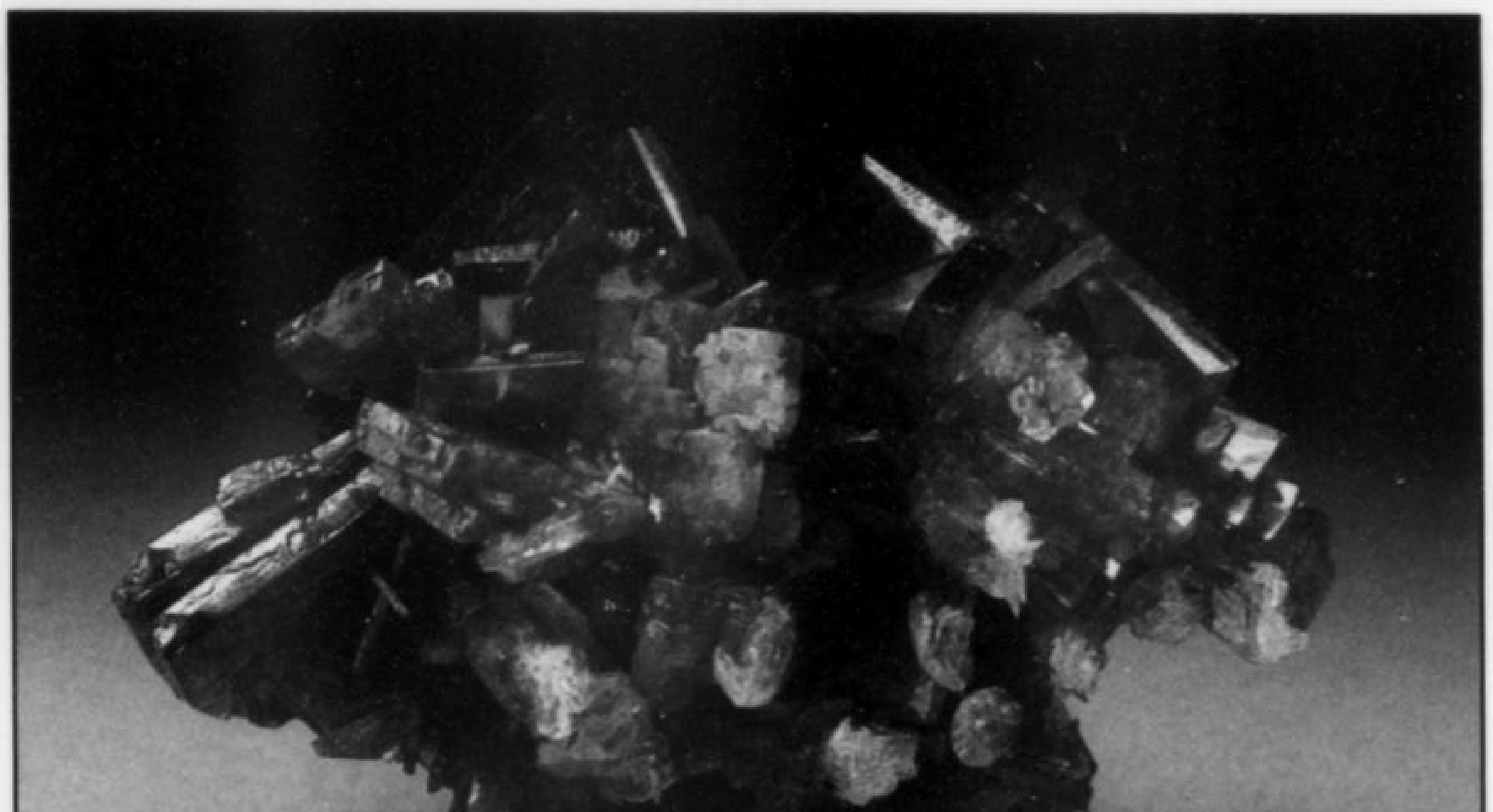


Figure 2. Chalcostibite (world's largest crystal, 16.2 cm) in siderite matrix, from St. Pons, France. Frédéric Escaut specimen; Jeff Scovil photo.

Figure 3. Chalcostibite crystal, 2.9 cm, on matrix, from St. Pons, France. Frédéric Escaut specimen; Jeff Scovil photo.

Figure 4. (below) Wulfenite crystal group with calcite, 4.7 cm, from the La Aurora mine, Chihuahua, Mexico. *Blue Sky Minerals* specimen; Jeff Scovil photo.



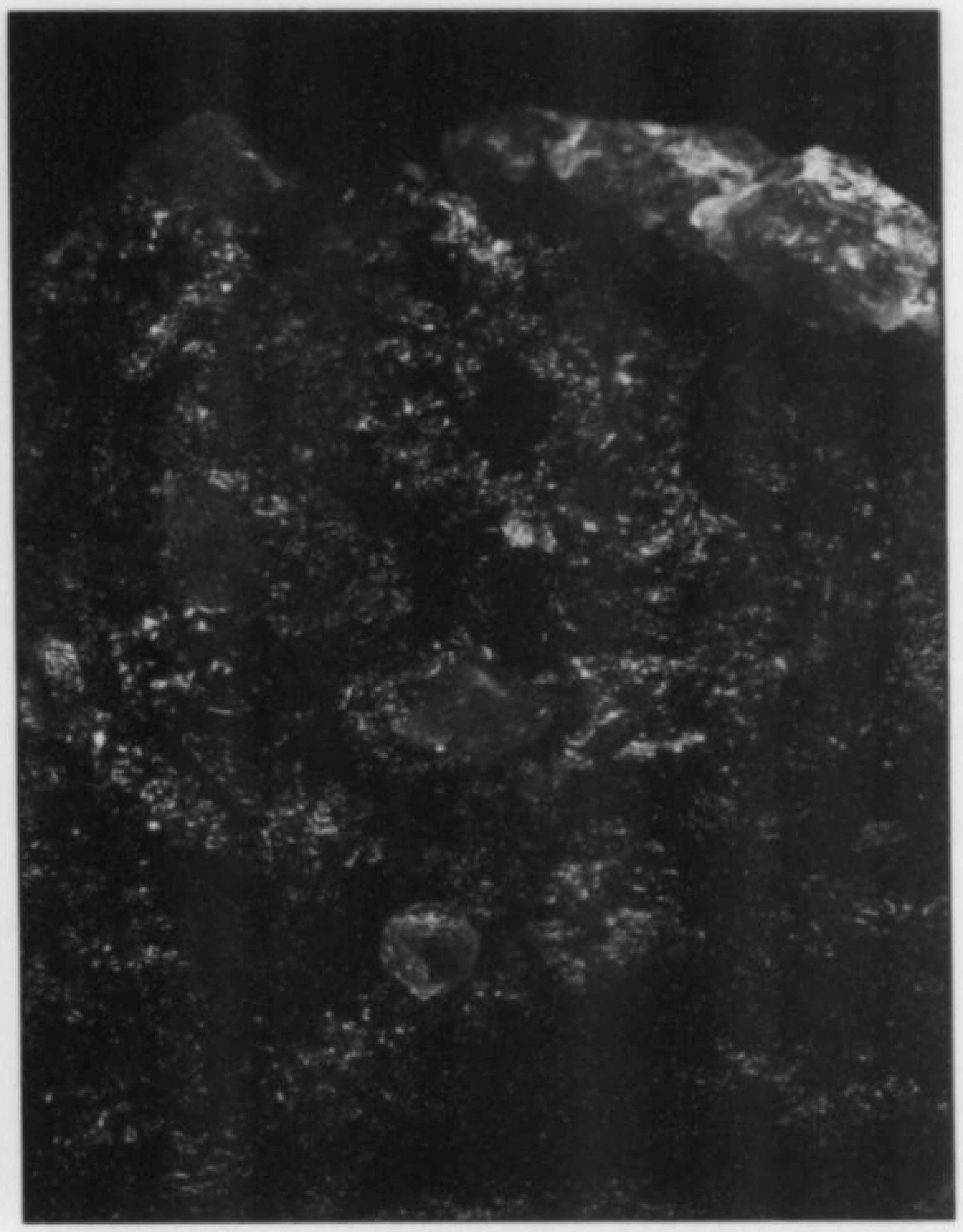


Figure 5. (above and above right) **Copper on cobaltian calcite specimens, 4.4 cm wide (left) and 5.3 cm tall (right), from the Mashamba West mine, Zaire.** ***Gobin Mineraux*** **specimen; Jeff Scovil photos.**

Figure 6. (right) **Smoky quartz crystal groups from Morella, Victoria, Australia.** ***Mineral Classics*** **specimens; Mick Cooper photo.**

Figure 7. (below) **Anatase crystals on quartz crystal, 7.3 cm, from Lapcha, Northern Urals, Russia. Dave Bunk and Dan Weinrich specimen; Jeff Scovil photo.**

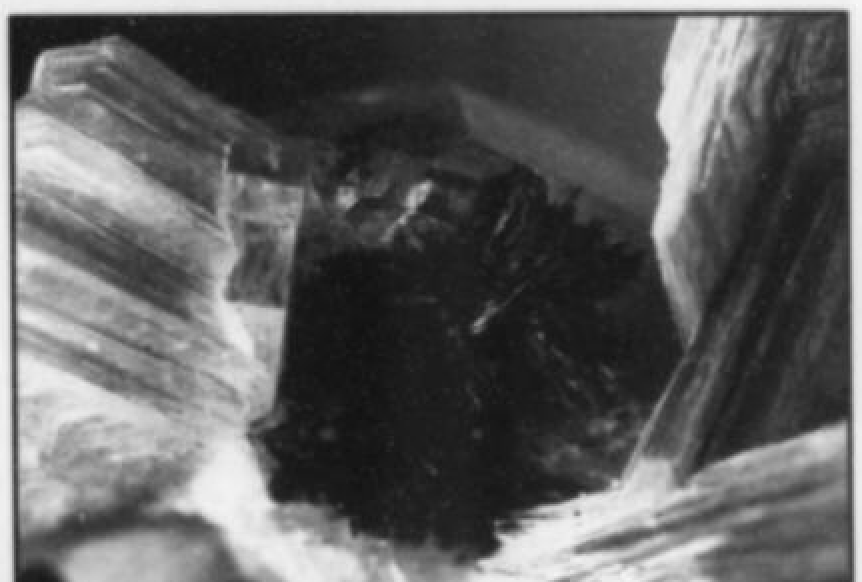


Figure 8. (left) **Mangano-tantalite crystal spray, 1.5 cm, on quartz with muscovite, from near Gilgit, Pakistan. Andreas Weerth specimen; Mick Cooper photo.**

collector's passion for the mineral. Almost every significant fluorite occurrence was represented, generally by specimens of very high quality, some of extreme rarity and desirability. For instance I found the London Natural History Museum's contingent cross-eyed over an unusual item from Saxony showing almost *"scalenohedral"* fluorite crystals. This unique occurrence, in the Grube Căcilia, is supposed to be the result of selective but symmetrical growth of certain hexoctahedral faces. Similar distortions more commonly occur in pyrite.

But how can such an exhibit be described in what is intended to be a brief letter? My notes run to half of my pocket notebook and can hardly be transcribed verbatim. After some thought I decided to group these pieces by color. Fluorite, after all, is one of the quintessentially colorful minerals, and the color at individual occurrences is often unique to that place; who, for instance, would confuse purple Cumbrian fluorites with counterparts from anywhere else? Where but the Alps produces octahedra of that shade of pink? Well, this is dangerous ground, and I'm sure that if there are such similar localities someone will tell me. Anyway, starting at the red end of the spectrum, the best must be the pink octahedra from the Alps, and Eric Asselborn showed his fine suite including the monster named "Georges"—18 cm of serious fluorite crystal from the Aguille des Péllerins. Herb Obodda showed a beautiful rose-pink cleavage octahedron from Novo Ramansko, Kazakhstan, about 9 cm on edge (fluorite crystals from here can be over 1 meter across!). Incidentally, a nice touch in the Houston exhibit was a large matrix specimen of octahedral pinkish fluorite crystals from Huanzala, Peru. This had been broken in two at some time and the fragments lodged in two collections. The two specimens, now in the collections of Houston and of Rock Currier, were temporarily reunited for this occasion. Orange doesn't seem to be well represented, though some of the material from Rios, Argentina, inclines that way (more of this later). In yellows the British and German localities shone: Hilton mine, Scordale, Cumbria, and some of the Saxon localities were beautiful. In the latter, Herb Obodda scored again with an old (Bement Collection) and gorgeous deep yellow fluorite with galena from Schönbrun, Saxony, which must have made many a German collector envious.

Getting into the green we come back to England again. Green fluorites from Cumbria have long been coveted, and dealer friends tell me that even mediocre specimens are highly sought after and rarely stay on the table long. The Heights mine, Cumbria, is supposed by many to be the peak of perfection here, but look again. Very often these specimens, though showing a fine color, are not otherwise particularly handsome, being dinged or lacking appeal in the way the crystals are disposed. Compare these with the deep electric-green cubes with amber cores from St. Peter's mine, East Allendale, Northumberland. The specimens in Munich were collected by Sir Arthur Russell in 1937 and must be some of the finest fluorites anywhere. The Heights mine specimen beside them was quite overshadowed. There was also some fine green fluorite from the Grube Căcilia, in a fine, pale olive-green with black inclusions. A combination of pale green cubes with red "eisenkeisel" quartz from the Grube Hermine was a nice contrast. Going to wilder shades of green there was a remarkable example from the American Tunnel, Sunnyside mine, Silverton, Colorado, brought over by the Houston Museum of Natural Science for its exquisite display. This specimen has been featured on the cover of *Rocks and Minerals* and on the show poster for the 1987 Denver Show (which I'm looking at on my wall as I key this). But don't trust those images; this specimen's color is an amazing electric-green and the contrast with its drusy rhodochrosite matrix quite unique; color film—so far—has no chance against this reality. There is also some spectacular green fluorite from China on the market I'm told. It has a remarkable emerald-green color and reputedly is very attractive. It is, however, produced by irradiation and the color will fade in daylight after a while. Beware of this and also of the so-called "periclase" recently offered from China: these gray cauliflowers are sublimates broken from magnesia furnace flues.

Moving through the fluorite spectrum brings us to blue, and here the competition gets a little fiercer: British, French, American and Chinese specimens vie for honors. Beautiful and subtle though our own pale blue cubes from Cumbria or Cornwall may be, I have to hand the laurels to France. From Le Burg (Tarn), Le Biex and the Puy-St-Gulmier come blues of intensity increasing in the listed order, reaching in the last a wonderful deepest sea-blue. The rather similar Illinois blues are often too dark or masked by overgrowths, though of an exquisite shade; to see the joys of these you had to look in the case of cut stones by Art Grant where a huge and wonderful 3,965.35-carat stone dominated the proceedings.

Purple again brings in a lot of competition. I have to be patriotic and say I prefer the large glassy purple cubes from the Boltsburn mine, County Durham, England, but there are many fine specimens from the Elmwood mine in Tennessee. Jordi Fabre displayed a nice suite with contrasting white barite from Berbes in Spain.

And we must not forget the colorless fluorites. Herb Obodda's display of dozens of well-chosen pieces from worldwide localities included a fine "optical fluorite" in flawless colorless cubes from Dal'negorsk, Russia. Material of this sort seems to have been one of the latest phases of fluorite production at Dal'negorsk, and a few pieces could be seen for sale around the show, though not up to this standard.

Of course, one of the attractions of fluorite is that it often displays dramatic color zoning. One of the classics is the unique blue-purple-white banded "Blue John" from Derbyshire, and this was represented by specimens and worked examples of bowls and inlaid slabs and table tops (loaned by British dealers Clinton Burhouse and Don Edwards) accompanied by a magnificent Victorian urn from the Royal Museum of Scotland, one of the largest known. In a nearby case was the recent green and bluish banded Chinese answer to Blue John. This tends to be a much more compact stone and thus easier to work without the resin bonding common in British Blue John items. It's often worked into fine bowls, some of which are enhanced by a layer of compact pyrite left on the rim of the bowl to great effect, though it may pose conservation problems later on!

The *pièces de résistance* at the exhibit were undoubtedly the scores of faceted fluorites displaying the work of lapidary Art

Grant. This really drew together all the incredible colors to be seen in this mineral. Some seemed almost too rich or too large to be real, and I admit I was momentarily fooled by one almost blood-red bar-cut stone labeled "United States" until I saw the word "synthetic" underneath. In the center was the huge, deep blue stone from Illinois, and here and there a couple of absurd jazzily banded stones from Rios, Argentina, showing sharp parallel bands in shades of green, red, yellow and brown.

The other main special exhibit was *200 years of Crystal Models,* put together by long-time experts in the field Lydie Touret of the Ecole des Mines in Paris and Uli Burchard. This excellent display showed models and associated crystal-measuring equipment, from the terra cotta models of Romé de l'Isle all the way up to the latest computer drawing package *SHAPE for Windows.* It contained many beautiful and rare sets of models in substances as varied as cast iron, brass, porcelain, plaster, wood and colored glass, along with antique goniometers, and images and biographical notes regarding the principal players in the development of the science. It was a great opportunity to see such a variety of items and to feel the excitement of the unfolding understanding of the challenging forms of crystals. The delicacy and perfection of some of these complex and ancient models fill an amateur model-maker like me with admiration.

Elsewhere in the show there are always areas dedicated to smaller thematic displays by dealers and collectors, and these are always worth a close look. I noted some interesting items here including a killer malachite-coated cuprite from Onganja, Namibia, in the display of Ula-Ulricke Kahn; I liked the cockscomb hematite from the Toinot mine, Haute-Saône, France (like sparkling black cockscomb barite); and I was impressed with the Mocha Stones displayed by Brian Lloyd, these old masterpieces making the currently available material look trivial. There was an exhibit of minerals named after Danes which included carlsbergite, probably the best mineral in the world named after a brewery.

So what was hot in the dealers' halls? **Minerals from Russia**, especially from Dal'negorsk and Kola, are still plentiful and seemed to me to offer somewhat better value than last year, especially if one bought from the Russian dealers. Access to Germany is relatively easy for dealers from at least the western part of the old Soviet Union, so Munich is a good place to see plenty of selection. Numbers of foreign (i.e. non-German) dealers from the CIS and Ukraine were second only to France this year. There were more good things from Spain and France, from Africa, and especially from China and Pakistan. And, of course, special displays of fluorite were dotted about on many dealers' stands.

Of Russian minerals one could do worse than start with **calcite** from Dal'negorsk, which seems to have adopted almost every form known in the species, and one is constantly surprised to find that a new variety is yet from the same place. A selection of the best from here would be quite an eye-opener, given the huge variation and high quality seen from time to time. There were some remarkable specimens in the special exhibits, including a doubly terminated colorless prism pierced by aragonite needles, but none like that for sale unfortunately. Many of the pieces offered for sale just don't quite make the grade aesthetically; careful searching of dealers' stands is necessary to find the good ones. A similar story applies to those still coming in quantity from Rudnyy in Kazakhstan. The honey-yellow specimens from here are well known now, their often pseudo-cubic habits difficult to decipher. I saw, however, one piece of this color that was a nice and easily recognizable butterfly twin (on the stand of *Ammonite* from Moscow); though this piece was unfortunately too dinged to make the top grade it might presage better ones to come. The latest display-quality calcite specimens from this locality show colorless, lustrous crystals to several centimeters with a drusy amber-colored mineral described by some as **stellerite**, though opinions varied. Good ones—like those on the stand of Pierre and Martine Clavel—can be very nice. Similar material was also on offer from India: Martin Rosser (Orthstrasse 14, 81245 Munich, Germany) had some very attractive material from Jalgaon.

Looking at the sulfide suites on offer, the Nikolaevskiy mine at Dal'negorsk continues as the main Russian source, and specimens were widely available. These were challenged only for quantity by Romanian sources such as Herja whence a great deal of superb **stibnite** continues to be available. The best I saw this time belonged to Mike Bergman, who shared the booth of Andreas Weerth. His specimen was a perfect hemispherical spray of delicate stibnite blades some 15 cm across on matrix: a very fine piece indeed and destined for the Houston Museum—an institution which seems from its several public showings over here to have a happy combination of money and good taste. Chinese **realgar** and **stibnite** were everywhere, in some spectacular crystals, seemingly bigger at every show these days. One stibnite I saw, on the stand of *China Hunan Natural Mineral* (along with dozens of blood-red realgar crystals), is as thick as my arm, which, admittedly, is not enormously thick, me not being a Schwarzenegger, but it's still an impressive size for a stibnite. Unfortunately, although wonderfully lustrous, these stibnites are still generally too dinged to really challenge the Japanese classics. Let's hope that collecting techniques improve. Truly remarkable, however, are the new **arsenopyrite** specimens from Hunan. These sharp, simple crystals reach 10 to 15 cm and may be associated with bright, clean **stannite** crystals to 1 cm or more. Frédéric Escaut had an exclusive suite of these. And a real killer find was the **chalcostibite** belonging to Frédéric and fellow Frenchman Christophe Dubois. This is from Saint-Pons, Haute-Provence, France, where several rare sulfosalts occur in lenses of siderite in marl. Many fine specimens were available in Munich showing excellent needles of **zinkenite** as well as fine crystals of chalcostibite. The best of the latter was a matrix piece bearing a remarkable 7-cm prism in a fold of siderite along with other lesser crystals. This outshines the previous best-of-species (a mere 4 cm long) from the same place reported in the article on the locality in *Mineralogical Record* (vol. 24, p. 41).

Although predictions of a fond farewell to the Nikolaevskiy mine[1] seem to have been premature, the demise of the First

[1]Spellings follow Smith and Smith's "Guide to Mineral Localities in the former Soviet Union," *Mineralogical Record,* vol. 26, no. 6.

Figure 9. (above) Crocoite crystal group, 2.6 cm, from the Dundas Extended mine, Dundas, Tasmania. Martin Rosser specimen; Jeff Scovil photo.

Figure 10. Scheelite crystal group, 5.3 cm, from near Skardu, Pakistan. Kurt Hefendehl collection; Jeff Scovil photo.

Figure 11. (left) Scapolite crystal, 3.3 cm, from the Pamir Mountains, Tajikistan. *International Mineral Exchange* specimen; Jeff Scovil photo.

Figure 12. Gold on calcite, 3 cm across, from Hope's Nose, Devon, England. *Crystal Classics* specimen; photo by Ian Bruce.

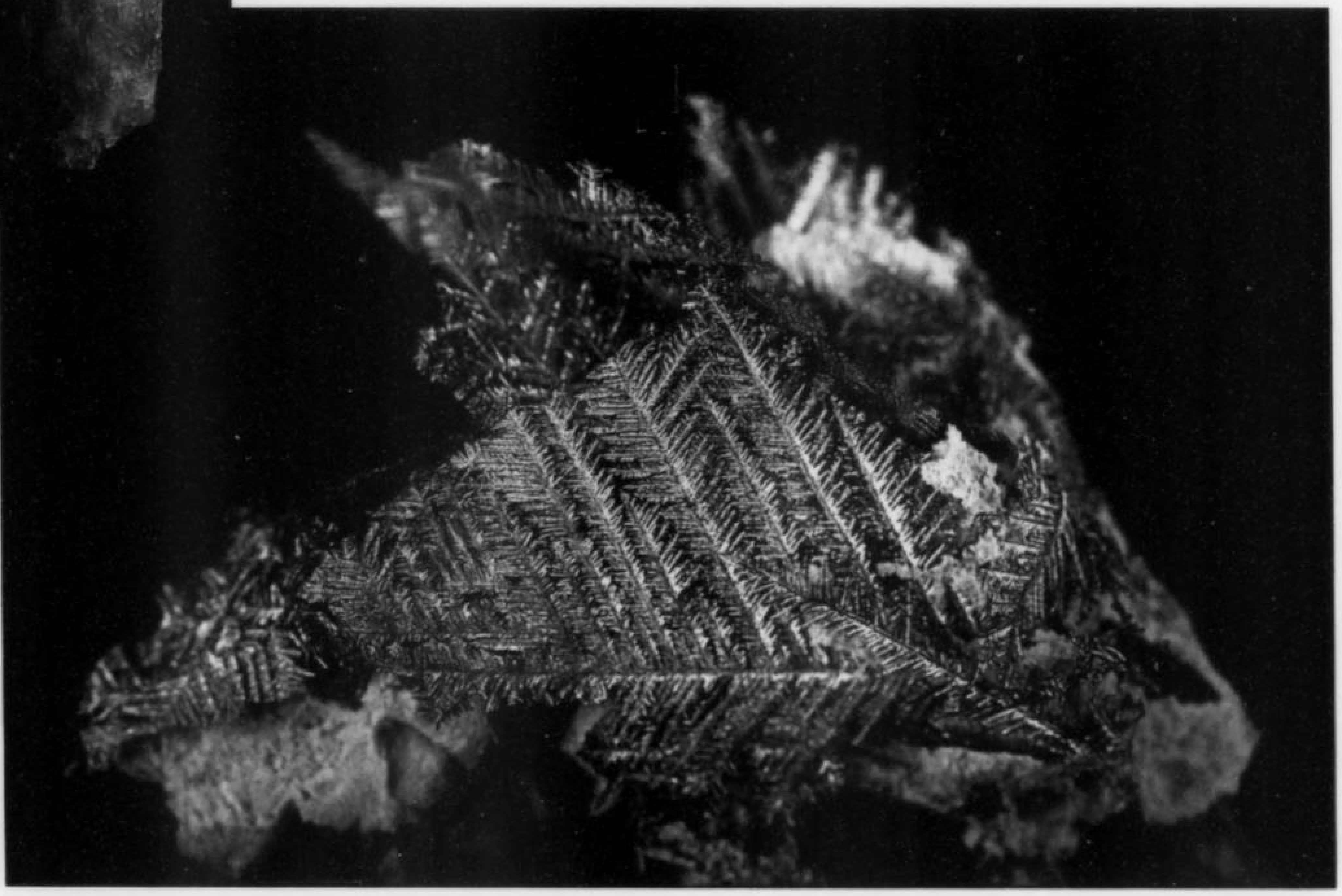


Figure 13. Chalcanthite crystal group, 7.6 cm, from the Hedmark-Oppdal mine, Norway. *Roberts Minerals* specimen; Jeff Scovil photo.

Figure 14. (above) Brazilianite crystal group on quartz, 5.4 cm, from near Mendes Pimentel, Minas Gerais, Brazil. *Hawthorneden* specimen; Jeff Scovil photo.

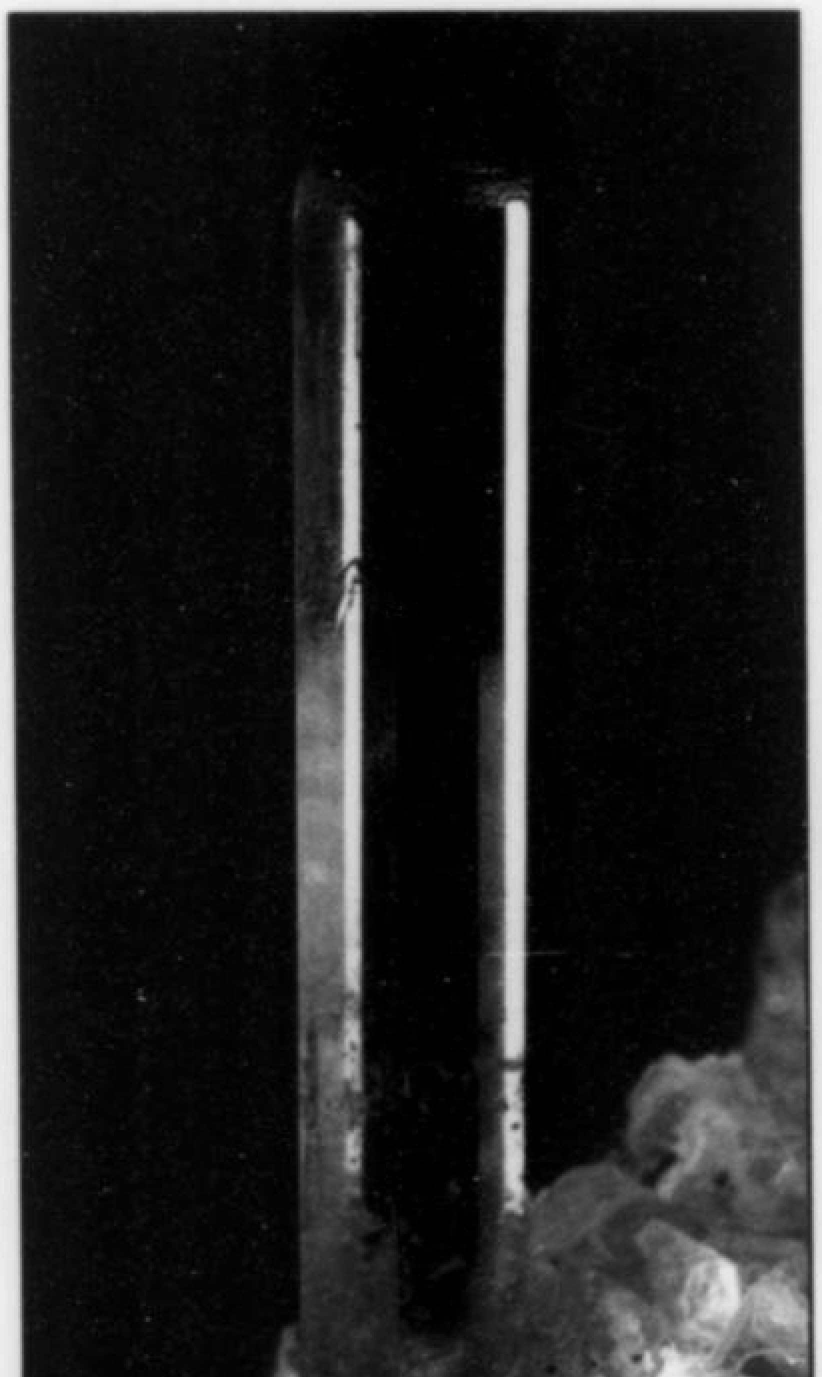


Figure 15. (left) Beryl crystal, 2.6 cm, from Zelatoya Vada, Pamir Mountains, Tajikistan. *The Arkenstone* specimen; Jeff Scovil photo.

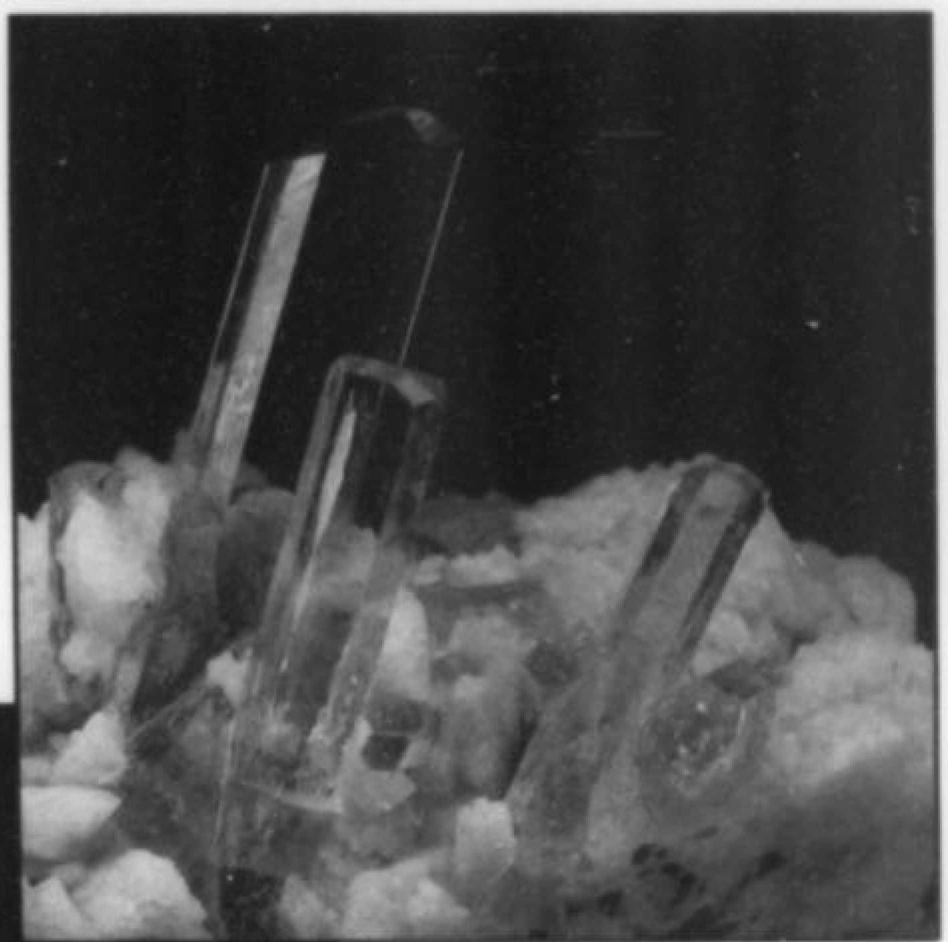


Figure 16. (above) Beryl crystals to 2.9 cm, on matrix, from Zelatoya Vada, Pamir Mountains, Tajikistan. *The Arkenstone* specimen; Jeff Scovil photo.

Figure 17. (left) Beryl crystals to 2.6 cm, on matrix, from Zelatoya Vada, Pamir Mountains, Tajikistan. *The Arkenstone* specimen; Jeff Scovil photo.

Sovietskiy mine at Dal'negorsk, source of much fine ilvaite, was recounted to me by several dealers. It had been closed for many years when collectors started working it for specimens, but all the relatively easily recoverable material (i.e. what you can get without blasting) is said to be gone now and the mine has been abandoned once again to the ice. (Abandoned mines in England drown; in the nether reaches of Russia they freeze.) Unfortunately for sulfide collectors, too, there is less and less material coming from Bulgaria where the 9th of September mine at Madan has produced many fine specimens. According to Pierre Clavel, the principal movement of specimens to collectors of recent years has been from the accumulations made by miners over the last few decades. This resource is almost exhausted now and the actual production rate from the mine is too slow to satisfy demand.

As well as minerals, Munich is also a good place to see and buy mining memorabilia and historical artifacts such as miner's lamps and stock certificates, and of course is seventh heaven for those interested in lapidated stones. A nice combination of the two was to be seen on the stand of Pierre and Martine Clavel, who had two old specimens of what can best be described—stylistically at least—as scrimshaw. But scrimshaw of an unusual kind: these are engravings on cut and polished **datolite** nodules from the Michigan copper deposits of the Keeweenaw Peninsula. One showed the "Adventure mine" and the other the "Delaware mine." According to the *Mineralogical Record* special issue devoted to these deposits (vol. 23, no. 2), the Adventure mine is in Ontonagon County and there is a Delaware mine in Keeweenaw County, Michigan. These somewhat crude but nonetheless charming items were obtained by Pierre in the U.S. from an old man who had acquired them in a car trunk sale; they were probably made about the turn of the century.

Mineral shows these days seem to be lacking in good supergene minerals. There are lots of fine sulfides, gangue minerals, pegmatites and zeolites, but not so much in the way of secondary minerals. Or is it just me? Certainly the Mexican and African mines that supplied so much many years ago are dead or long past their best and there's not a lot new about. I'm pleased to note, therefore, a new find of **wulfenite** from the La Aurora mine, Chihuahua, Mexico, offered by Dan Belsher (8890 N. Federal Boulevard, Denver, CO 80221). This material is a sort of hybrid of San Francisco mine and Los Lamentos, with crystals to about 1.5 cm with calcite in groups to 6 cm across. The locality is an old one and has produced orange bipyramids to 3 cm in the past. Christian Gobin (Chemin des Terres Longues, F-13770 Venelles, France) had a nice lot of native **copper on cobaltoan calcite**, the copper in bright, delicately crystallized dendrites and masses protruding from their deep pink matrix. This very attractive material is from Mashamba West, Kolwezi, Shaba, Zaire, and is superior to the similar lot from the Kamoto mine that I saw at Ste-Marie-aux-Mines a few years ago. Only one boulder was found on the dumps.

I was intrigued also by some new **rhodochrosite** from Kazakhstan on the stand of *AZ Minerals.* This is a fine raspberry-red and forms thick botryoidal coatings on matrix to about 10 cm across. There's also a lot of cutting rough available. The locality is a working iron-manganese open pit, which might pin the otherwise vague locality data down a bit (Kazakhstan being the tenth largest country in the world), but no other information was to be divulged just yet. A few associated species have been noted, but so far—with the possible exception of some lustrous black cerussite to 2 cm—no other specimen-quality minerals have come to light. There was also a spectacular (Peruvian) rhodochrosite specimen on the stand of Ramos Mills of Lima: a gemmy doubly terminated prismatic crystal with low rhombic terminations, about 3 cm long on a bed of smaller crystals. It drew a lot of admirers.

Gilles and Françoise Barras-Gauthier (Le Besset, 63880 Olliergues, France) had their usual spectacularly colorful stand, outstanding on which was some of the best from a recently acquired 200-strong collection of **dioptase** from Reneville, Zaire. These hand-picked pieces, all from one old collection, were, as one would expect on the B-G's stand, almost all very aesthetic, with fine, bright, deeply colored crystals to 2 cm or so, a select few associated with bright yellow wulfenite or smoky quartz. It was a rare opportunity to browse through so many fine specimens from this classic occurrence.

Quartz always features prominently in one form or another, though it doesn't often turn my head. However, one unusual item making a bit of a come back at Munich was the odd polyhedral masses of compact quartz or agate from Brazil first available some 10 or 15 years ago. This material then gave us some of the most unusual agates ever seen, having sharply angular banding following precisely the outline of the mass. They appear to have formed by deposition in the cavities between large intersecting quartz crystals. At Munich a couple of dealers had specimens, labeled variously "Rondovia" (Pierre and Martine Clavel) and "Paraiba" (B.J.A. Verholen, Holland), Brazil. Some good quartz from India was reported to me by Jeff Scovil, who spotted some interesting material from Kulu Manali, in the Himalayas, a locality previously known only for low-grade quartz which had recently yielded some very sharp, lustrous and gemmy clusters of colorless crystals, looking just like the Arkansas specimens. The specimens were being offered by *Kristall Ocean Export* (7 Vaswani Nagar 9, Koergoan Park, Poona 411001, India). *Crystal Classics* had a new find of smoky quartz from Morella, Victoria, Australia. These are singles and groups of sharp, bright crystals to several centimeters long with very attractive appearance; the coloring is zoned or patchy in some pieces and actually looks like brown smoke swirling within the crystal. The seal of approval has been given by the Houston Museum, which acquired the best piece at the show.

Fluorite was for sale all over the show. Pierre and Martine Clavel had some interesting stepped crystals from the old-established locality of Múzquiz, Coahuila, Mexico. These are mostly colorless cubes with complex purple overgrowths. Among them were a few with intergrown celestine. A second lot was of the dark purple variety once known as *antozonite* which emits fluorine gas (once thought to be ozone, hence the name) when crushed or bruised. Also from (way) south of the border, Ramos Mills had a nice group of purple cubes with bright pyrite from the Huanzala mine, Peru, along with a lot of other well formed Peruvian pyrites, but at 15,000 DM I figured it wasn't for me.

No major European show these days is complete without a new find of fluorite from Spain and, of course, Jordi Fabre of Barcelona had such a suite of specimens at Munich. These are almost colorless crystals with prominent hexoctahedral faces, associated with white platy barite, and are characterized by an interesting set of inclusions: red cinnabar, black sphalerite and brassy chalcopyrite all in minute crystals. The locality is the Jamina mine, Caravia Baixa in Asturias, and is only a small concern, likely not to last too long. Current fluorite specimen production from Dal'negorsk is so-called "optical fluorite" in perfectly water-clear flawless cubes in crystals to several centimeters; similar quality crystals, though larger and associated with quartz, have also been reported from China and are likely to make their debut in Europe at the Paris show.

Andras Lelkes (Hercegprimás u. 11, H-1051 Budapest, Hungary) had a few new Russian things with good potential. Some **cassiterite** from Merek, Habarousk Region, in eastern Siberia in sharp prisms to about 3 cm of a dark smoky brown, shows a reddish transparency under a good light. These are available in small groups and were collected from an outcrop rather than a working mine. From Lapcha in the northern Urals, Andras also had a few **anatase** specimens showing sharp bipyramids on quartz, associated occasionally with orange **monazite**. The material is similar to the well-known Norwegian occurrence, though not so spectacular. Dave Bunk Minerals also had a batch and I saw a few unlabeled specimens on some of the Russian stands.

The display of Andreas Weerth is always a good place to stop and browse, always colorful and spectacular from a wealth of pegmatite minerals. Big morganites, aquamarines and other gem minerals like these always amaze me, and not just because of their beauty; somehow they also have an aura of really *serious* mineral collecting. Andreas certainly had some fine examples this time, but what caught my eye more was a pair of interesting **manganotantalites**, one a large slab of a crystal about 5 cm high, of familiar form and color (from Nuristan, Paprock), and the other rather less obvious as it forms sprays 1.5 cm across of thin, dark brown blades on quartz. This unusual piece from the Shigar Valley, Gilgit, Pakistan, had only just been identified by the University of Munich.

Across the aisle from Weerth was the smaller display of *Crystal Classics* (Ian Bruce) which contained, despite its modest size, a most interesting range of material. Here was the finest suite of **gold** feathers (too delicate to be called ferns) to come for a long time from Hope's Nose, Devon, England. These were collected, we're assured, from outside the boundary of the Site of Special Scientific Interest to which the occurrence has been assigned by conservationists. Not to be left out of the show theme, Ian also had some **fluorite** forming pale green frosty octahedra overlapping drusy **argentite** from the Huanzala mine, Peru; a curious and attractive combination. Ian's selection of **atacamite** nodules of excellent quality from the Mt. Gunson mine, South Australia (whose tailings ponds yield sprays of green copper-stained gypsum) were selling well and contrasted with some nearby specimens of attractive *blood-red* **variscite** from Iron Knob, also in South Australia. And while looking at a rich **sperrylite** on the stand I noticed that it had on one side a mold of the edge of a cubic crystal over 1.5 cm long . . . could it have been the one that got away? Another Australian classic making one of its periodic comebacks was **crocoite** from the Dundas Extended mine, Tasmania. A good pocket of crystals was found earlier this year and yielded a lot of generally fairly small groups of delicate cavernous prisms. Martin Rosser had a nice lot.

And lastly, there was a new find of **brazilianite** at Mendes Pimentel, Minas Gerais, Brazil, specimens from which were to be seen on several stands. Luiz Menezes (110 Belo Horizonte, R. Andre Cavalcante 761, Brazil 30430) had some fine ones with sharp, flattened crystals in singles and clusters on quartz; and on the *Crystal Classics* stand was a fine display piece (actually belonging to Anthony Fraser, PO Box 119, Golden Square, Victoria 3555) with a single pale lime-green blade on quartz. The material had been collected in September. Crystals reach 5 cm.

Well, that was Munich—for me anyway: very enjoyable, and basking in bright autumn sunshine, the tail end of this year's record-breaking long hot summer. Next year we can't guarantee the weather, but we can say the special exhibits are planned to be the collections of Royalty . . . and pebbles. As disparate and eclectic a selection as you could get, and I'm sure they'll be fascinating. I've always liked both myself.

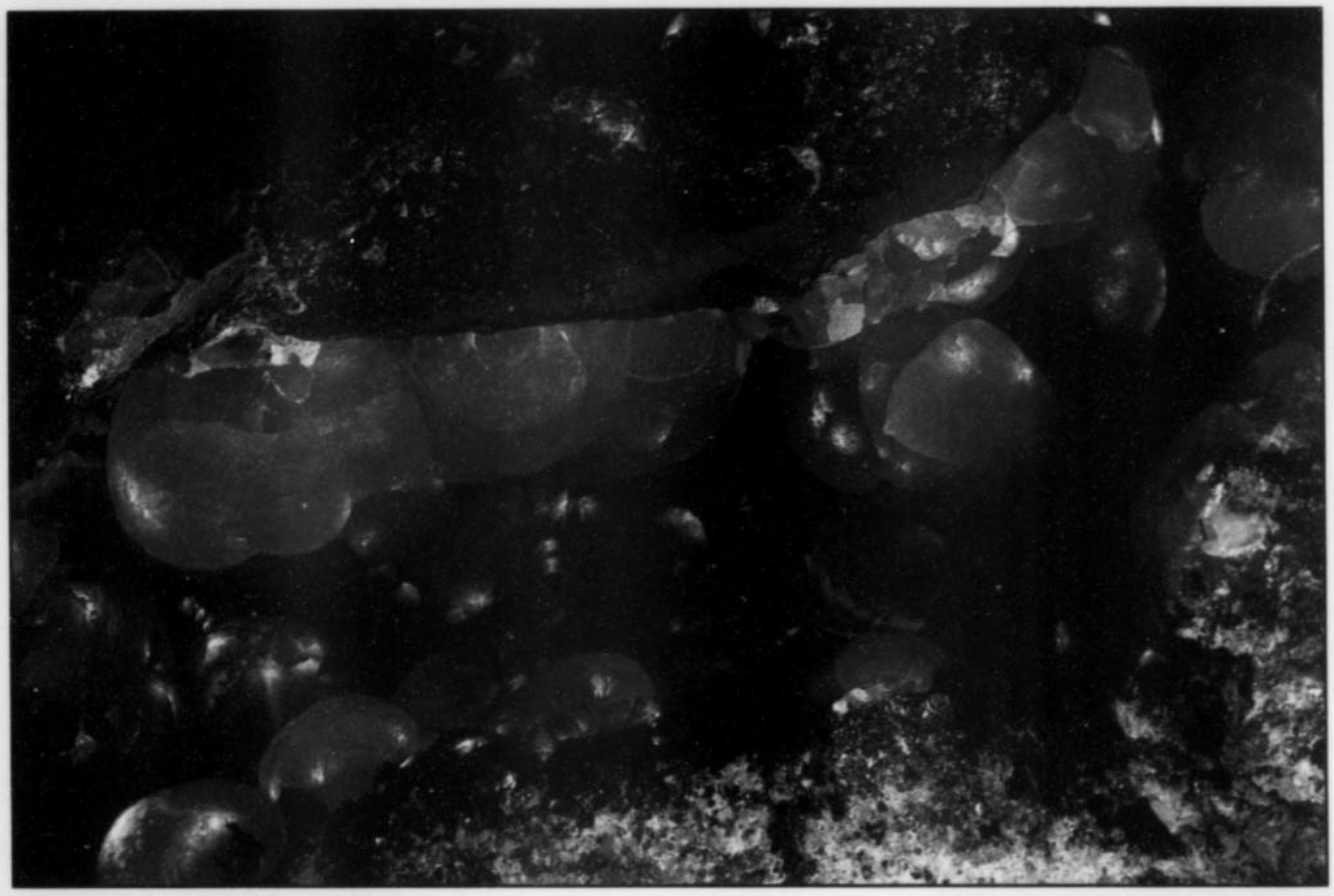
California Show 1995 — by Jeff Scovil

[November 17–19]

The new *California Mineral, Fossil, Gem, Jewelry and Lapidary Arts Show* (which for the sake of brevity I will refer to henceforth as the Pomona Show) made its debut this year. It is the updated version of the old Pasadena Show, and is now run jointly by Martin Zinn Expositions and the Mineralogical Society of Southern California. The new location is at the spacious Los Angeles County Fairgrounds in Pomona, easily accessible from Route 10, and offering countless acres of parking space.

The dealers in both wholesale and retail totaled 100 and filled the cavernous hall, along with fine exhibits from dealers, collectors and museums. The show theme was **emeralds**, with many fine exhibits on the subject. Marty secured the services of several fine speakers including Bob Jones, John Sinkankas and Tony Kampf.

There were several items of note to report on. The new **heliodor** (yellow beryl) from Tajikistan seen earlier at the Springfield Show was well represented by the fellow who was responsible for their appearance in the West: Rob Lavinsky of *The Arkenstone* (6163 Lakewood St., San Diego, CA 92122). Rob told me that until he came on the scene, the crystals, which commonly occur on matrix, were broken off and sold for cutting material. The most accurate locality designation so far is Zelatoya Vada, near Rangkul, Pamir Mountains, Tajikistan. The crystals are quite lustrous, sharp, gemmy and a pleasing shade of yellow with no green tint. Rob has found very few that show any etching. There has been some concern over the possibility of the pieces being irradiated to



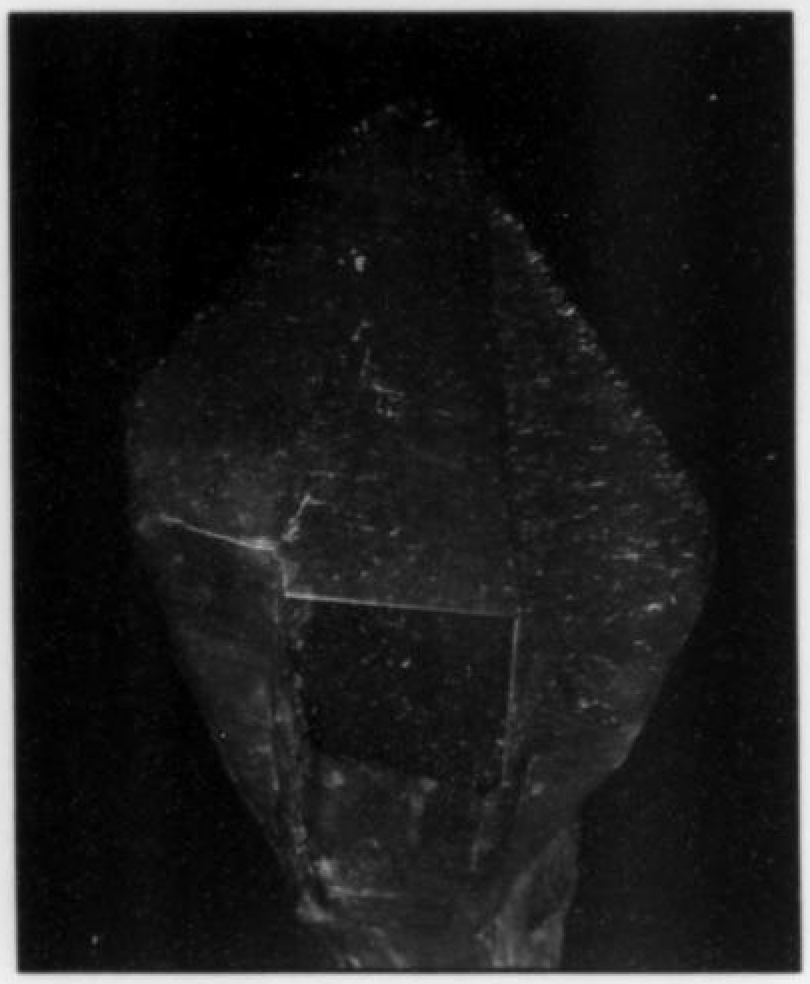
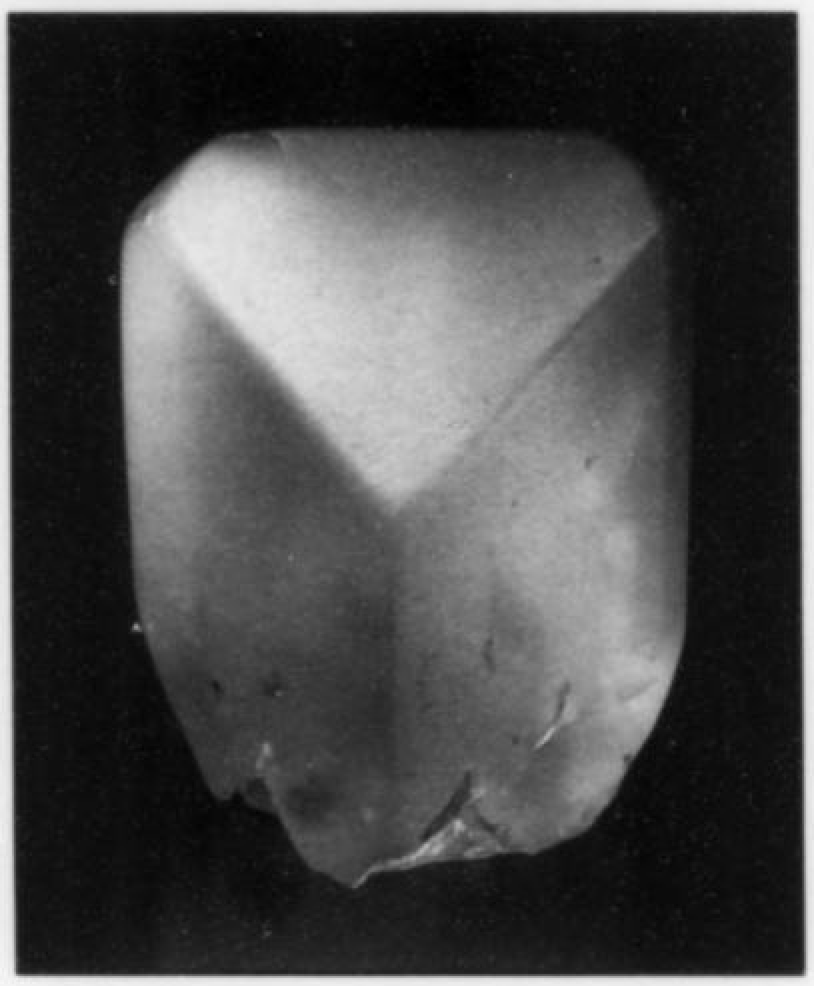


Figure 18. (above) **Smithsonite on matrix, 10.7 cm, recently collected from the Kelly mine, Magdalena, New Mexico.** ***Copper City Rock Shop*** **specimen; Jeff Scovil photo.**

Figure 19. (left) **Quartz crystal, 5.3 cm, containing red (hematite?) inclusions, from Madagascar.** ***International Mineral Exchange*** **specimen; Jeff Scovil photo.**

Figure 20. (right) **Water-worn topaz crystal, 7.2 cm, from Lam Dong Province, Vietnam.** ***Excalibur Gems*** **specimen; Jeff Scovil photo.**



produce the fine color. But considering that the crystals are found on matrix, occasionally with colorless quartz crystals, this seems doubtful.

For those who like strange things from the mineral kingdom, Harvey Gordon had the ticket: **quartz epimorphs after barite** from Hot Creek Valley, Nye County, Nevada. The material was collected at an old barite mine in August of 1995. Individual epimorphs are up to 8.5 cm, long in attractive clusters.

Chalcanthite usually occurs as crusts or ram's horn formations on the walls of abandoned mines. An abandoned copper mine in Hedmark-Oppdal, Norway, produced some very well-formed crystals of the copper sulfate this past August. Individual crystals up to 2.5 cm occur in groups to 25 cm. The material was being handled by *Roberts Minerals.*

It seems that Vietnam is the source for more than memories of a destructive war these days. James Hoffman of *Excalibur Gems* (3673 Linwood Pl., Riverside, CA 92506) was selling some very interesting **topaz** crystals from Lam Dong Province. Like the Vietnamese tourmalines seen at the 1995 Tucson Show, these topaz crystals are from placer deposits. Some are extremely worn, and others only slightly, indicating that the source is quite close by. A number of the crystals weigh several kilograms. We should keep an eye on this Southeast Asian country, as Jim indicated that there were several other similar localities nearby. Once the easily worked placers run out, the locals will probably start working the pegmatites themselves.

International Mineral Exchange had a purple **scapolite** from the Pamir Mountains of Tajikistan, and an included **quartz** crystal from Madagascar. The quartz is just like the "strawberry quartz" that used to come out of Mexico, and similar to material that has come out of Russia.

Last but not least is **smithsonite** from the famous Kelly mine, Magdalena, New Mexico. *Millennium, Inc.* now owns the property, which is being mined for specimens by John Mediz of the *Copper City Rock Shop.* Little work has been done so far, but a few nice specimens have been recovered. Keep an eye on the locality for further developments.

Franklin Show 1995 by Joe Polityka

[September 29–October 1]

The Franklin, New Jersey, show became a three-day affair this year, running from Friday to Sunday at the Franklin Elementary School on Washington Avenue. This created a dilemma for me: should I wait until Saturday to attend the show or take a vacation day on Friday and beat my fellow collectors to the punch? Well, you know the answer: I showed up Friday as would any other red-blooded, obsessive-compulsive mineral freak! The show committee had reserved Friday morning and early afternoon for the Franklin area school kids, and the grown up kids were allowed in after 4:00 pm.

The sixty-mile drive from my house to Franklin is a geologic field trip. I left the Cretaceous sediments of my neighborhood on Staten Island and drove over and through Ordovician serpentinite, crossed the sediments of the Newark Basin and drove up and over the Triassic basalt of the Piedmont before reaching the Precambrian gneiss, pegmatite and marble of northwest New Jersey . . . a billion-plus years of earth history within an hour's drive and lots of undiscovered minerals underfoot. If only I had X-ray vision? But back to the real world.

Eighteen dealers were set up inside the school gymnasium and offered the usual inventory from "a" to "z." *The Rocksmiths* had some **chrysoberyl** twins, in miniature and thumbnail sizes, from Fazenda Santa Isabel, Pancas, Espirito Santo, Brazil. They also had many one-of-a-kind pieces including a **danburite** miniature with 2.5-cm crystals that formed a hemispherical aggregate. This specimen is from the San Sebastian mine, Charcas, Mexico.

The Mineral Cabinet had a nice selection of New Jersey and Indian **zeolites** and related minerals. Bill also had some **agates** from Aurangabad, India, that look like eyeballs, complete with pupil and iris. Imagine a small table full of these orbs, of various sizes, looking at you from all directions. I had an eerie feeling I was being watched! I told Bill these would make good theft deterrents or, at least, neat Halloween gifts for our squeamish partners.

Victor Yount had a large inventory of **fluorite** from Berbes, Asturias, Spain. He also had a flat of thumbnail and miniature-size **axinite** from the Dodo mine, Puyva, Russia, and numerous one-of-a-kind specimens. The true show-stopper was a miniature of Les Farges, France, **pyromorphite** of intense apple-green color in the kilo-buck range. The price of this beauty was equivalent to about 800 pizzas or 500 pounds of lobster tails, whichever you prefer.

Detrin Minerals had a large selection of specimens from China and Russia. Most notable were Danny's large **calcites** and **fluorites** from Dal'negorsk, Russia, and large **realgars** from China. As usual, there were plenty of one-of-a-kind pieces in every price range.

Howard Minerals had several nice **emerald beryls** from Colombia in massive, white calcite matrix. *STD Minerals* had **inesite** from the Wessel's mine, and **amethyst** crystals from Brandberg, Namibia. *Willis' Earth Treasures, Excaliber-Cureton* and *David Crawford* had a variety of worldwide pieces in all price ranges.

The following morning (Saturday) I was up before the seagulls—we don't have live chickens where I live. I shooed my neighbor's cats out from under my car and headed back to Franklin and the swap-sell being held in the open field next to the indoor show. I was certain I would again beat the crowd. After all, who would be crazier than me and arrive before 7:00 am? About 25 tailgaters to be exact! Some of these guys must have set up in the dark because their inventory was already fully displayed. I wonder how they felt their way around? Maybe they had some of those agate eyeballs!

After paying a modest fee, tailgaters were allowed to set up on a first-come-first-served basis. By 10:00 am, close to 100 tables had opened for business offering everything you would expect to see at a mineral flea market—books, magazines, minerals, fossils, rocks, hammers, chisels, etc. Show attendance was good, the crowd was friendly, the sun was shining and hawks were gracefully gliding overhead. The day was perfect!

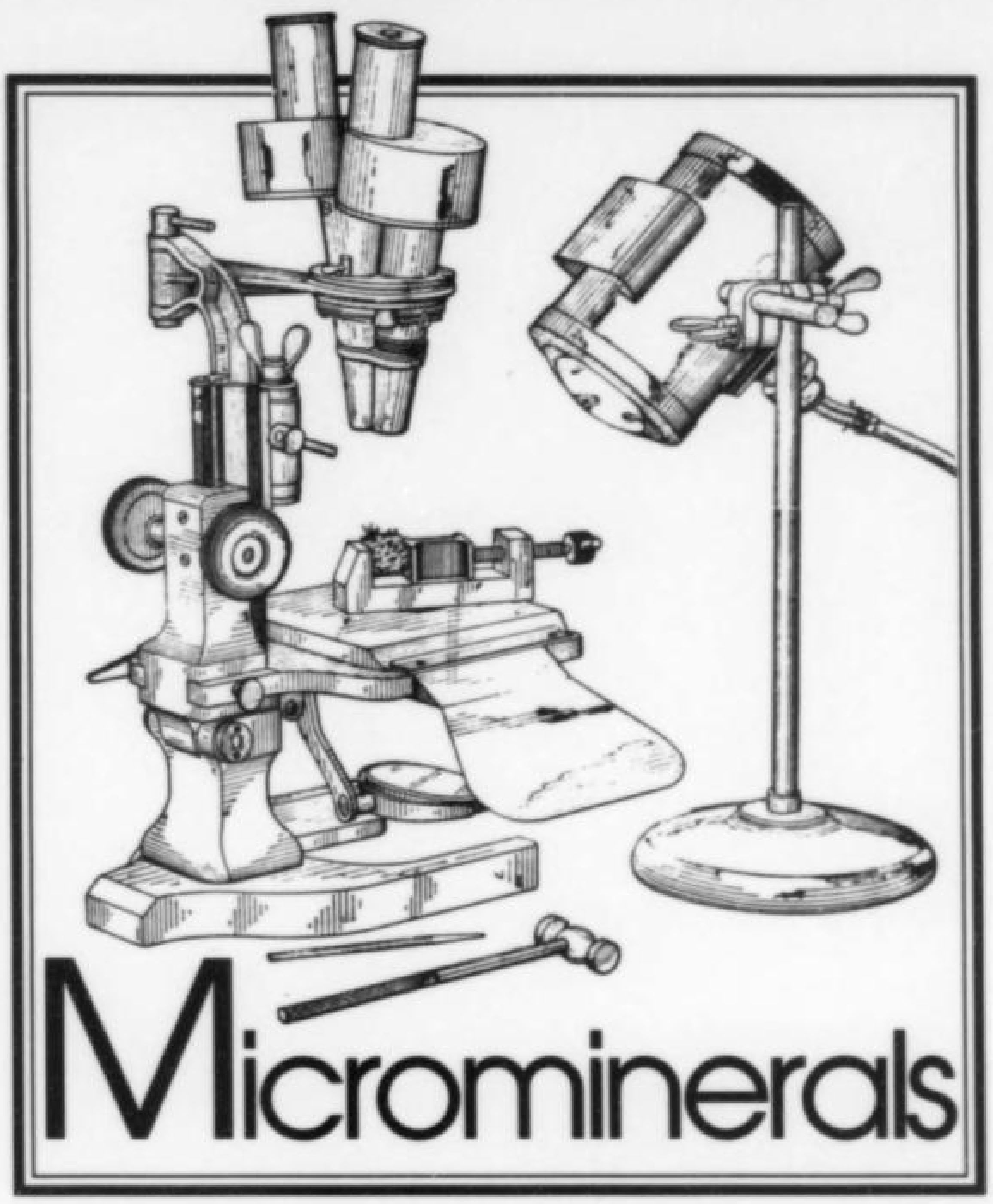
Like most tailgate extravaganzas of this type, the quality and quantity of minerals varies from year to year. This time, there was not much new available. However, some local collectors had a good selection of **zeolites** and related minerals from Millington, New Jersey. There was plenty of pink **pectolite**, **prehnite**, **apophyllite** and **calcite** from this famous quarry. A good representative suite of specimens could be acquired in small cabinet sizes for under $75. Of course, there were plenty of **Franklin fluorescents** in all price ranges. Several collectors had gone on summer field trips and had excellent Herkimer, New York, **quartz** and Pierrepont, New York, **uvite**. This show is a prime outlet for collectors who are selling or trading their duplicates, therefore, many interesting pieces were available. You just walked 'round and 'round until you spotted something you liked.

Several tailgaters of note were *Broken Back Minerals,* Newark, Delaware, who offered more of the Fred Keidel collection with a lot of oxidized zone stuff from Tsumeb and Mexico. Fred Keidel was a founding member of the Delaware Mineralogical Society who donated his collection to the University of Delaware; *Coisas Preciosas,* Newark, Delaware, who had a large selection of Brazilian pegmatite minerals at reasonable prices (4-mm crystals of **purple apatite** from Brazil were going for $15); and *Jeff Fast,* from Connecticut, who was disbursing about ten flats he acquired in Dal'negorsk, Russia. I picked up several nice calcites and a miniature pyrrhotite from Jeff.

Exhibits inside the show were exclusively dedicated to Franklin-Ogdensburg, New Jersey, minerals and memorabilia. There were lots of exceptional franklinites, willemites, rhodonites and many rarities on display. The fluorescent display room, with its myriad of colors, gave me the impression I was entering another dimension (or a 1970's New York disco).

I took a side trip later in the day to the Franklin Mineral Museum and the Sterling Hill mine in Ogdensburg. Both have excellent mineral and mining memorabilia displays. The Franklin Museum also has the Wilfred Welsh collection of Native American artifacts, some of which are from the Lenni Lenape tribe, the first known humans to dig in the Franklin-Ogdensburg area. One of the tribal chiefs, James "Lone Bear" Revey, gave an interesting talk at the New Jersey Earth Science show several years ago.

Well, as the cliche goes, all goods things must come to an end: the crowd dispersed, the sun set, the hawks went to sleep, and some of the tailgaters stayed exactly where they were, hoping for a repeat performance on Sunday.



Exchanging with Italian Micromineral Collectors

by **Bill Henderson**

For its size, Italy has a wide variety of rock types and geological settings. These have produced a surprising number of well crystallized and/or rare minerals and mineral suites. Many of these species occur as superb microspecimens, and Italian collectors have been extremely industrious at seeking them out.

Many Italians collect microminerals as a specialty, while others acquire them to expand species collections. Over the years, I have exchanged microminerals with perhaps two dozen Italian collectors. Several of those with whom I have traded recently, and others who are interested in exchanging by mail, are listed below.

Mr. Roberto Allori
viale di Marino, 81
00043 Ciampino
Roma, Italy

Mr. Luigi Chiappino
Via Palmanova, 67
20132 Milano, Italy

Mr. Giancarlo Galvani
Via De Amicis, 35
20123 Milano, Italy

Mr. Claudio Albertini
Via Grandi, 22
28026 Omegna (Novara), Italy

Mr. Giancarlo Pierini
Via Campigli, 91
21100 Varese, Italy

Mr. Ugo Ostan
Via Arenili, 10
26100 Cremona, Italy

Mr. Pier Giuseppe Prandoni
Via Roma, 47
20025 Legnano (Milano), Italy

The photographs which follow will show the quality and variety of the micromineral specimens which can be obtained by exchange with these collectors. In many cases, the initials of the person in the above list who sent me the specimen are included in the photo caption.

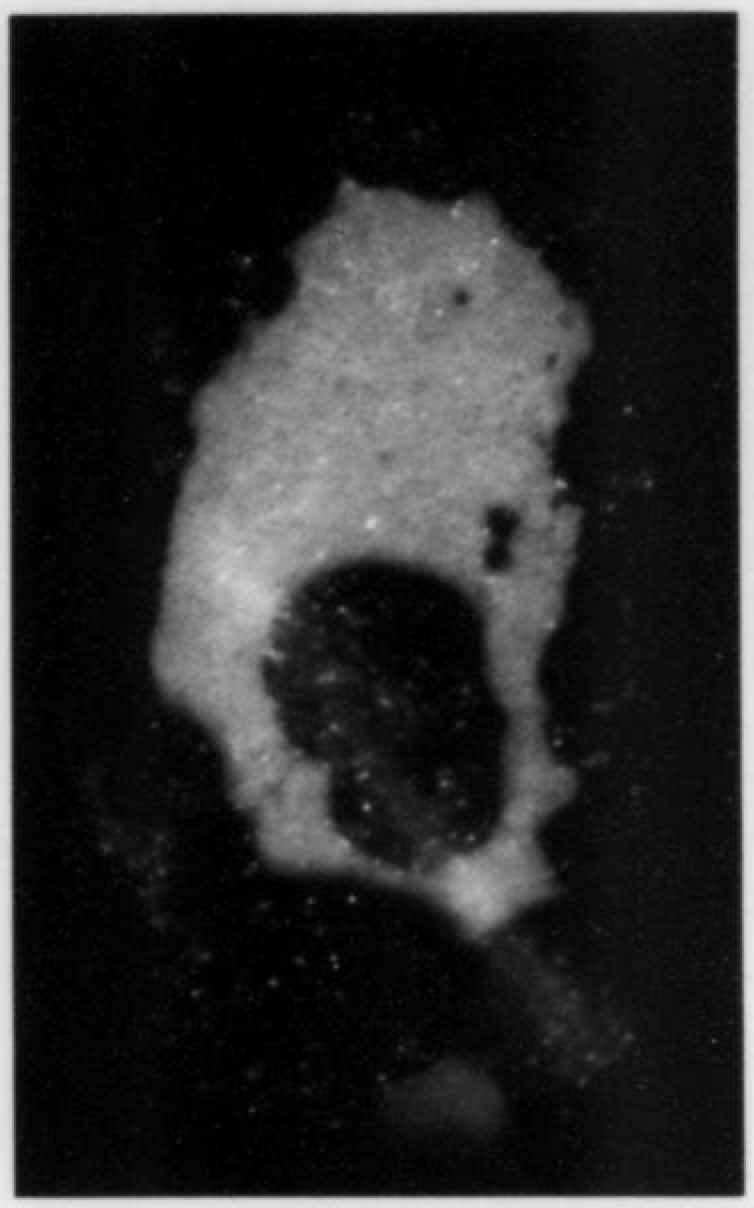
Samarskite is usually thought of as being jet-black, sometimes altered on the surface to brown or yellow-brown. The microcrystal from Cuasso al Monte shown in Figure 1 appears to be pale tan throughout. There are several quarries on the mountain, the bedrock of which is a quartziferous porphyry looking like granite. The locality is known for samarskite and a variety of other interesting species such as fayalite, gadolinite, zinnwaldite, bastnaesite, synchisite and xenotime.

The hellandite and vonsenite shown in Figures 2 to 4 are from two of three known localities: Km 60 Cassia and Tre Croci. No minerals from the third locality, Le Carcarelle, are shown. The three are quite close together, the whole area being only 7 km in its greatest extent. All three are also closely related geologically since, in each case, the country rock is volcanic ejecta of various types. This is not to say that rare species abound. The interesting minerals are found only in sanidine, which makes up a small fraction of the whole. The percent of "mineralized" sanidine is estimated at 5% of *all* sanidine, and the fraction of ejecta with well crystallized minerals is about 1%! It is interesting that (a) both the above minerals plus many of the other species found in these rocks contain essential boron and (b) boron is present in significant amounts in many volcanic rocks. Also obtained by exchange from one or several of these localities are many other rare and interesting species such as superb danburite, nosean, afghanite, transparent allanite, tadzhikite-(Ce), green thorite, uranothorianite, asbecasite, stillwellite-(Ce), transparent brown baddeleyite, tiny red-brown crystals of betafite, *very* small, dark brown crystals of zirconolite-3T, and beautiful, greenish yellow, transparent crystals of vicanite-Ce.

Monte Cervandone in the Val d'Ossola is the source of many rare alpine-type minerals. Two such are the superb synchisite in Figure 5 and the rare species tilasite (Fig. 6). Two other species found on Monte Cervandone, asbecasite and cafarsite, are interesting because they are named for their compositions; the former is an *AsBeCaSi*licate, while the latter is a *CaFeArs*enate. Incidentally, a simple and almost completely pronounceable mnemonic allows one to memorize the eight most common elements in the earth's crust in their order of abundance: OsiAlFeCaNaK-Mg.

We turn next to two fairly new minerals named for their (Italian) type localities. The first is cetineite, an antimony oxide-sulfide, from the Cetine mine in Tuscany (see Sabelli and Brizzi, 1984). This beautiful mineral (Fig. 7), like several of the minerals formed by alteration of lead/silver slags by sea water at Laurium, Greece, is a bit of a cheater in that it too is a slag mineral. Other fine antimony minerals found at the Cetine mine are cinnabar, cervantite, coquandite, kermesite, onoratoite, mopungite, senarmontite, stibiconite and valentinite. Still more exotic species are found: brizziite, rosenbergite, elpasolite and ralstonite. The second namesake mineral (Fig. 8) is peretaite, another antimony mineral but a hydroxide/sulfate. It is named for its type locality, the Pereta mine (see Scortecci and Tazzini, 1984), although the mineral is also found at the Cetine mine. Operated for stibnite, the Pereta mine is also the type locality for coquandite. Interestingly, coquandite is also found at the Cetine mine!

While Italy does not have the flashy zeolites of India, New



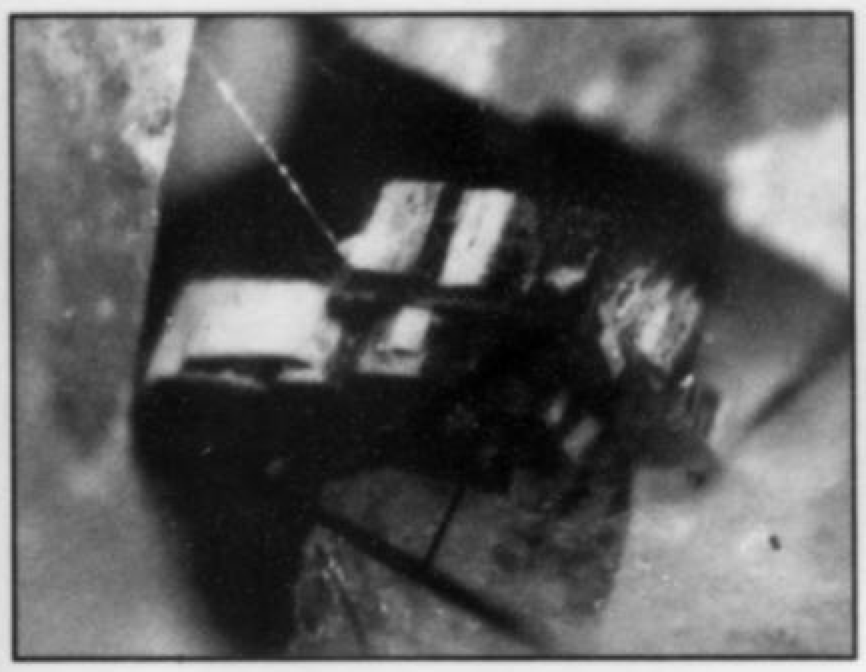


Figure 2. (above) Honey-colored, slightly frosted, equant crystals of hellandite from Kilometer 60 Via Cassia near Cura di Vetralla, Viterbo province, Lazio region, Italy. Crystal group: 0.4 mm across. LC.

Figure 1. (left) Samarskite, partially coated with chlorite(?), from Cuasso al Monte near Cavagnano, Varese province, Lombardia region, Italy. Height of crystal: 1.2 mm. LC.

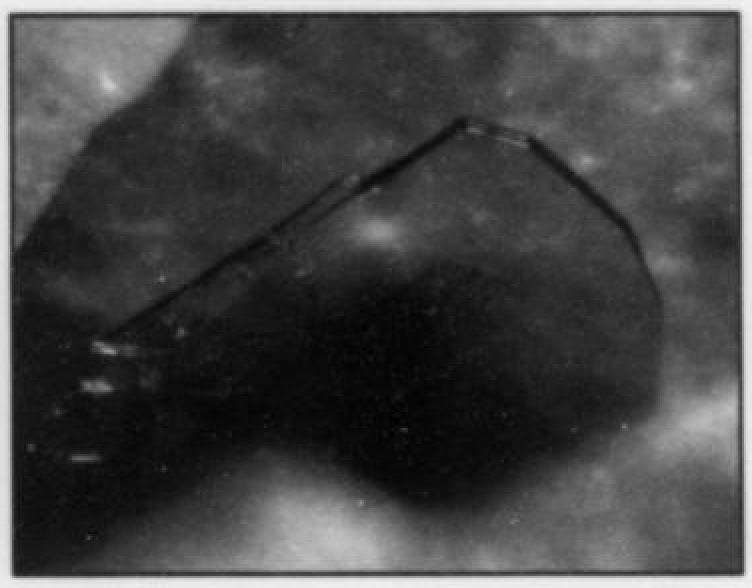


Figure 3. Tabular, transparent hellandite crystal, 2.0 mm long, from Tre Croci near Vetralla, Viterbo province, Lazio region, Italy.

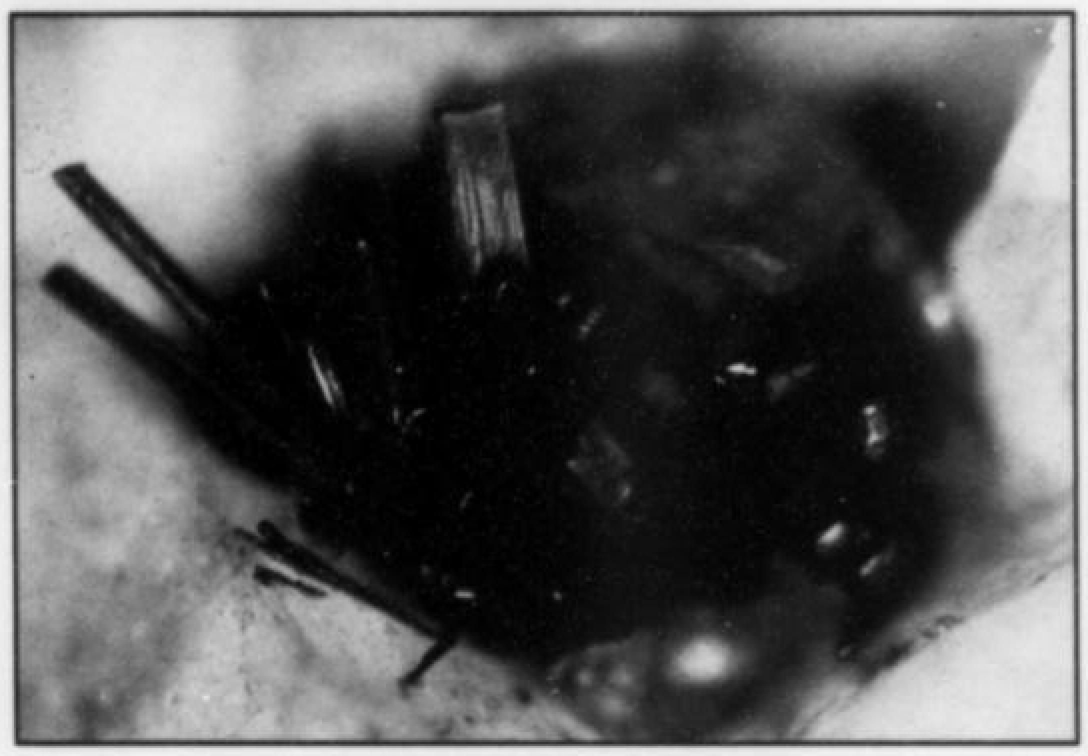
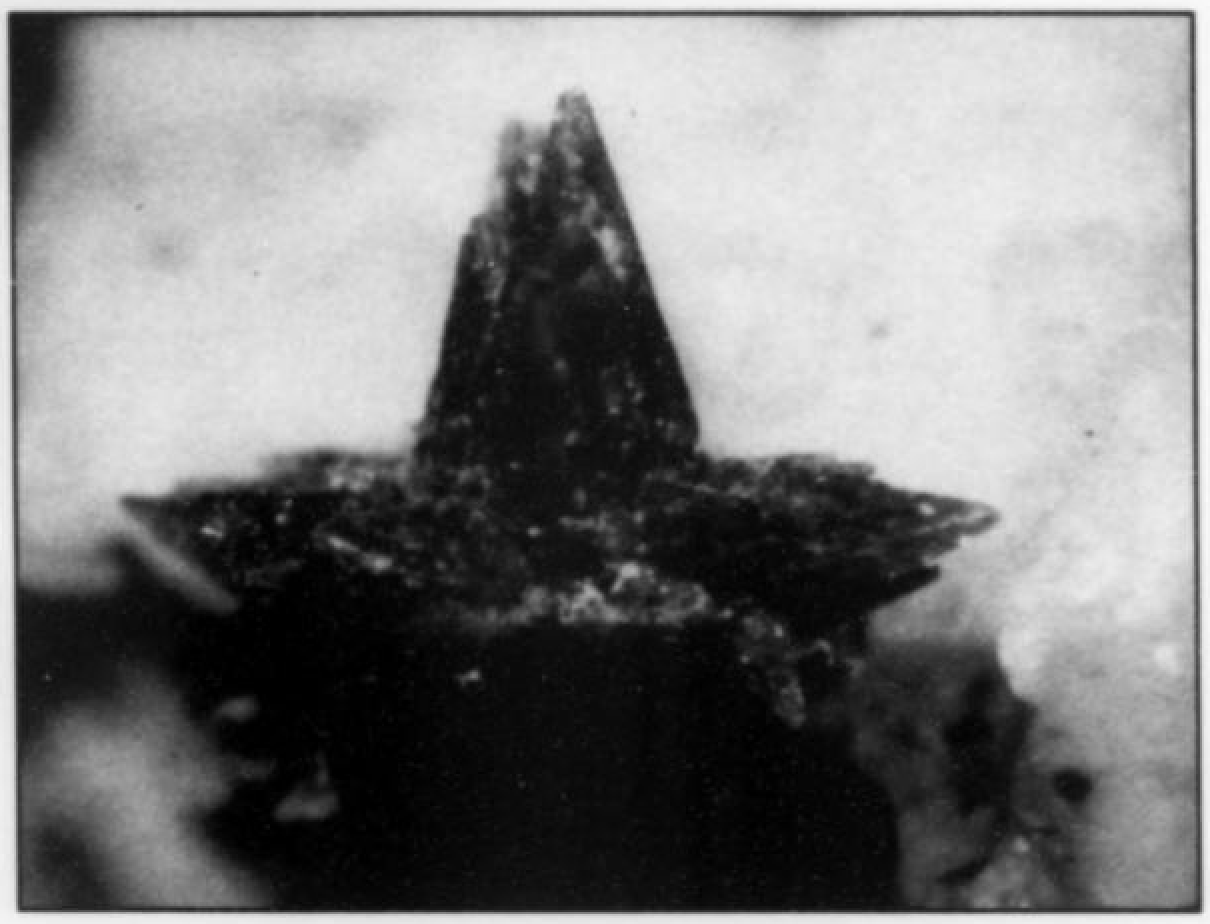


Figure 4. Black striated crystals of vonsenite with deep orange titanite from Kilometer 60 Via Cassia near Cura di Vetralla, Viterbo province, Lazio region, Italy. Size of crystal group: 2.2 mm. LC.

Figure 5. Deep orange crystal of synchisite, height 8 mm, from Monte Cervandone near Alpe Dévero, Val Dévero, Novara province, Piemonte region, Italy. Photo and specimen: Domenico Forloni.

Figure 6. (below) Star-shaped group of twinned tilasite crystals, 1.2 mm across, from Monte Cervandone near Alpe Dévero, Val Dévero, Novara province, Piemonte region, Italy.



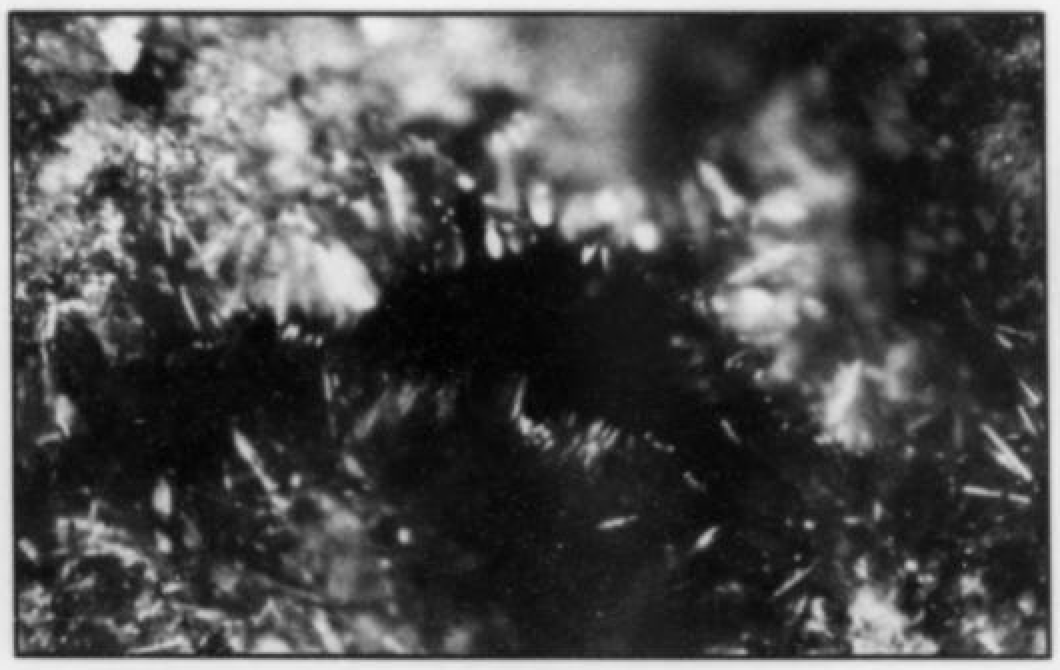
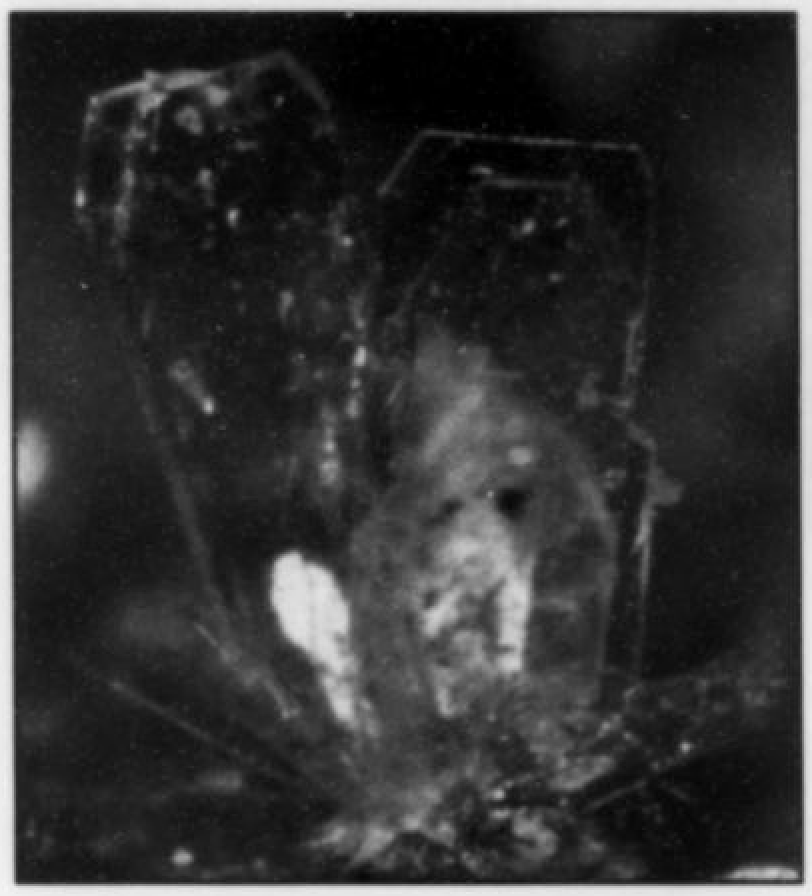


Figure 7. Bright orange-red tufts of cetineite in slag from the Cetine mine near Rosia, Siena province, Toscana region, Italy. Field of view: 1.2 mm.

Figure 8. Transparent, 1.3-mm crystals of peretaite from the Pereta mine near Scansano, Grosseto province, Toscana region, Italy. Specimen and photo: Carlo Cassinelli.



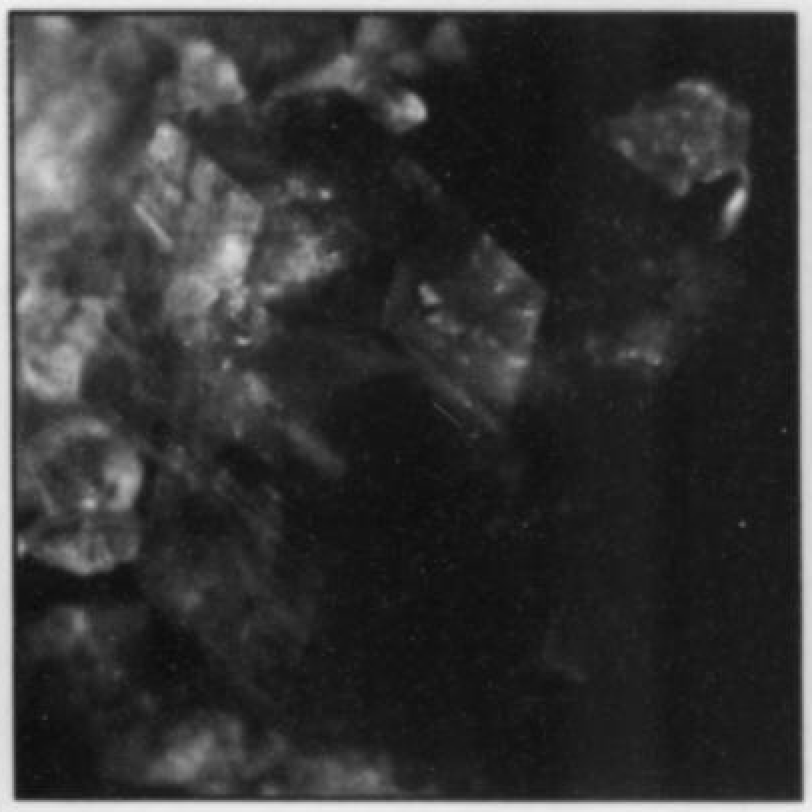


Figure 9. Iron-stained, multiply twinned crystals of wellsite from Monte Calvarina near Ronca, Verona province, Veneto region, Italy. Field of view: 5 mm. RA.

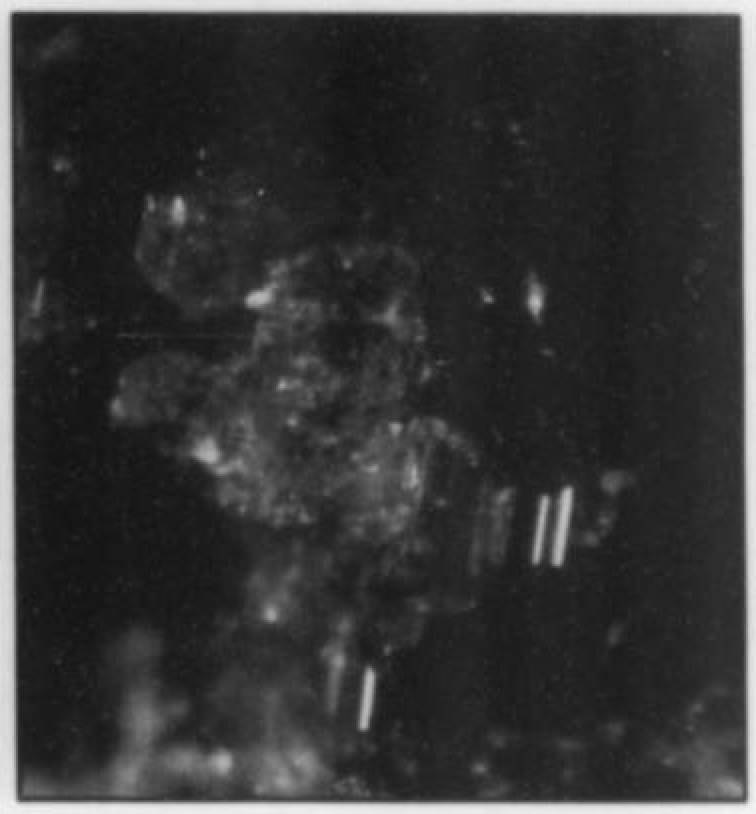


Figure 10. Colorless, hexagonal crystals of liottite with andradite (variety melanite) from the Montenero quarry near Onano, Viterbo province, Lazio region, Italy. Field of view: 1.6 mm. RA.

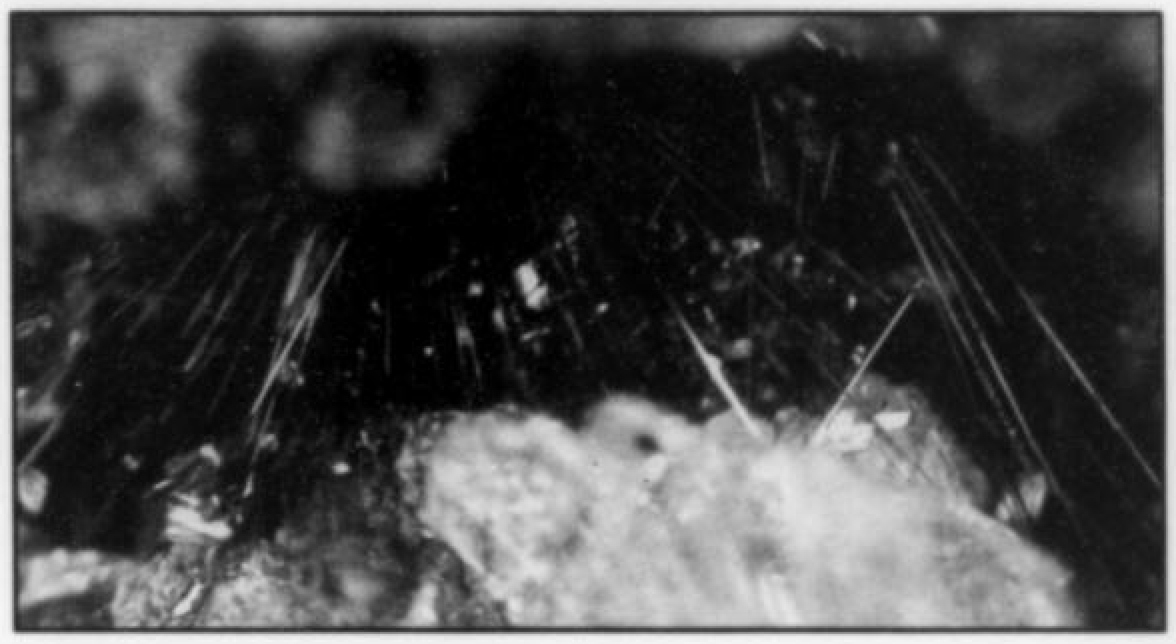


Figure 12. Black needles of ludwigite with phillipsite from the Vallerano quarry, Kilometer 9 Via Laurentina, Roma province, Lazio region, Italy. Field of view: 3 mm. RA.

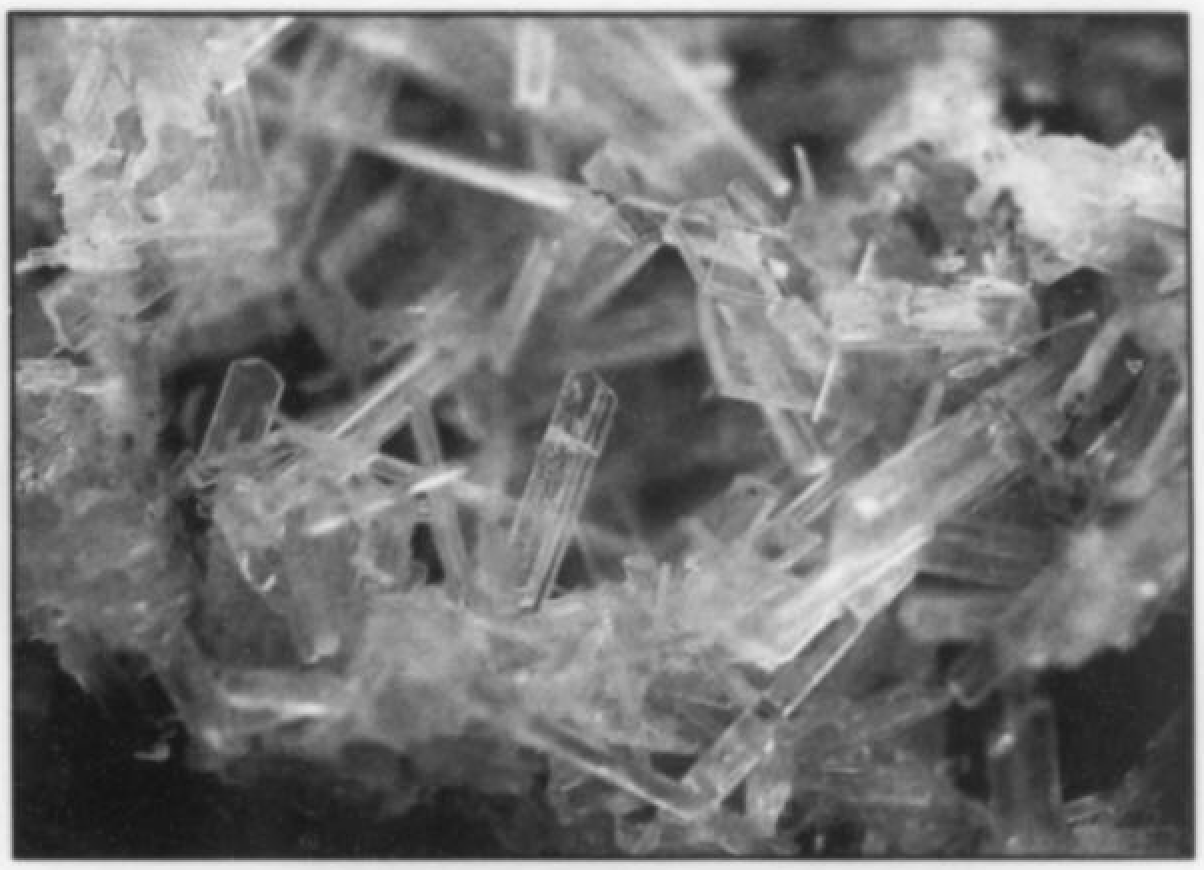


Figure 11. Columnar crystals of tuscanite to 1.5 mm in length, from Valle Biachella near Sacrofano, Roma province, Lazio region, Italy. Photo by Dan Behnke. RA.

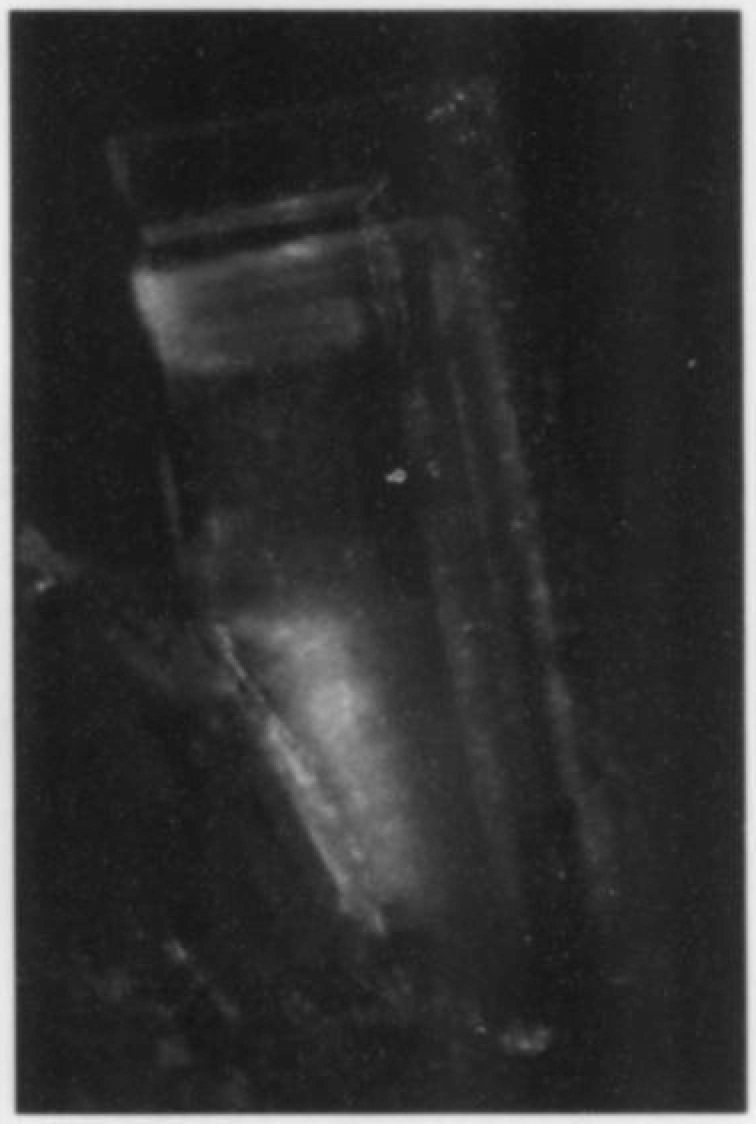


Figure 13. Acicular aragonite sprays with black psilomelane coating kutnohorite in a 1-cm-wide cavity, from Levane near Montevarchi, Arezzo province, Toscana region, Italy. Photo by Dan Behnke. RA.

Figure 14. Transparent, tabular crystals of saleeite from Arcu Su Linnarbu near Capoterra, Cagliari province, Sardegna region, Italy. The largest crystal is 0.8 mm long.

Jersey or Australia, it nevertheless ranks high in the zeolite world. The type localities for no less than eight of the approximately 49 known zeolites (barrerite, dachiardite, gismondine, merlinoite, montesommaite, phillipsite, pollucite, and willhendersonite) are within its borders. The Island of Elba is home to the world's finest dachiardite; wagon wheel-like, cyclic eightlings which have never been found elsewhere. Another example of excellent multiple twinning is the wellsite from Monte Calavarina shown in Figure 9.

The Latium volcanic area near Rome is host to a wide range of volcanic minerals similar to those of the better-known Eifel district of Germany and the Monte Somma/Vesuvius complex near Naples. No less than 11 new species have been described from the area in just the last few years (liottite—see Fig. 10—, franzinite, sacrofanite, giuseppettite, pitiglianoite, cesanite, vertumnite, rossiite-Ce, tuscanite, merlinoite and vicanite-Ce). The first five of these, plus microsommite, davyne, afghanite and vishnevite, are all hexagonal and members of the cancrinite group. They differ in the stacking pattern of their A, B and C layers. A nice example of tuscanite from the Latium volcanic area is shown in Figure 11. Most of these species, plus excellent microcrystal specimens of sodalite, meionite, hauyine and sodalite, are easily obtainable by exchange.

Three minerals from less well known localities follow. The first (Fig. 12) was given the now discredited name "breislakite." The name is still used by local collectors, as "breislakite" is now known to be either ludwigite or vonsenite, the two occurring together and even as mixed crystals at this locality, and being indistinguishable without chemical analysis. The specimen shown is probably ludwigite, a magnesium iron borate, from the Vallerano quarry. The country rock is a hard, dark gray lava, in veins and vugs of which are found well-crystallized minerals. Note again the presence of essential boron in a species found in volcanic rocks, although ludwigite is found in a variety of other rock types as well. Very fine cahnite crystals are also found at the Vallerano quarry, as are gismondine, leucite, melilite and others.

Second is the specimen of common but beautifully crystallized, acicular aragonite with black psilomelane shown in Figure 13. Inside the globular aggregates of psilomelane are found microspherules of kutnohorite. From Levane, these crystals are contained within what look like tiny geodes. These are found after spring ploughing of the fields.

Last but not least are the deep orange-yellow crystals of saleeite from Arcu Su Linnarbu. Shown in Figure 14, these are superb crystals of a rare magnesium uranium phosphate. Other beautifully crystallized uranium minerals such as bassetite, parsonsite, phosphuranylite and sabugalite are also found at these prospects (see Vochten and Brizzi, 1987).

And now, a word about the size of initial trades. Some traders of microminerals, in addition to sending the specimens requested by a new trading partner, send still more species as gifts. Others, rather than sending a single specimen of a species which has been requested, send as many as a dozen. While in either case they are being generous, their actions raise problems for the people receiving their material. Several other traders to whom I have spoken, and I also, feel it is our duty to send an equal volume of material. In many cases, we do not have sufficient material to do so; and in other cases, we just do not want or cannot use the unexpected material which we had not requested. I feel that it is far better to *send only what was requested and, unless otherwise requested, only one of each item* in first exchanges. Perhaps in later exchanges, sending gift items specifically labeled as such might be appropriate.

With the above, I reach the end of the first of two columns on trading with Italian micromineral collectors. Part 2 will cover the wonderful minerals of Vesuvius/Monte Somma.

I am greatly indebted to Roberto Allori, an extremely knowledgeable and discriminating Italian collector, for reviewing the rough draft of this column, and for supplying accurate and complete locality descriptions.

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Madison, CT 06443

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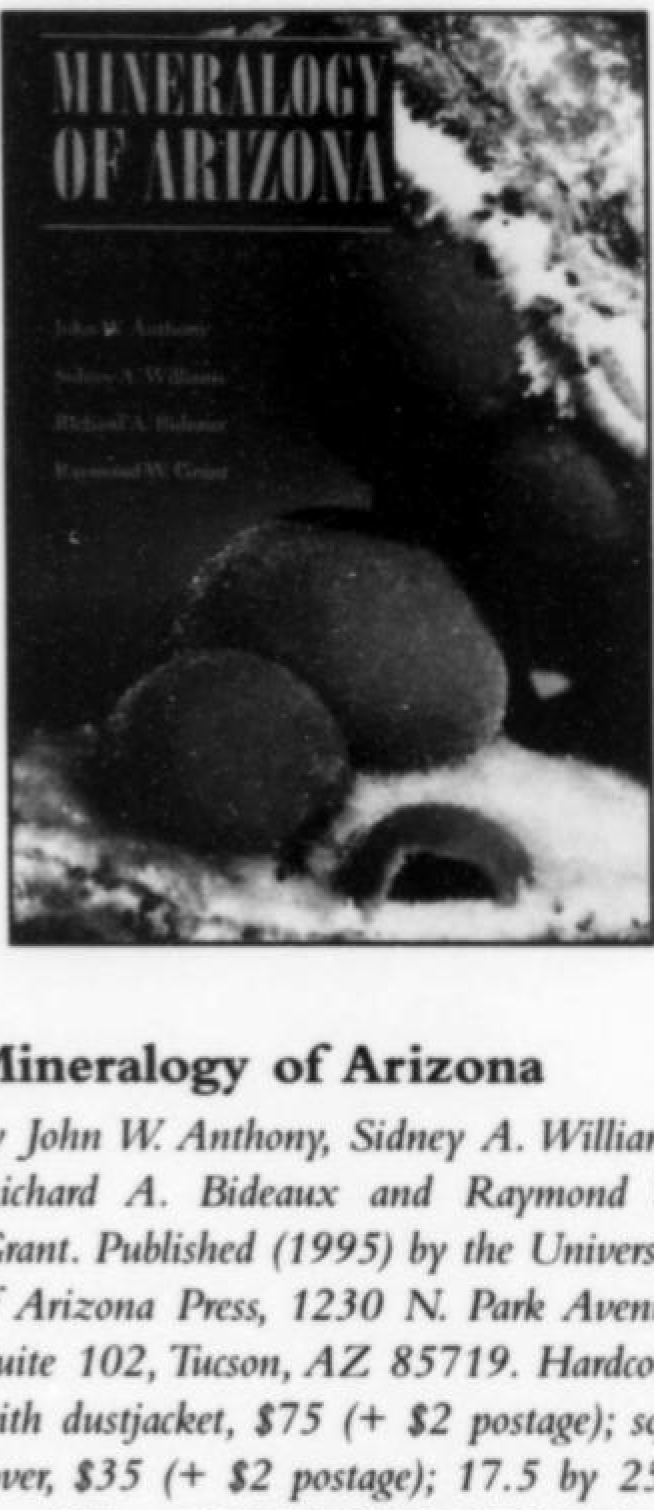
Book Reviews



Mineralogy of Arizona

by John W. Anthony, Sidney A. Williams, Richard A. Bideaux and Raymond W. Grant. Published (1995) by the University of Arizona Press, 1230 N. Park Avenue, Suite 102, Tucson, AZ 85719. Hardcover with dustjacket, $75 (+ $2 postage); softcover, $35 (+ $2 postage); 17.5 by 25.5 cm, 508 p., ISBN 0-8165-1579-4 (hardcover) and 0-8165-1555-7 (softcover).

Many of the best topographical mineralogies are defined by political boundaries. In geological terms these boundaries are meaningless, but not to the mineral collector. Some of the most fanatical collectors use state or province boundaries to *define* what is an acceptable mineral specimen. Among the fraternity of "state" collectors, Arizona holds a special place. Every collector knows of Red Cloud wulfenites and Bisbee azurites, but Arizona's mineral heritage goes much deeper. The state is home to 809 different mineral species (at this time a *record* for any state), 76 of which were first identified in Arizona. These species, and much more, are documented in *Mineralogy of Arizona,* a reference work which belongs on every serious collector's bookshelf.

Mineralogy of Arizona, third edition (1977 and 1982 were the first two editions), contains so many revisions and additions that it is practically a new work. The book is divided into three parts: (1) history and description of Arizona's mining, mineral deposits, and mineralogy, (2) a catalog of mineral occurrences, and (3) reference materials, including maps of Arizona's mineral districts. The historical and descriptive chapters make this book an invaluable reference and bring to life the importance of minerals to the development of the state. For example, *Arizona* is derived from the Tohono O'odham Indian (Papago) word *Arizonac,* which was the name of a large ranch located east of the present town of Nogales. In 1736 the famous Bolas y Planchas de Platas (*Balls and Plates of Silver*) discovery was made on the ranch. This discovery caused Mexican prospectors to explore farther north, and the entire area took the name *Arissona.* The authors have compiled a whole chronology of the mineral development, which makes the book a real joy to read.

The Catalog of Arizona Mineral Occurrences is organized alphabetically—from *acanthite* to *zunyite.* Each entry contains a description of the mineral and its typical geology followed by a detailing of occurrence grouped by county. The authors document many occurrences with references to specific mineral specimens which are housed in one of nine museums. A list of "real" specimens to document localities is missing in most topographical mineralogies but is extremely useful to the researcher. A case in point is the type specimen of spangolite (a copper aluminum sulfate hydroxide chloride hydrate). The specimen resides in the Yale collection and is identified as being from "near Tombstone." Close examination of the specimen yields a mineral assemblage identical to known Bisbee material, suggesting that "near Tombstone" means 30 km to the southeast!

The maps of the Arizona Mineral Districts are significantly better than those in previous editions. Sixteen maps, based on counties or portions of counties, show the areal extent and name of some 240 mining districts. These maps are important in a state like Arizona, where much of the locality information in the literature refers to "districts"—and many of the district names have disappeared from modern maps.

Mineralogy of Arizona is illustrated by 60 immaculate color photos paginated in a central section of the book. The photographic quality is excellent and reproduces the mineral colors with remarkable fidelity. Wendell Wilson served as photographic editor, and it is clear that his long experience with mineral photography and color printing was invaluable when the book was going through the printing process. Many mineral books have suffered because the "color separations" (printing negatives for each color) were not graded by professional mineral photographers. One wishes that there were more photos in the *Mineralogy of Arizona*, especially of some of the rarer species. However, economy limited the number that can be reproduced with such high quality. None of the photos in the third edition appears in the earlier editions.

The only criticism of the *Mineralogy of Arizona* I have is the price structure. The softbound edition is $35—a bargain! However, the hardback edition is more than *twice* as expensive at $75. This is an unusually large cost increment ($20 is much more standard) and serves as an impediment to purchasing the hardback. Most serious collectors would prefer the hardbound edition but will probably have to settle for the shorter-shelf-life softback version.

Mineralogy of Arizona has been extremely well researched and produced with remarkable care and attention to detail. It is one of the best topographical mineralogies in existence, and I heartily recommend it to *any* mineral collector. The fact that the art work is different from the previous editions means that serious Arizona collectors will want to own *all* the editions. The University of Arizona Press has produced only 6,000 copies of the softbound edition, and I expect that it will sell out in its first year.

Terry C. Wallace

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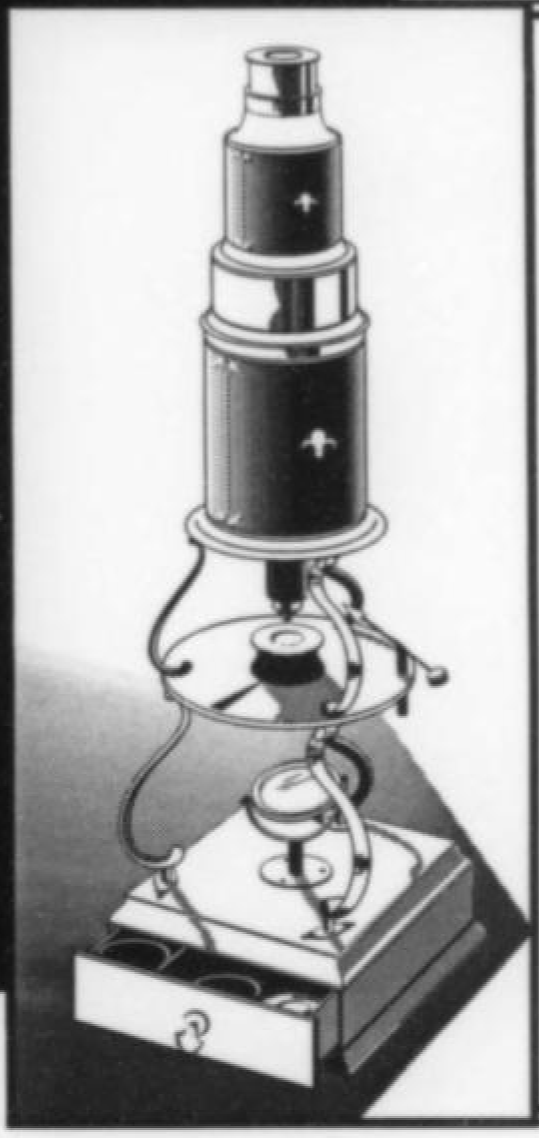

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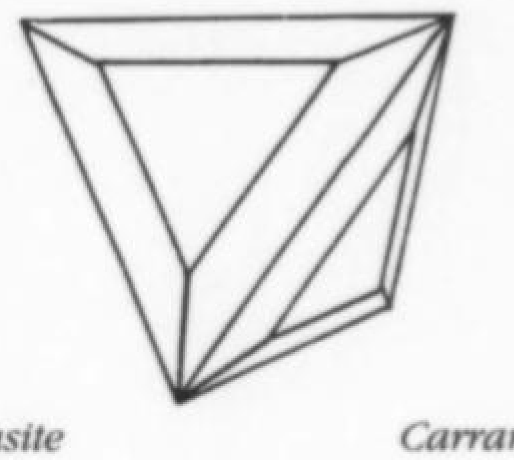

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Design
Wendell E. Wilson

Graphic Production
Capitol Communications
Crofton, MD

Printing
Cadmus Journal Services,
Easton, MD

Color Separations
Hollis Phototechnics
Tucson, AZ

Circulation
P.O. Box 35565
Tucson, AZ 85740
520-297-6709

Editing, advertising
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Tucson, AZ 85750
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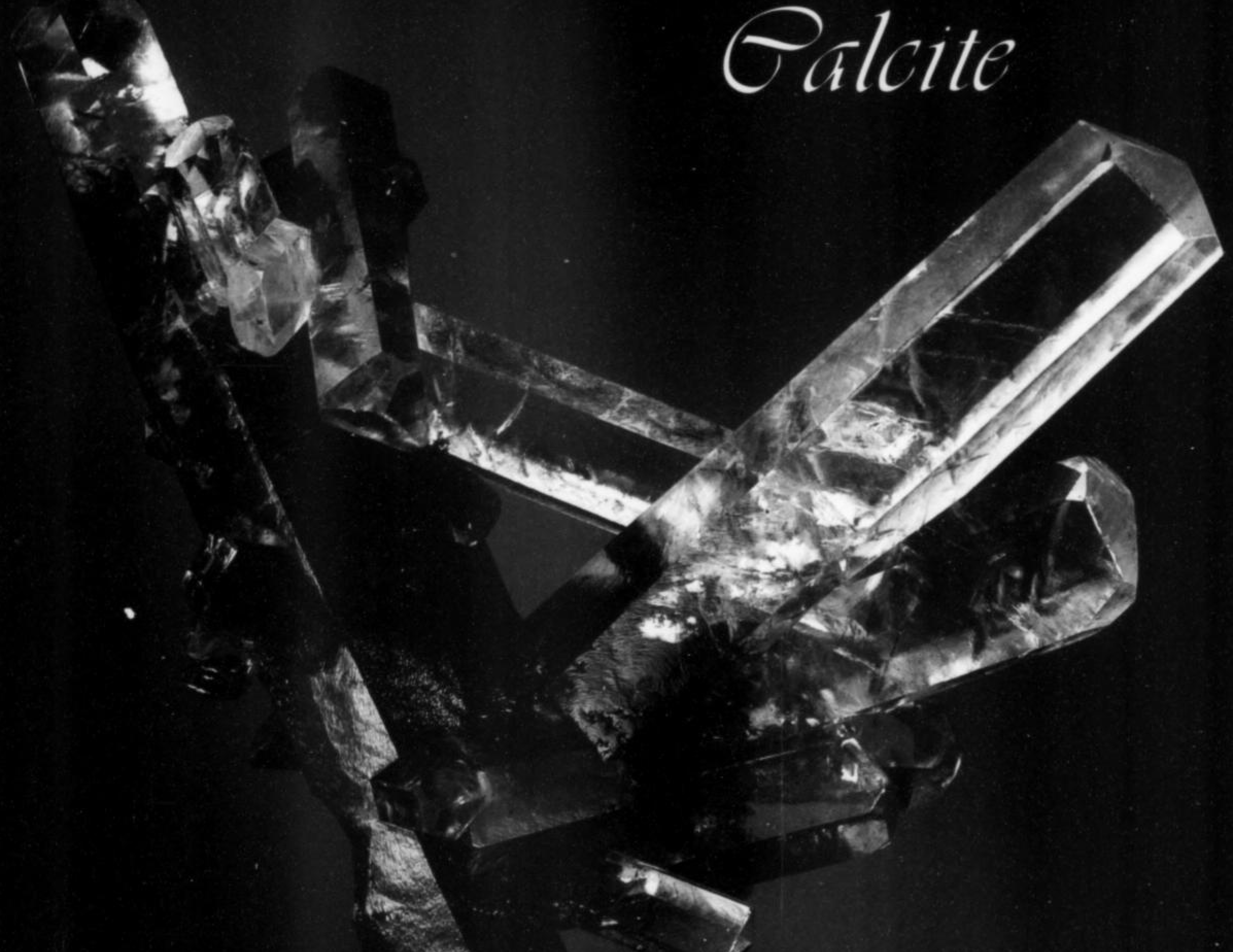
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