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Articles

Columns

COVER: FORSTERITE ("Peridot") from the new Pakistan locality at Sumput (or Suppatt), between Kamila and Naran, Kohistan. The large crystal measures 5.1 cm, and the cut stone weighs 64.6 carats. Wayne Thompson and Laura Thompson specimens; Jeff Scovil photo.

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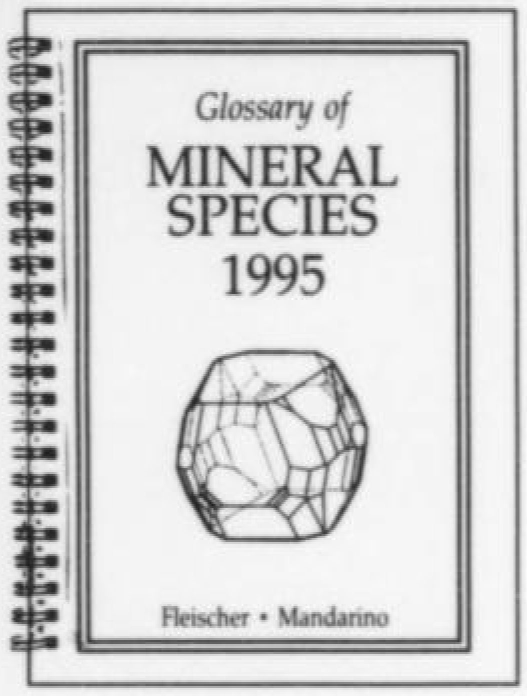

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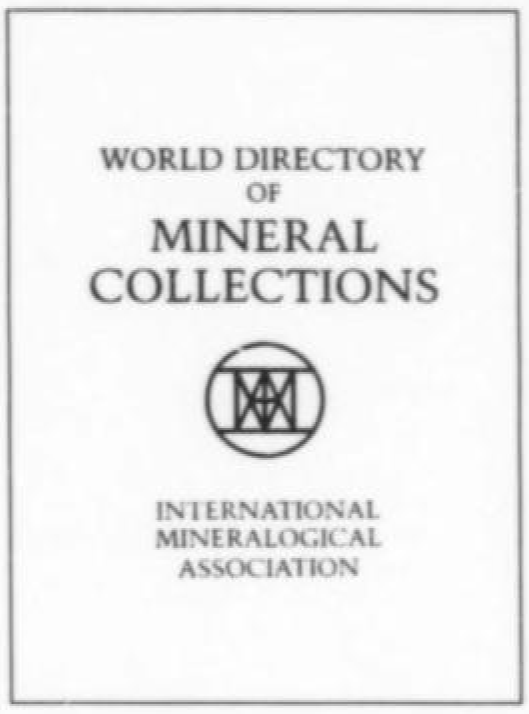

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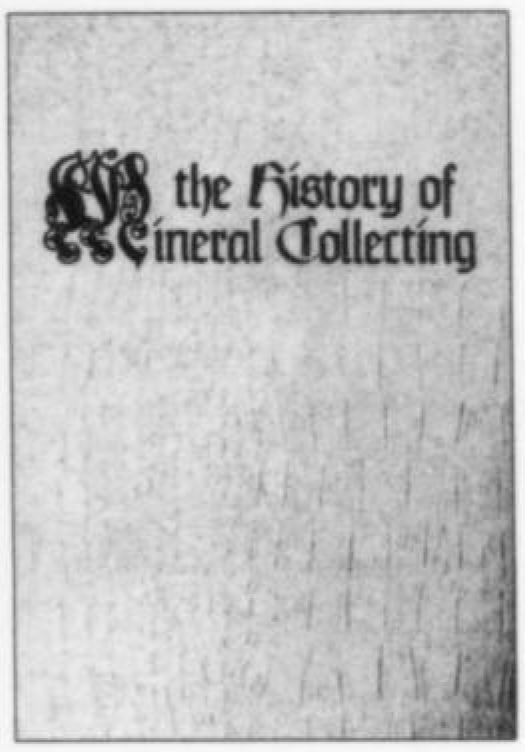

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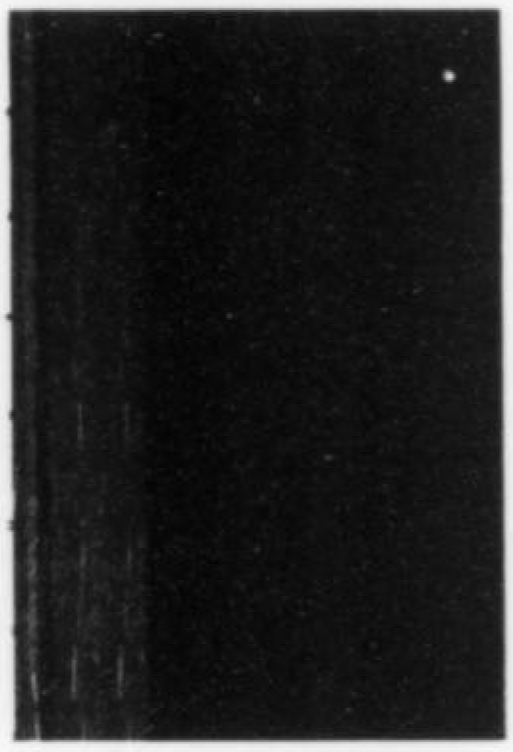

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Famous Mineral Localities

THE KIPUSHI MINE

ZAIRE

Joseph J. Lhoest
P.O. Box 141
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Kipushi is famous as a rich pipe-like deposit of zinc, copper and associated rare metals. Bearing similarities to Tsumeb, and situated near the Shaba Crescent, it has yielded many valuable specimens. Kipushi is the type locality for renierite and kipushite and the joint type locality (with Tsumeb) for briartite and gallite. It was also among the first known occurrences of veszelyite. Recently, nice rosettes of reichenbachite have been found as pseudomorphs after kipushite.

INTRODUCTION

Several authors (Cahen, 1954; Picot *et al.*, 1963) have emphasized the presence in the late Precambrian rocks of South Central Africa of a polymetallic province, distinct from the stratiform Cu-Co-U seams of the copperbelts, and situated at a higher stratigraphic level in the Katanga System or its equivalents. This province includes deposits of Zn-Pb-Cu with an array of associated metals including Ag, Mo, W, Ge and Ga. Hughes (1979) points out that Tsumeb belongs to a unique group of orebodies of similar age, which are widespread around the Angola-Congo craton, examples being M'Passa in the People's Republic of the Congo and Kipushi in southeastern Shaba. Orebodies of this group show similarities to deformed Mississippi Valley-type deposits. Tsumeb and Kipushi are by far the most renowned occurrences of this type. They are sometimes called "sister deposits" (de Magnée and François, 1988); moreover, they are located in a similar hydrogeological environment. Another rare feature is that Tsumeb is iron-poor, which allowed copper ions to remain longer in solution, cementation having taken place rather sparingly. In addition, the circulation of supergene fluids was not hampered by infillings, crusts or inclusions of iron oxi-hydroxides (Keller, 1984). The major difference in the extent of oxidation of primary ore explains the drastic difference in collector significance between Tsumeb and the less oxidized Kipushi. On the other hand, Kipushi has supplied material of choice to scientists, who have been able to study the phase relationships in relatively undisturbed primary sulfides, and thereby complete studies begun in Tsumeb (Deutzmann, 1961; Viaene and Moreau, 1968; Moh, 1973 and others), which are not without contradictions (Keller, 1977, 1984).

The Broken Hill deposit at Kabwe in central Zambia is also famous economically. Hosted just outside the Katangan rocks, it is interesting in comparison because of its rare copper-zinc minerals; this is mainly a zinc deposit, containing only about 0.035% copper (Mennell, 1920; Notebaart and Korowski, 1980).

LOCATION AND ACCESS

The locality is situated 28 km S60°W of Lubumbashi, 5 km to the south of the Shaba Crescent (Gauthier *et al.*, 1989), the northern portion of the Lufilian Arc wherein the tectonic structures are generally rich in stratiform mineralizations. The outcrop is only 500 meters from the Zambian border, represented by the crest line separating the basins of the Zaire and Zambezi rivers (see Fig. 1). The tarred road from Lubumbashi is excellent, having been modernized during the early 1980's. On the Zambian side, Kipushi is connected by a good road to the old Kansanshi mine and the neighboring Solwezi town, about 100 km S60°W (see Fig. 2). This border road has historical significance. Kipushi-Zambia is a much smaller town than Kipushi-Zaire, the two cities being separated by a control post with customs

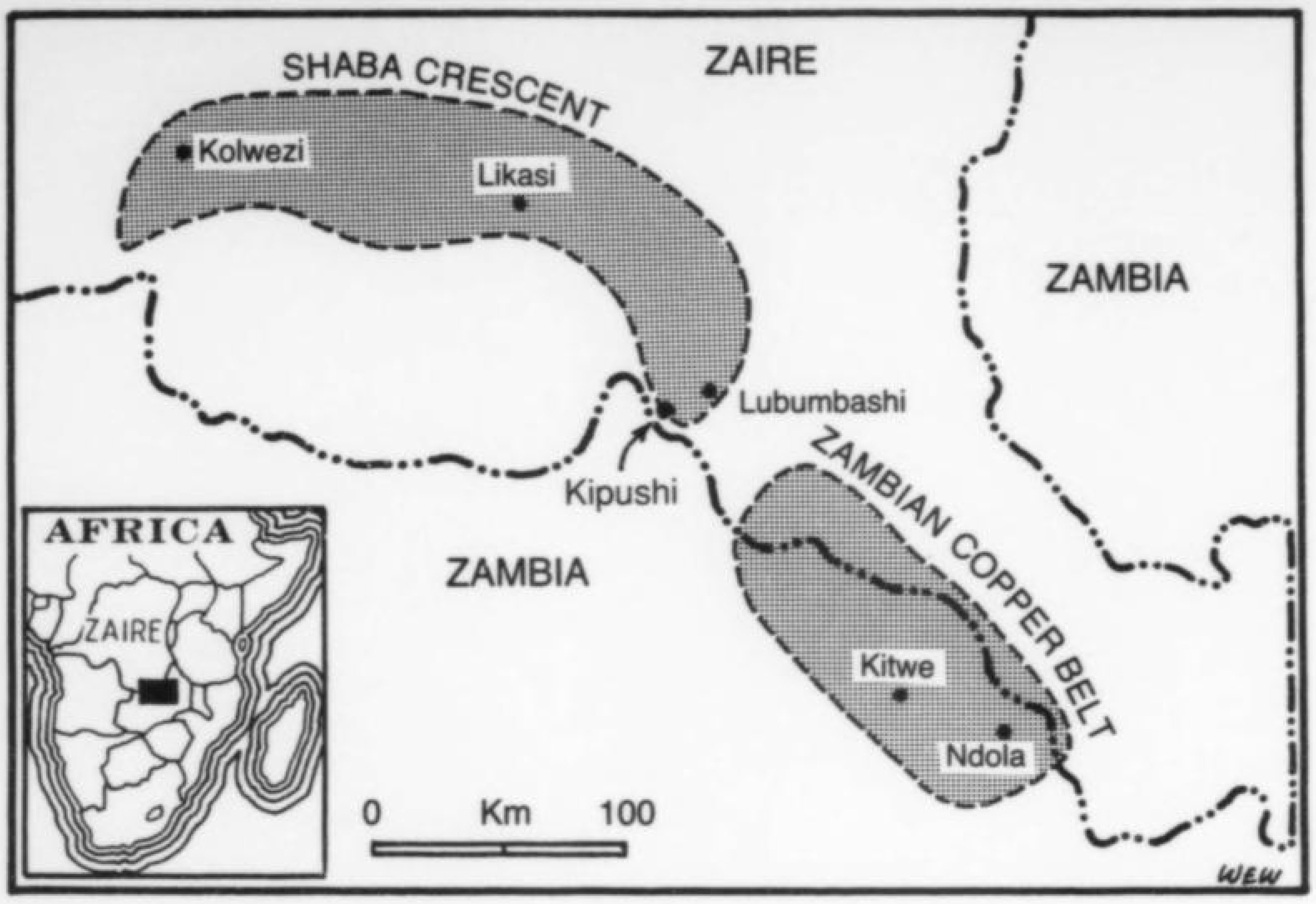
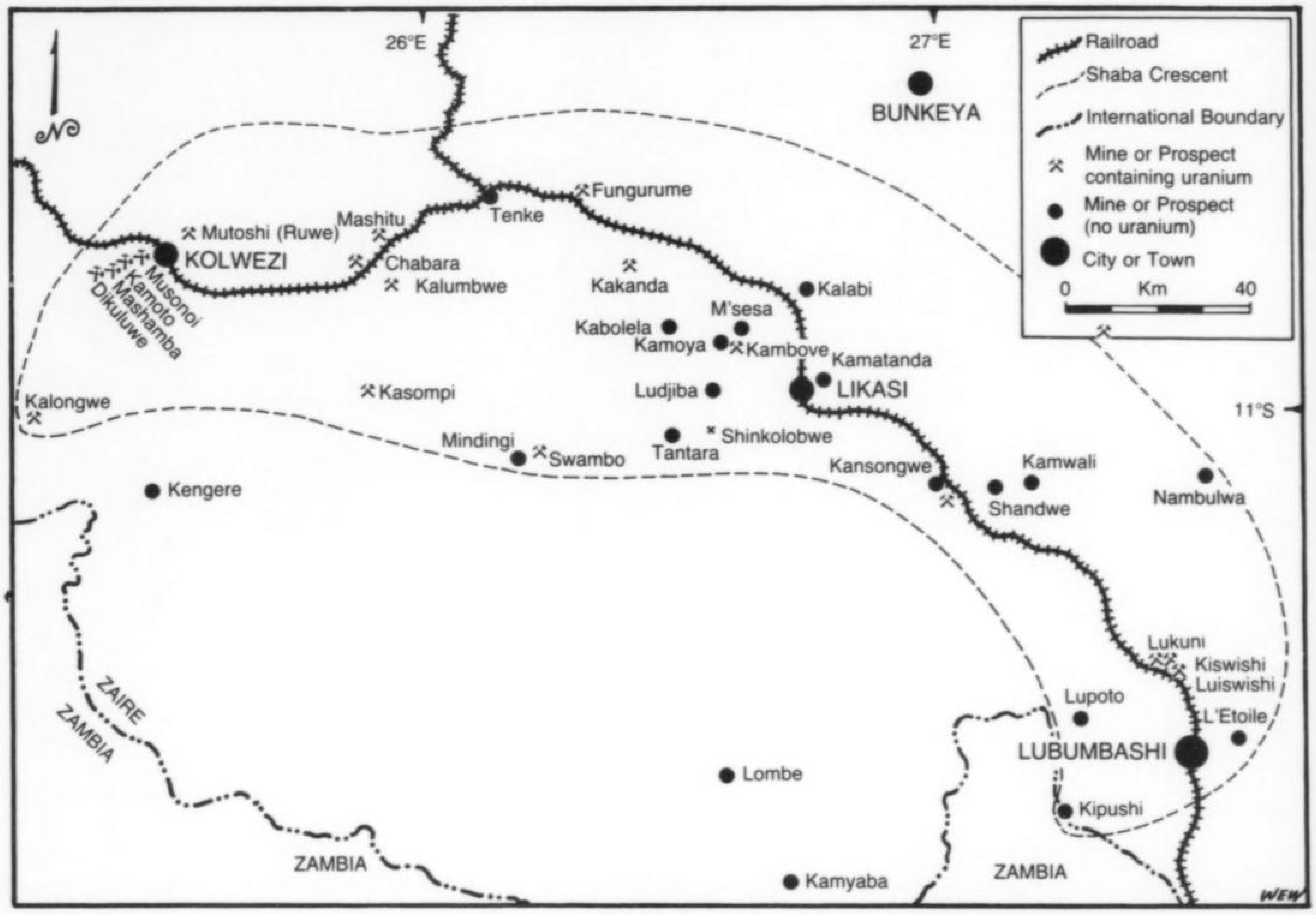


Figure 1. **Location map.**

Figure 2. **Localities in the Shaba Crescent.**



and immigration. During the Katanga secession war in 1960–63, these localities played a strategic role because of their location and connections.

HISTORY

As with many copper deposits cropping out in the region, the history of Kipushi traces back to the Bantu tribes who settled in that part of Africa during the 4th century A.D., and displaced the Neolithic populations to the Kalahari (this timing being confirmed by Korowski and Notebaart, 1978). The settlers had already learned the technology of iron; the Bronze Age is missing here as a distinct period of civilization. The metallurgy of copper and the technology of iron have been utilized at the same time (Gauthier *et al.*, 1989), though not by the same persons. The art of forging was always endowed with a touch of mysticism. Trade (in copper and other products) was established with the East Coast soon after the settlement of Arabs during the 7th century, but trading had probably begun earlier inside the continent. Trading with the West Coast didn't begin before the 16th century, after settlement by the Portuguese.

Following the European expeditions of the second half of the past century, the Kipushi deposit was discovered in August of 1899 by George Grey, chief of the first prospecting mission to the Zambezi-Congo border organized by Robert Williams' Tanganyika Concessions Ltd. (T.C.L.). In fact, they went on trying to locate the richest (gold)

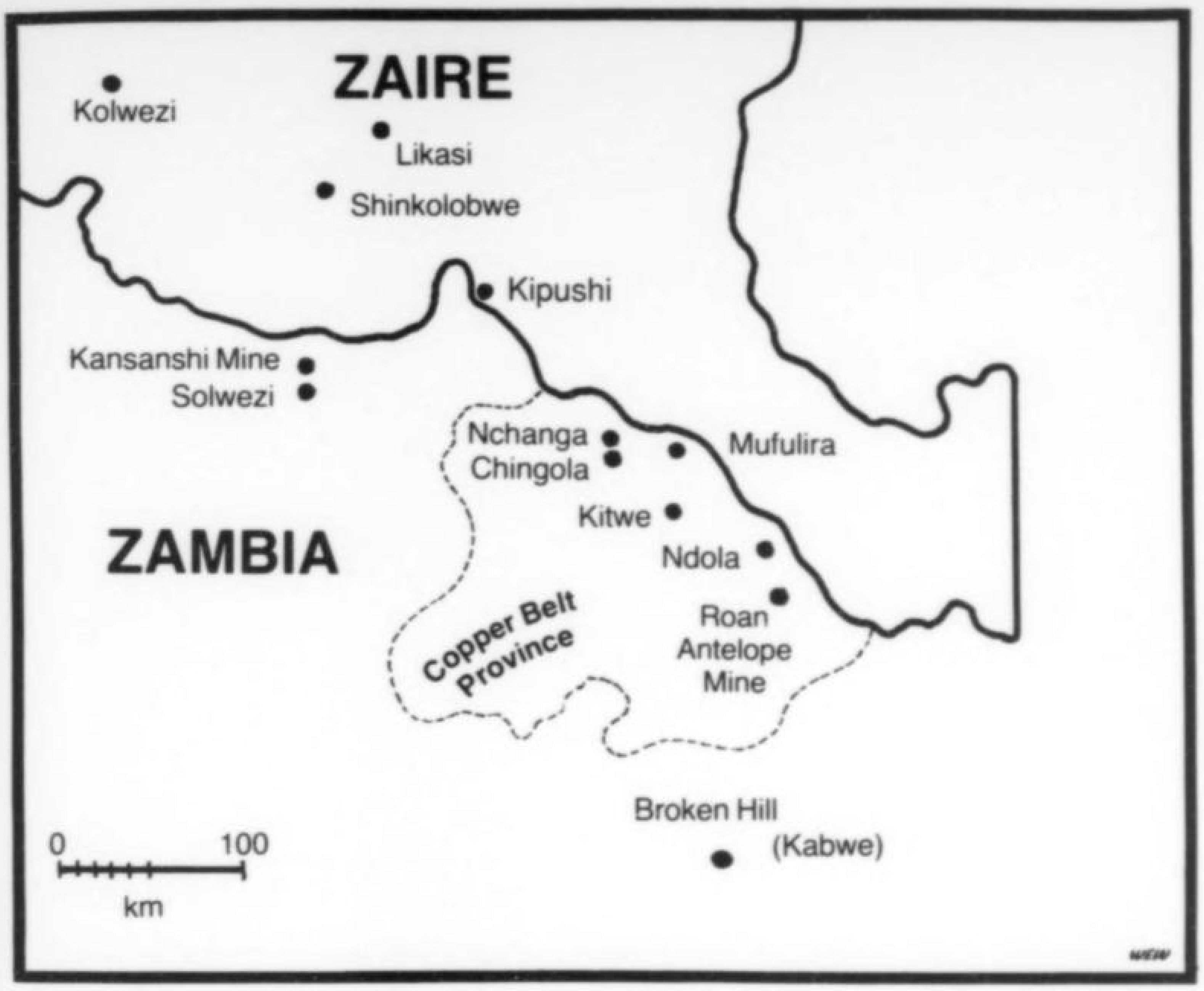


Figure 3. **Location map showing important mines and towns in the Zambian Copperbelt, as well as other nearby famous localities such as Kolwezi, Shinkolobwe and Broken Hill. The Rokana mine is located near Kitwe.**

deposits in order to establish the path of the planned Cecil Rhodes Cape-to-Cairo railway. Employing indigenes as guides, Grey came from the copperbelt of Zambia, where he had already pinpointed a deposit, and went on to establish temporarily the headquarters of the T.C.L. in Kansanshi, which seemed an ideal advanced post for the exploration of Katanga. Being of the Shaban type, though situated far to the south of the Shaba Crescent, Kansanshi was spectacular but not heavily mineralized. The outcrops of the Zambian type were less exciting, only one (other than Kansanshi) having been exploited before the early 1930's (Korowski and Notebaart, 1978).

On instructions of the Special Katanga Committee of King Leopold II (Gauthier *et al.*, 1989), Kipushi was visited in 1902 by the Belgian mineralogist Henri Buttgenbach, also with local indigenes serving as guides.

In 1915, the Kipushi district was delineated by the famous prospector Major R. R. Sharp, who had discovered the Shinkolobwe deposit a few months before. Sharp had been a prospector for the T.C.L., and became an employee of the Union Minière du Haut-Katanga (U.M.H.K.) after its creation in 1906. The problem was to determine on which side of the border Kipushi was situated. It required checking the flow of all the local streams "inch by inch." Kipushi was thereby established as being within the Belgian Congo.

In early 1922 the U.M.H.K. sent a mission to evaluate the deposit, an assignment which became a difficult task for employees who had been city-dwellers and metallurgists but not prospectors. Only the local indigenes knew the footpaths which snaked through the bush, particularly at the apogee of the rainy season. After wandering in circles, members of the team had to ask some of their servants to climb trees in order to finally locate the small clearing in an ocean of greenery. Unlike other outcrops, which appeared as large, irregularly shaped hills without trees, the Kipushi site here was limited in size and situated in a karstic depression, more precisely in the eastern part of its floor and on its eastern wall. (This depression corresponded to the brecciated zone cropping out to the west of the mineralized area.) Exploitation followed, Kipushi soon producing the basic feedstock for the Lubumbashi smelter, and continuing to do so until recent years. Production in the other mines of the southeastern sector was limited to small amounts of oxidized ore. A concentrator was built in 1935 and, because sphalerite had become a contamination problem for the smelter, differential concentrations were achieved. The crude sphalerite concentrates were exported until 1954, when a facility specifically for refining zinc and cadmium became operational at Kolwezi. Separation of sphalerite allowed not only the recovery of a new valuable metal, but it also reduced the quantity of coal that had to be imported from Wankie, Rhodesia. Furthermore, grilling of the sphalerite concentrates in the roasting furnaces of a special chemical plant in Likasi permitted the recovery of sulfur for manufacturing the sulfuric acid used in the lixiviation plants, and thus reduced importation from South Africa.

Exploitation down to the 700-meter level has produced a total of 14 million tons of ore with an average content of 18% zinc, 10% copper, 1% lead and 60 g/ton silver (Intiomale and Oosterbosch, 1974). The total potential production is estimated at 10 million tons zinc, 5 million tons copper, 400,000 tons lead, 45,000 tons cadmium and 120 tons germanium, plus other rare metals recovered at a second refining site outside Zaire. For comparison, the production of Tsumeb, from 1906 to 1984, has been evaluated at approximately 20 million tons of ore from which were recovered some 2.5 million tons lead, 1 million tons copper and 850,000 tons zinc (Keller, 1984). When the pioneer geologist Jules Cornet stated in 1894 that Katanga was a "geological scandal" (Gauthier *et al.*, 1989), he had not been aware of the richness of Kipushi, or even of its existence.

MINE WORKINGS

The general rule followed elsewhere in Shaba that ore containing 3.5% copper is at the limit of profitability in underground mining is not applicable at Kipushi. If the deposit had to be re-exploited today, it would still be as an underground mine, despite the mechanized shovels and other heavy equipment now available.

Exploratory workings were begun at the end of 1922 and by 1930 had been carried out down to level 40 by subcontractors. A pillar of low-grade oxidized ore was left in place adjacent to shafts sunk in the stable rocks of the middle Kakontwe (to the side of the footwall). The "open pit" was then partially filled back to the level of the original floor. No attempts were made to recover the totality of superficial ore (cropping out or not), because room was needed for processing plants. Ore became more interesting with depth, especially the masses of

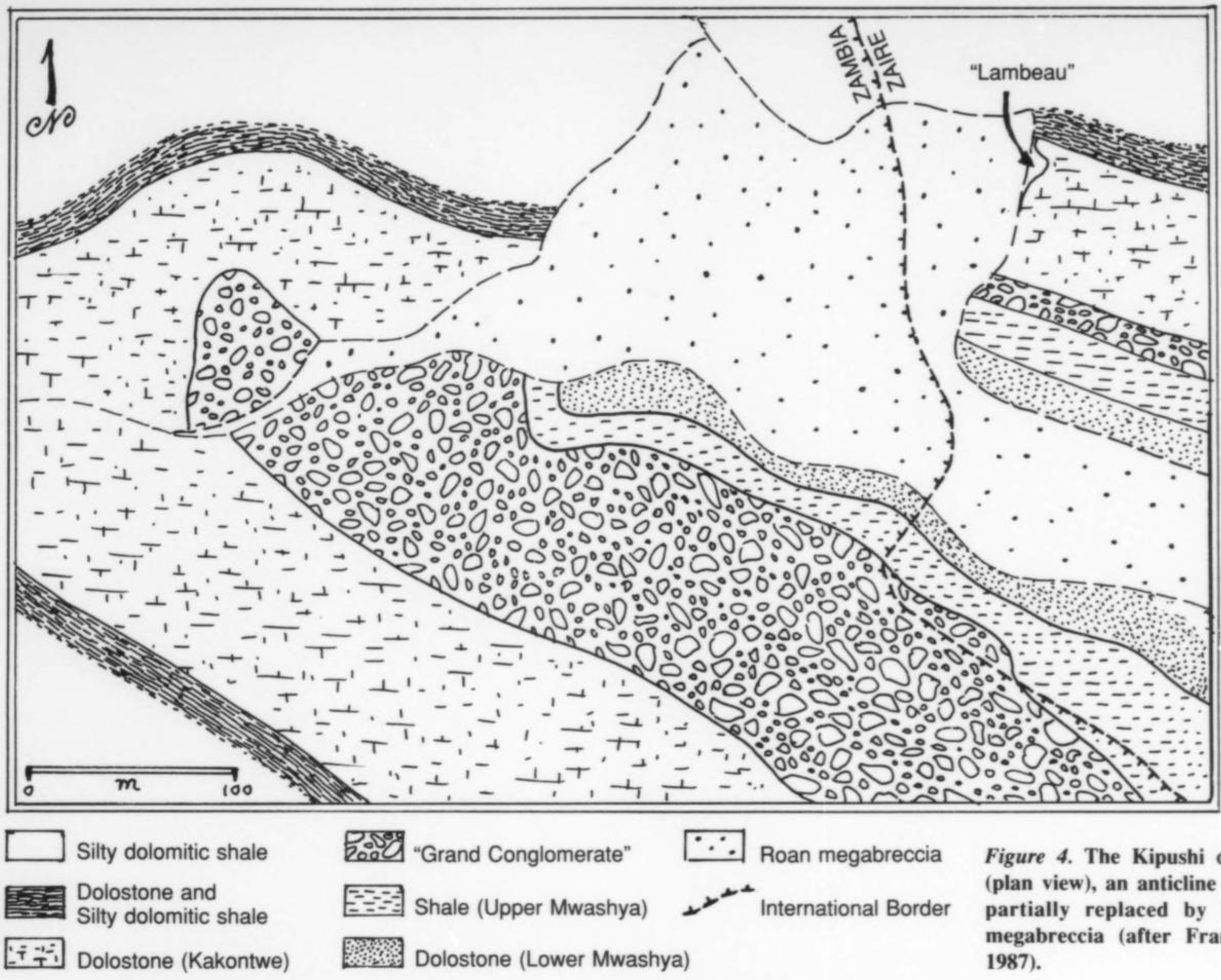


Figure 4. **The Kipushi diapir (plan view), an anticline flank partially replaced by Roan megabreccia (after François, 1987).**

Figure 5. **The Kipushi mine outcrop in a natural karstic depression, 1915 (photo by Maj. R. R. Sharp).**

Figure 6. **Kipushi shafts I, II, and III in the 1960's (photo by R. Vandenbussche).**

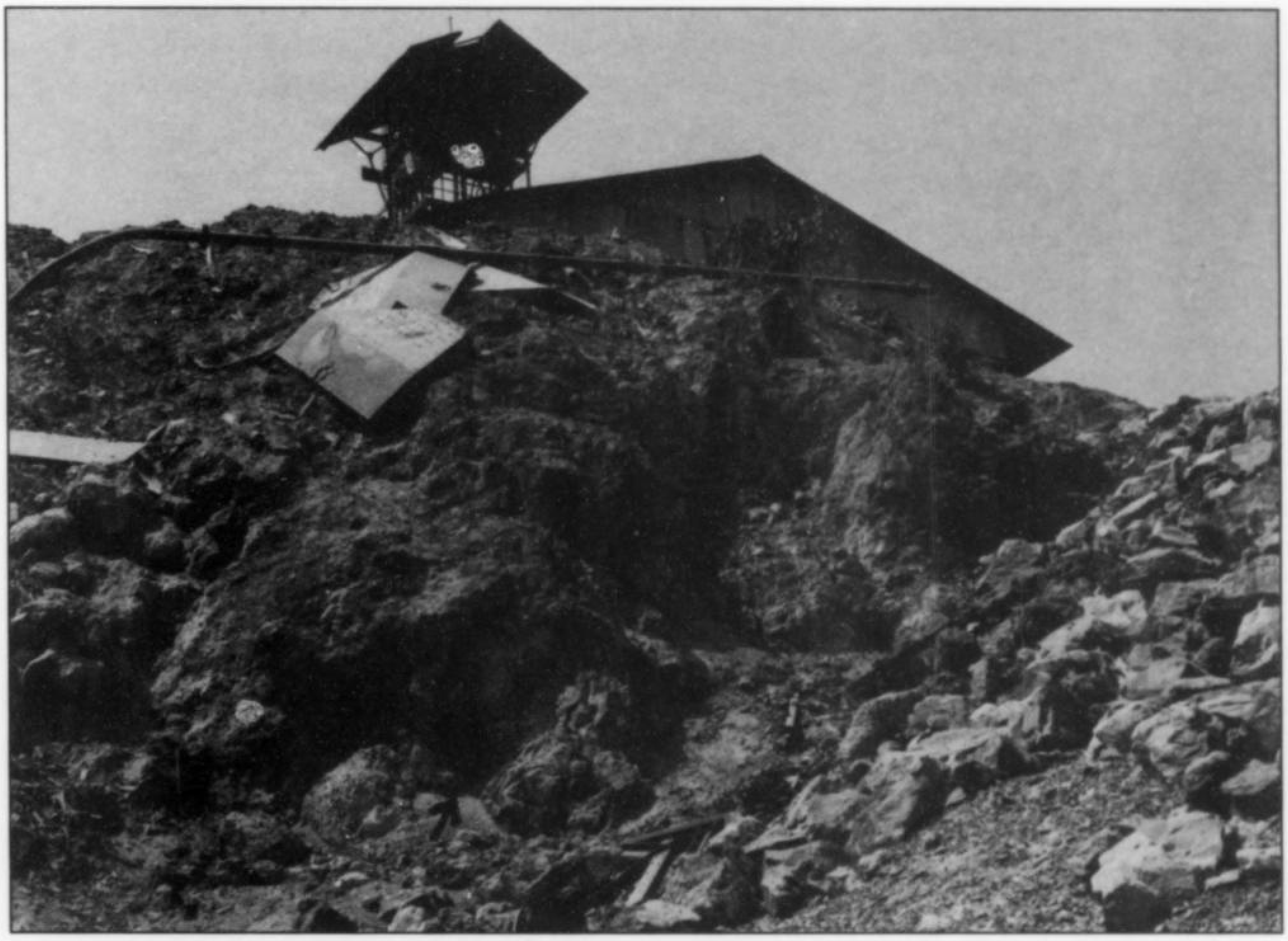


Figure 7. **Front on the mineralized promontory showing the location (arrow) of the recently found kipushite pocket at the 8-meter level just below shaft I.**

Figure 8. **Miners working underground at Kipushi (R. Vandenbussche photo).**

cementation chalcocite; two dumps of oxide ore were left behind after sorting out. An ancient exploratory incline through the pillar was kept intact and even later re-timbered. Joining the ventilation shaft, it served as a passage for pipes carrying compressed air and tailings (employed to fight fires in ancient timberings and later to backfill the large sublevel stopes).

The first preparatory workings were carried out in 1924–25: sinking of shaft I for hoisting, of shaft II for service and digging out of the crosscut tunnels at levels 65 and 100, followed by preliminary workings (in ore) which initiated underground production in 1926. There were also the ventilation shaft (III) to the north and the water pumping shaft (IV) to the south. Shafts I and II descended to level 500, and from there ore and men were relayed by shafts I-b and II-b. The ventilation shaft had to follow the trend of the vein, and eventually involved successive portions of old workings with variable slopes, added level by level. Shaft IV, which also served as a passage for the electrical cables, was continuous to depth, successive pumping stations having been constructed at selected levels. The distance between levels was initially 35 meters and later 50 or 60 meters.

Underground exploitation was begun from level 65 upward to level 40, with complete timbering and backfilling by the square-set method. This was changed to top-slicing from level 100 downward. The new technique, based on the removal of horizontal descending 3-meter slices, was well-adapted to maximum recovery of high-grade ore from the main body. Timbers were still used, and served as flooring, in continuous descent. Backfilling was no longer necessary, thanks to the steeply dipping lode.

Fires in old wood layers have long been a hazard to ventilation (which was probably the weakest aspect of the overall mining plan); work had to be suspended several times for up to a month. The top-slicing technique was improved around the 1960's, timbering being replaced by a supple metallic support laid in place beforehand. It was made up of a lattice work of crossed sheet-iron strips covered by a wire netting, supported by reusable shores with cotter pins.

No satisfactory method had been found for recovering the offshoots of low-grade ore until the early 1950's. The solution came with sublevel caving, started in 1954, for the Zn-rich lenses, from level 400 downwards. It produced large holes involving an entire level, 50 meters in height, which had to be backfilled to prevent air blasts and other hazards.

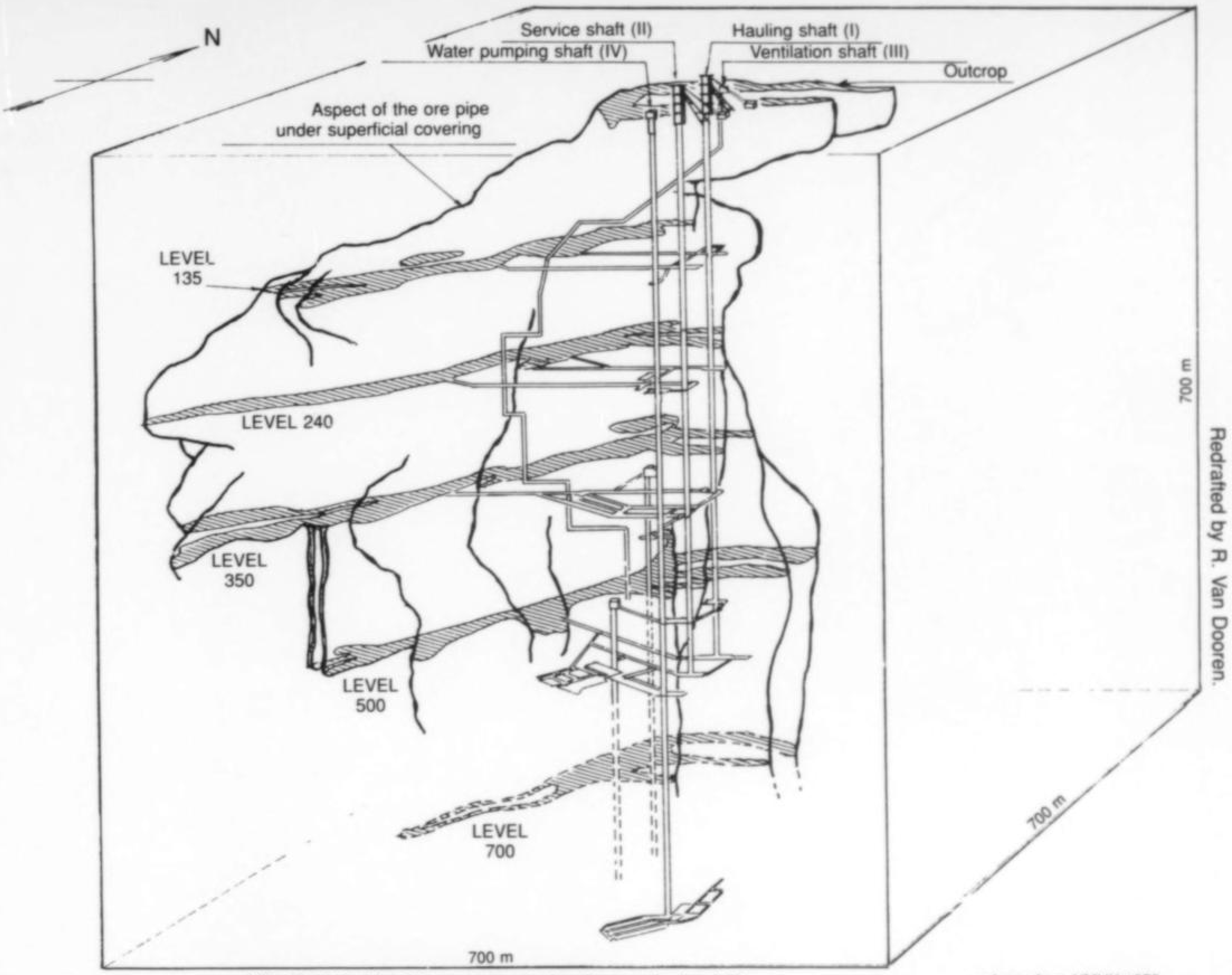
From about 1965–1975, Gécamines was willing to maximize the production. A new multipurpose shaft (V) was sunk and equipped by South African technicians directly down to level 1150, 2 km east of the lode, in stable Kakontwe rocks and outside the old mine buildings and houses. It was accompanied by a wet-milling plant connected by a pipeline to the concentrator. The bottom of this shaft was connected with the workings by a so-called tunnel V. The water flow was so great that the tunnel had to be constructed with two inclined portions (with a summit in its middle) for drainage, half going to shaft V and half to the ancient pumping stations. By that time, top-slicing had been progressively replaced by sublevel stoping, with the introduction of fuel-powered trucks. In 1993, exploitation had reached at least level 1200, and other workings extended still deeper, ore having been recognized at least as deep as level 1500.

With regard to specimen recovery, collectors have only been allowed to go over the old dumps containing material from the superficial levels or made up of relatively barren Kakontwe rock from levels above 400, wherein the occasional interesting mineralized block could sometimes be discovered by chance. The most persistent collectors eventually operated by night, or with (exceptional) permission, on the pillar and even in the incline. Except for the discovery of kipushite, made by collectors, the locality has been curiously silent for the last 15 years or so, probably due to the absence of motivated collectors, and the legend that the sulfides are only massive. In addition to the underground levels, the open workings on the site of the outcrop will probably be rewarding places to collect specimens.

As of mid-1994 the Gécamines operation had almost come to a halt, but Kipushi was still alive; the pumps were still operating, and small amounts of sphalerite were being mined for production of sulfuric acid. Much of Kipushi's richness remains on the tailings and slag heaps.

GEOLOGY

The regional geology has been reviewed by François (1987) in a comprehensive synthesis, surveyed by Gauthier and François (1989) In a following paper, François (in de Magnée and François, 1988) has laid particular stress on the role played by Roan evaporites and their diapiric ascent in various kinds of tectonic ruptures of the Kundelungu covering, followed by collapse brecciation, to explain peculiarities like the dislocation of the three lower Roan groups in a megabreccia and the cropping out of this megabreccia as fragments, often of large size, which can be mingled with blocks of the Kundelungu Supergroups, as in cases of partial scraping of an anticline flank. Also stressed is the role played by hot brines resulting from the solution of evaporites as



NB: The left side of the outcrop, sloping down to the level 30
has been worked out as open pit mine.

redrawn from UMHK 1958.
RVD 1993.

***Figure 9.* Three-dimensional diagram of the Kipushi ore pipe and associated mine workings in the upper levels (isometric drawing by R. Van Dooren after UMHK data, 1958).**

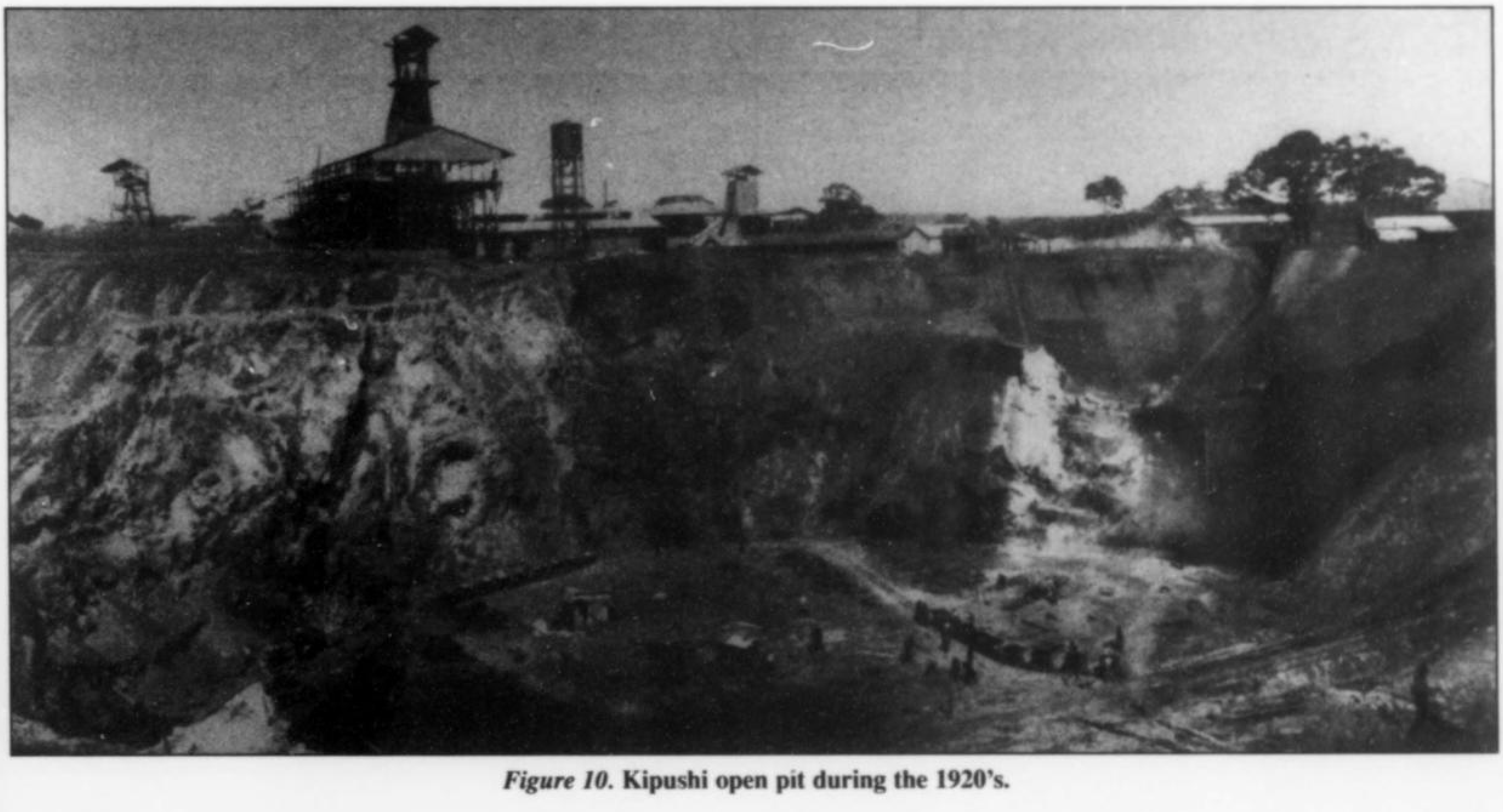


***Figure 10.* Kipushi open pit during the 1920's.**

Figure 11. **Headframe and mine buildings at Kipushi, shaft II.**

Figure 12. **Underground mucking at Kipushi in the 1970's. Photo by J. Baeke.**

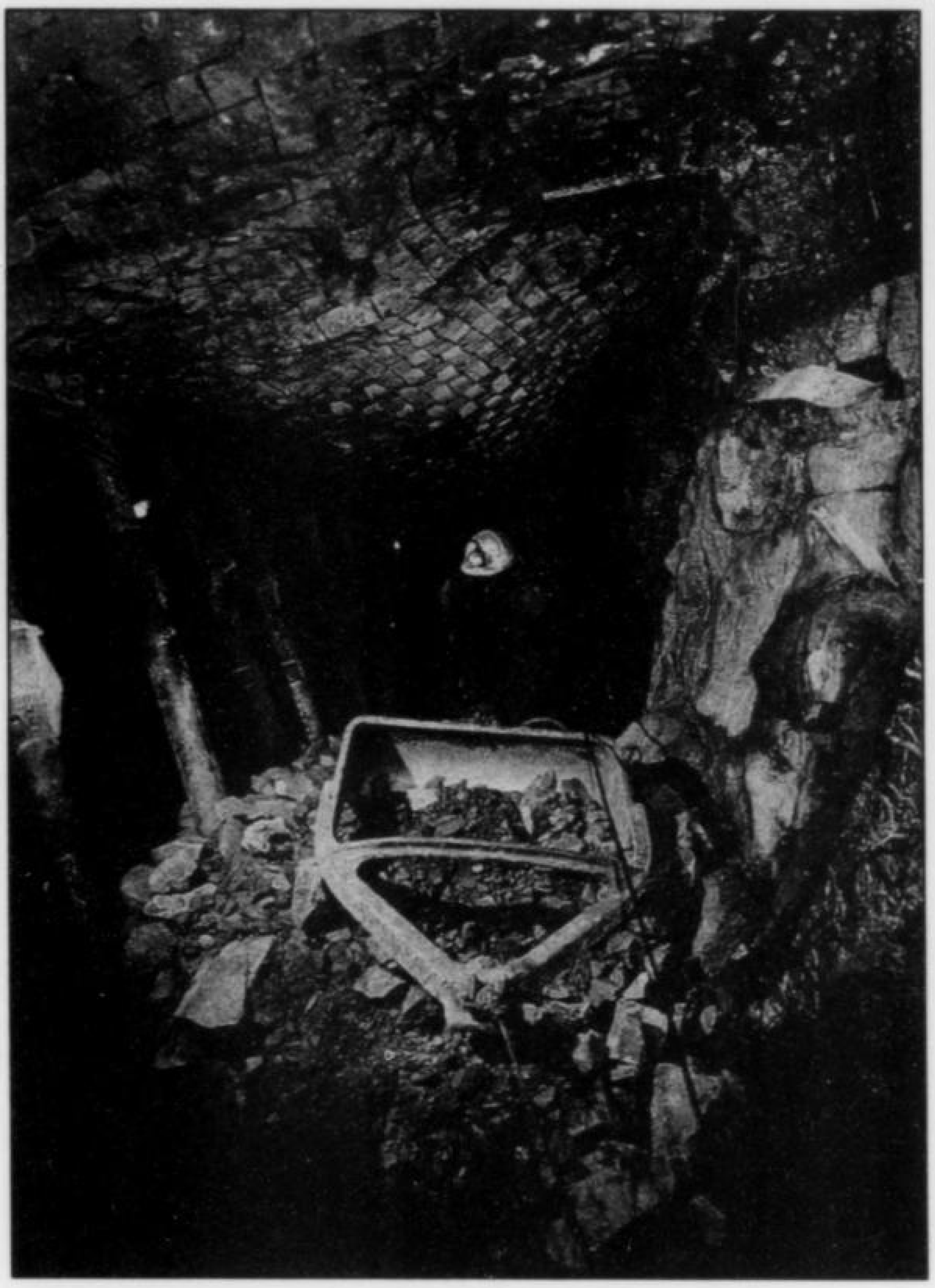


Figure 13. **The top of shaft II, above a mineralized promontory.**

Figure 14. **Kipushi shaft V and associated buildings. Photo by R. Vandenbussche.**

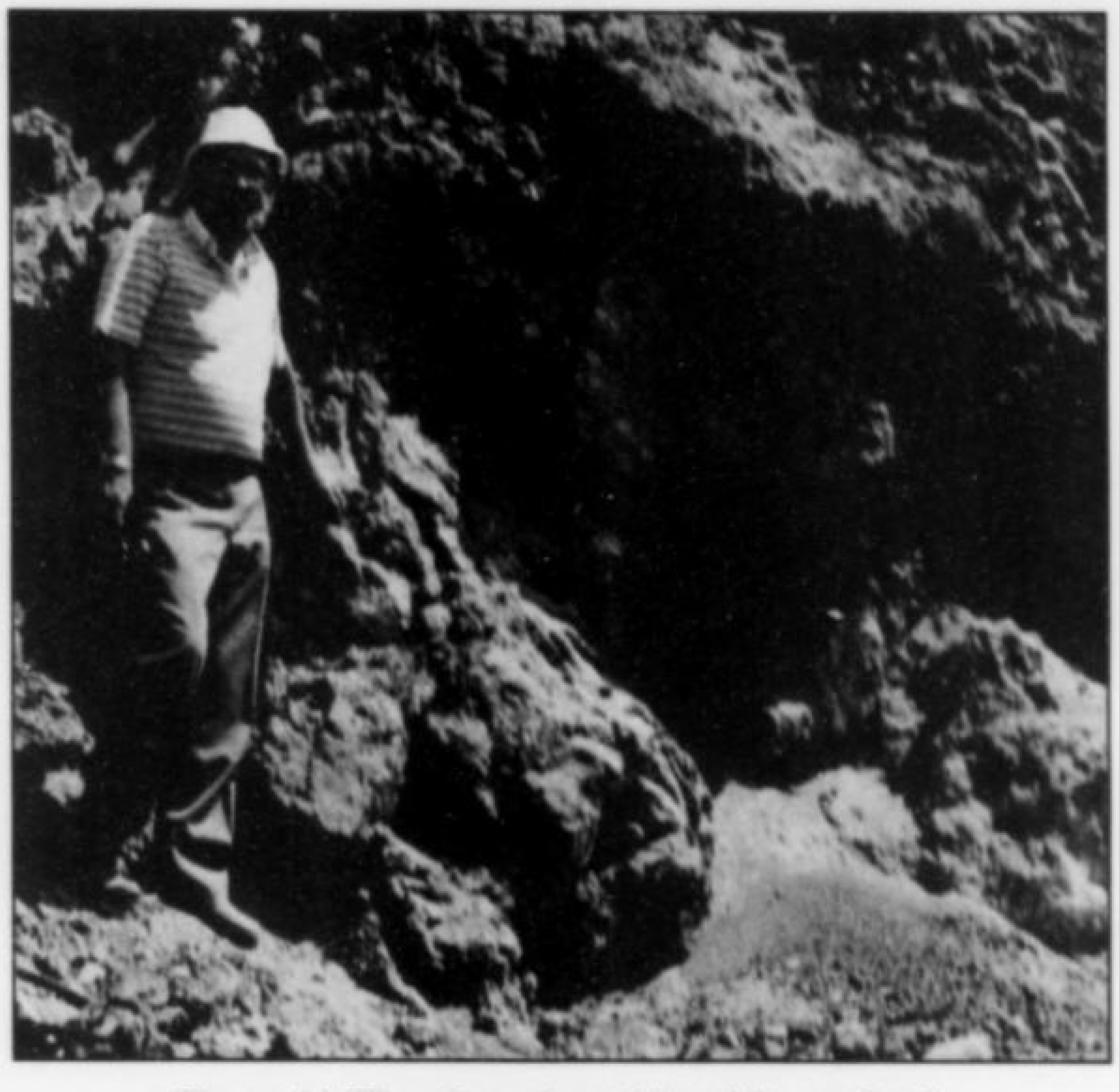


Figure 15. **The cleaned-out kipushite pocket in the promontory. Photo by J. Pendeville.**

Figure 16. **A collector splitting a mineralized block near the dump.**

mineralizing fluids, especially in epigenetic post-tectonic deposits like Kipushi.

Kipushi

To the south of the Lufilian arc, the anticlines become successively rarer in R2 (Roan) fragments. The Kipushi uplifted anticline straddles the border for a distance of 25 km, trending N60°W. Its axial core is filled with a megabreccia belonging in all likelihood to the R3 group. It ends at the Kipushi site where a huge portion of its northern flank, some 1800 meters in length and 200 meters in depth, has been torn away and replaced by a megabreccia. Toward the east, the breccia is in contact with a discontinuity surface dipping N70°W. The Kipushi fault exposes from south to north the normal stratigraphic succession from the lower R4 group to the upper part of the Lower Kundelungu

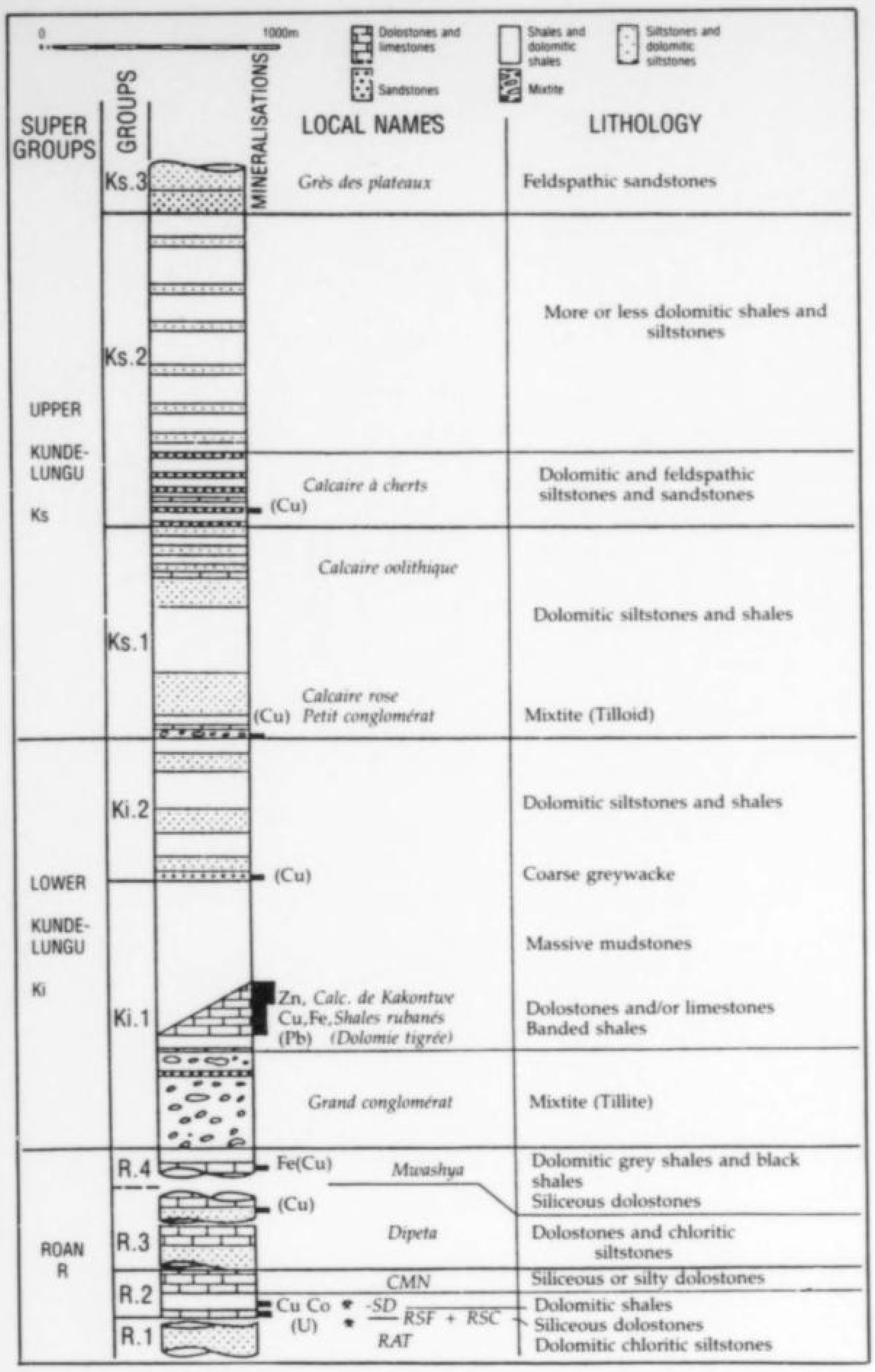


Figure 17. **Stratigraphy of the Katanga System (from François, 1987).**

Supergroup. The latter is present here as a southern facies, rich in permeable carbonate beds which deliver important quantities of water and are subject to karstification, ancient and recent.

Above the Ki 1.2.2 member, "Calcaire de Kakontwe" (more simply Kakontwe), lies the "Série Récurrente," a name given by miners to a banded alternation of silty dolomitic shales and dolostones, a member seen only in underground mine workings. Both form the footwall of the orebody, together with some breccia in the south. The Kakontwe, mostly made up of limestones in its southern facies, is heavily dolomitized over a distance of 200 meters from the lode, and to a lesser extent quartzified as a result of reworking of the country-rock before deposition of sulfides (Thoreau, 1928, and Hughes, 1979, for Tsumeb), and weak metamorphism (de Magnée and François, 1988). The early "feldspar-quartz-mica phase" of Thoreau (1928) cropped out as a chloritic breccia and enlarged the network of fissures in the Kakontwe. These openings later became lined with secondary gangue minerals, as seen particularly in fantastic caves and crystal-covered walls encountered during preparatory work near the lode. The roof of the orebody is formed by the "Grand Lambeau," a gigantic slice of stratified dolomitic and silty shales belonging to one of the Kundelungu Supergroups, a fragment of the anticline flank before its rupture (Intiomale and Oosterbosch, 1974). This impermeable roof, up to 250 meters thick and 500 meters long, is more or less continuous between the 200 and 1800-meter levels. Its stratification is nearly parallel to the bedding of the Kakontwe, dipping 70° to 80°NE. The Kipushi fault and the Grand Lambeau were the structures which channelized the ascension of the mineralizing fluids into a narrow space during the period of mineralization. Two horizontal tunnels terminated by drill holes at level 240 and 1150 have penetrated the megabreccia and crossed slabs of saussuritized gabbro (Intiomale and Oosterbosch, 1974). It does not appear igneous rocks were intruded at that time, but rather were present beforehand in the R3 group.

Features of the Deposit and Mineralization

Like Tsumeb, the Kipushi deposit is a typical ore-pipe, near-vertical, and irregular but roughly elliptical in cross-section. Unlike Tsumeb, it is composed mostly of massive ore and a few disseminated areas of low grade. It has an axial trend of N28°E, is 200 to 600 meters long, and 20 to 60 meters thick (average 30 meters) with the maximum thickness at the top of the Kakontwe, where it forms the northern massif. The pipe follows the fault at every level, and dips 70°NW (in a vertical cross section). This main portion of the orebody is rich in both zinc and copper sulfides, zinc ore becoming more and more segregated and predominating over copper ore in the lower levels.

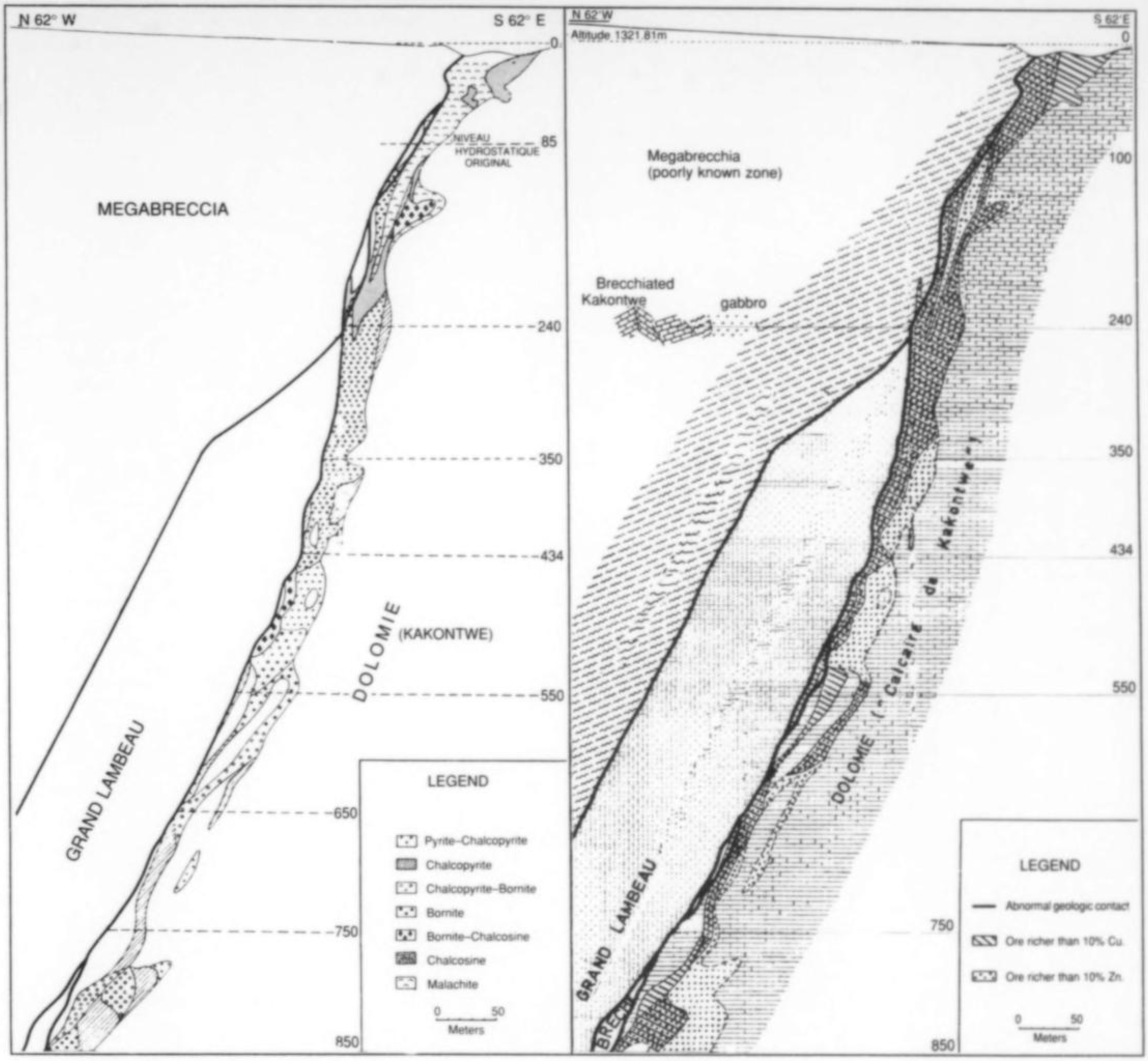
Mineralization did not penetrate into the "Grand Lambeau" to any significant extent. On the contrary, three zones can be distinguished on the footwall: (1) In the "Série Récurrente," over a stratigraphic distance (to the north) of 50 meters, where stratabound off-shoots have penetrated the more permeable shaley horizons over a distance of at least 100 meters, resulting in low-grade (about 2%) copper ore with just a trace of Zn; (2) In the upper Kakontwe, where the northern body is extended as off-shoots forming the so-called eastern apophysis, made up of low-grade zinc ore, with some lead; and (3) in the middle portion of the Kakontwe, where sphalerite-rich (to 40% Zn, with just traces of Cu and no Pb) appendicular pipes are often surrounded by a pyrite sheath, and invade the country-rock in a complex pattern branching laterally, upward and (mainly) downward (Ottenburghs, 1964), following a network of fissures and cavities that may be part of the network created by early brines. These latter are at least four in number, are well delineated, rounded or elliptical, and with cross-sections of 5 to 40 meters; they eventually connect to the main pipe. The longest could once be traced down to level 700, while the largest is still in place between levels 290 and 400. The oxidation zone reached level 120. Secondary sulfides are dominant down to level 250, but traces of oxidation-cementation are present to very great depth. The water table is at 85 meters. The zone of outcrop is rather limited in comparison to the horizontal extent of subsurface levels.

The average content of extracted ore (to level 700) was about 30% economic metals, 10% iron and 20% sulfur (Intiomale and Oosterbosch, 1974), or about 40% gangue.

Paragenesis

The literature that has issued from European institutions regarding complex sulfides in polished sections has been prolific. It began with a paper by Thoreau (1928), who had studied the first drill cores, and continued until about the mid 1970's, mainly at the School of Leuven, Belgium (Ottenburghs, 1964; Viaene and Moreau, 1968; Devos *et al.*, 1974 and others). Most authors suggested a scheme of successive phases for deposition of primary sulfides, sphalerite having as a general rule, preceded copper sulfides and each phase having been accompanied by accessory metals, either as trace elements or as distinct species. Earlier-deposited minerals have been partially dissolved, their metals being possibly redeposited as other mineral species. Since Thoreau (1928), all authors have agreed that sulfides were deposited by metasomatism of carbonates and not by filling of voids, although the banded structure typical of this mode of deposition has rarely been encountered. On the contrary, ore samples appeared porous (Thoreau, 1928; Dimanche, 1974). Because deposition lasted over a long period, replacement has been progressive, first as a stockwork and then as eventual complete replacement of the gangue

Figure 18. **The Kipushi orebody, in vertical profile: (left) mineralization, and (right) Cu and Zn mineralization limits (after Intiomale and Oosterbosch, 1974).**



(Masuy, 1938). According to Devos (1973), and to observations on the numerous blocks of gangue which collectors had to split, only the last phase of ore reached the surface; upper levels remained at the stockwork stage. Deutzmann (1961), after studying hundreds of polished sections from the Tervuren Museum, concluded that there were two parageneses, one formed at a rather high temperature (corresponding to the first two phases of other authors, e.g. the pyrite-arsenopyrite phase with some chalcopyrite and the sphalerite phase) and another one formed at lower temperature (corresponding to the Cu-II or cupro-zincian phase of others). Devos *et al.* (1974) summarized the general sequence: pyrite and arsenopyrite crystallized first, followed by sphalerite, then by chalcopyrite, tennatite and some germanium species (germanite, briartite) and finally by copper-rich sulfides (bornite, chalcocite) and renierite.

For the secondary minerals, a paragenetic sequence has not yet been established. The literature consists only of descriptions by early observers, which were summarized by Buttgenbach (1947). It seems logical that, as at Tsumeb (Keller, 1984), the supergene fluids followed the karstic channels, as evidenced by the gangue remnants. This could explain why the oxidation and cementation zones are quite extended in height, due to the presence of many gangue remnants in the very highest levels, and are also found as traces and pockets in depth. Examination of many specimens has confirmed this; these consisted of a matrix of one of the primary sulfides, like massive chalcopyrite, containing remnants of arsenopyrite crystals; and of a vug lined by iron oxides and quartz wherein crystals of a secondary mineral like hemimorphite had developed.

Dimanche (1974), who studied polished sections of ore from level 500, believed his samples had been modified by supergene alteration (as suggested by the presence of digenite, covellite and idaïte).

MINERALS

The list in Table 1 is a compilation primarily of data from the literature, unpublished reports by the geological staff of the companies (U.M.H.K. and later Gécamines), specimens in the collections of the Tervuren Museum (courtesy of Dr. M. Deliens), and personal observations. It is probably far from complete; for example, arsenates must occur more abundantly than reported if one considers the quantity of As in primary ore. Several descriptions of new species are still in preparation. Devos *et al.* (1974) have reported a Ge-bearing sulvanite, and also V-bearing and W-bearing germanites, probably related to similar phases reported from Tsumeb by Pinch and Wilson (1977). There was also an incompletely characterized sulfide of Ga, Cu and Fe, a Ga-rich briartite and others.

Adamite $Zn_2(AsO_4)(OH)$

Adamite has not previously been identified from Kipushi in the literature. Some years ago, however, collectors found a block of

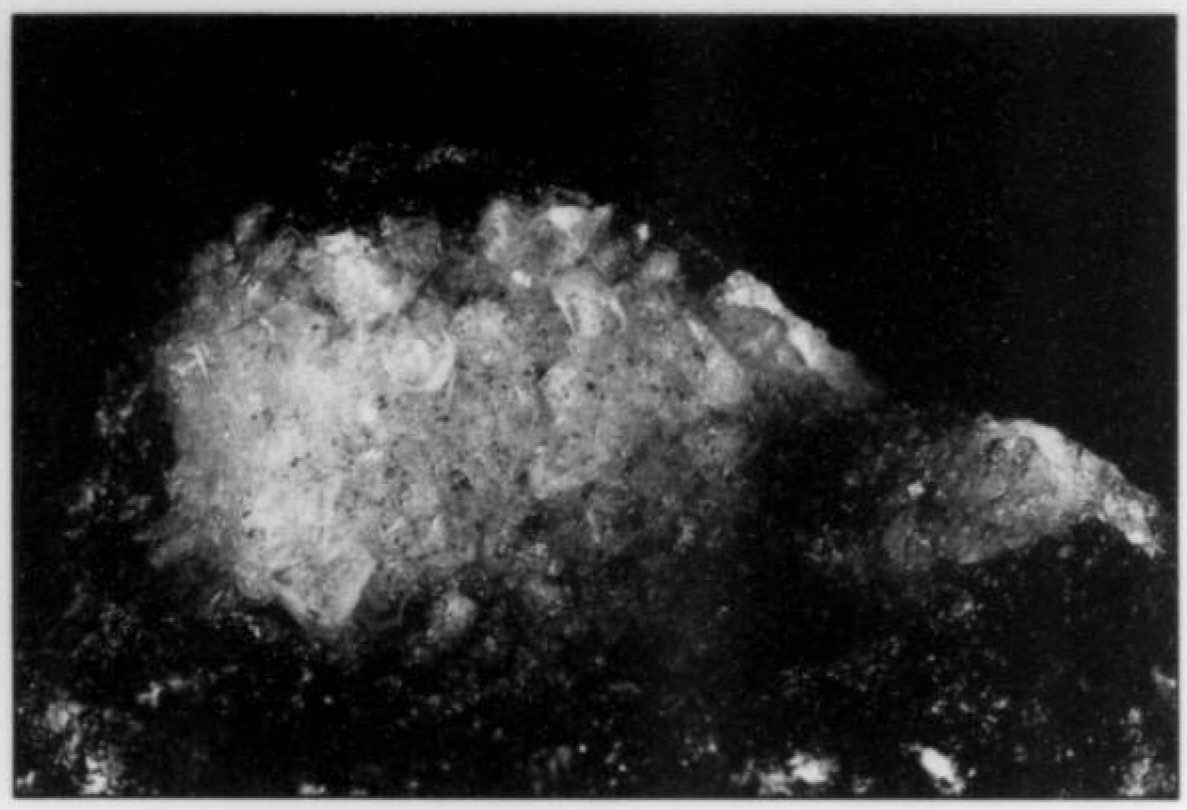


Figure 19. **Adamite crystal aggregate, 1.2 cm; Lhoest collection and photo.**

chalcopyrite showing traces of alteration; splitting this block revealed aggregates of yellow to white crystals since identified as adamite. Associations include hemimorphite, goethite and quartz. Six specimens were recovered from the find, including one good cabinet specimen.

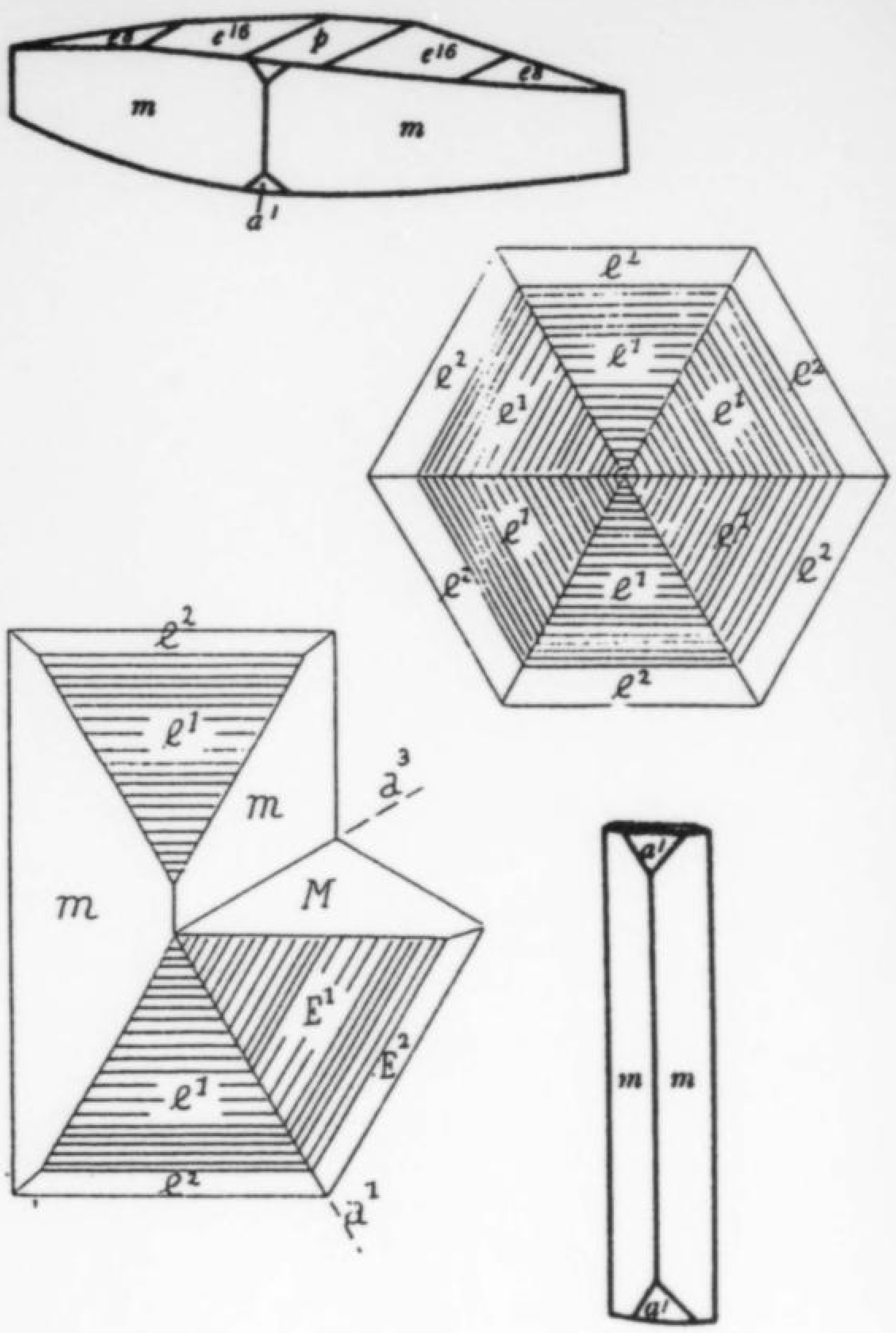


Figure 20. **Arsenopyrite crystal drawings (Umba *et al.*, 1977; Buttgenbach, 1947).**

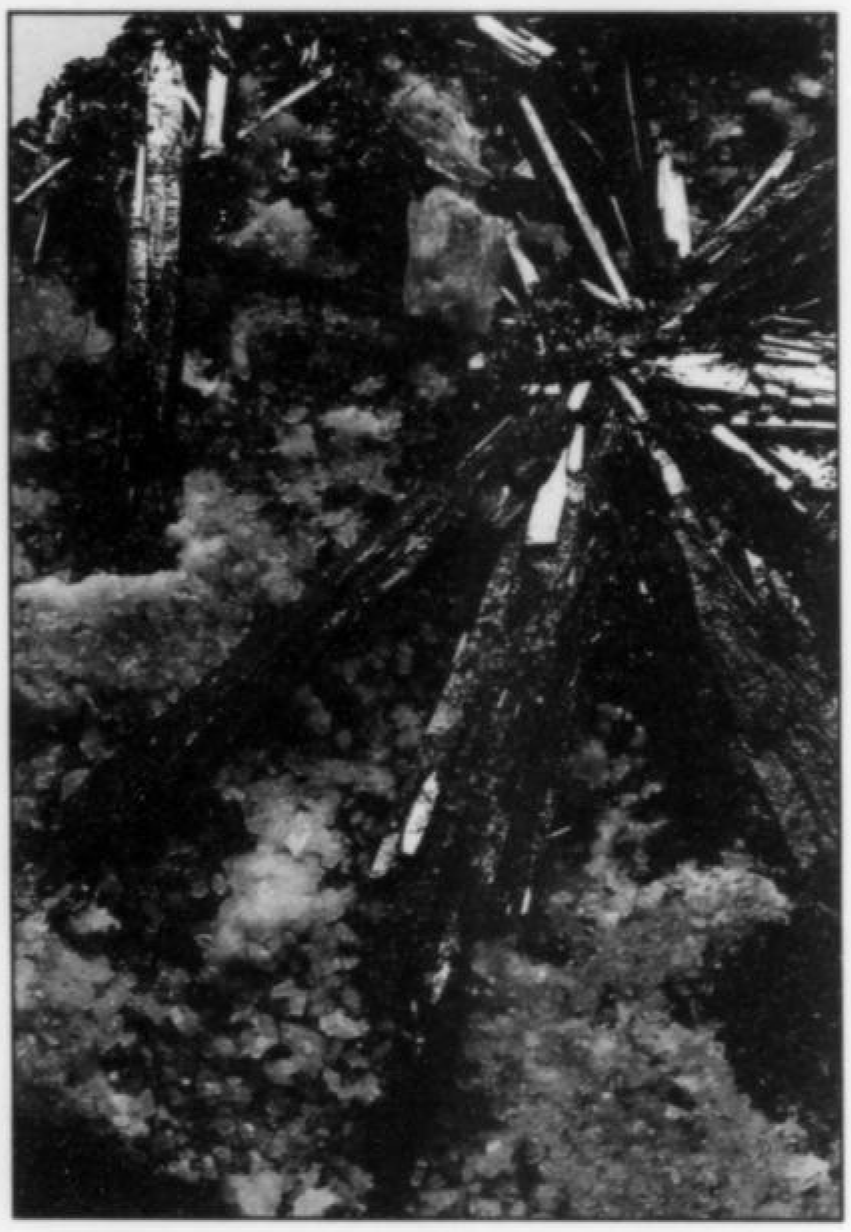


Figure 21. **Arsenopyrite crystals to 6 cm; Lhoest collection and photo.**

Arsenopyrite FeAsS

Arsenopyrite, one of the earliest-formed sulfides, has been known from near-surface exposures since 1927 (Buttgenbach, 1947). Buttgenbach described twinning on (101) and (103); because the angle with the longitudinal axis is about 60° in both cases, trillings about the *y* axis can result, as had been observed for the species by Dana in 1892.

Arsenopyrite is widespread as euhedral, silver-white crystals of long prismatic habit commonly up to 1 cm in size, and occasionally up to several centimeters, as single crystals, rosettes and sprays. The terminations are rounded and transversely striated, but the longitudinal faces show no striations. Crystals in the dolomitic and quartzitic country rocks which have escaped corrosion or replacement by later sulfides are found unaltered, whereas crystals found with sphalerite, tennantite and chalcopyrite are corroded.

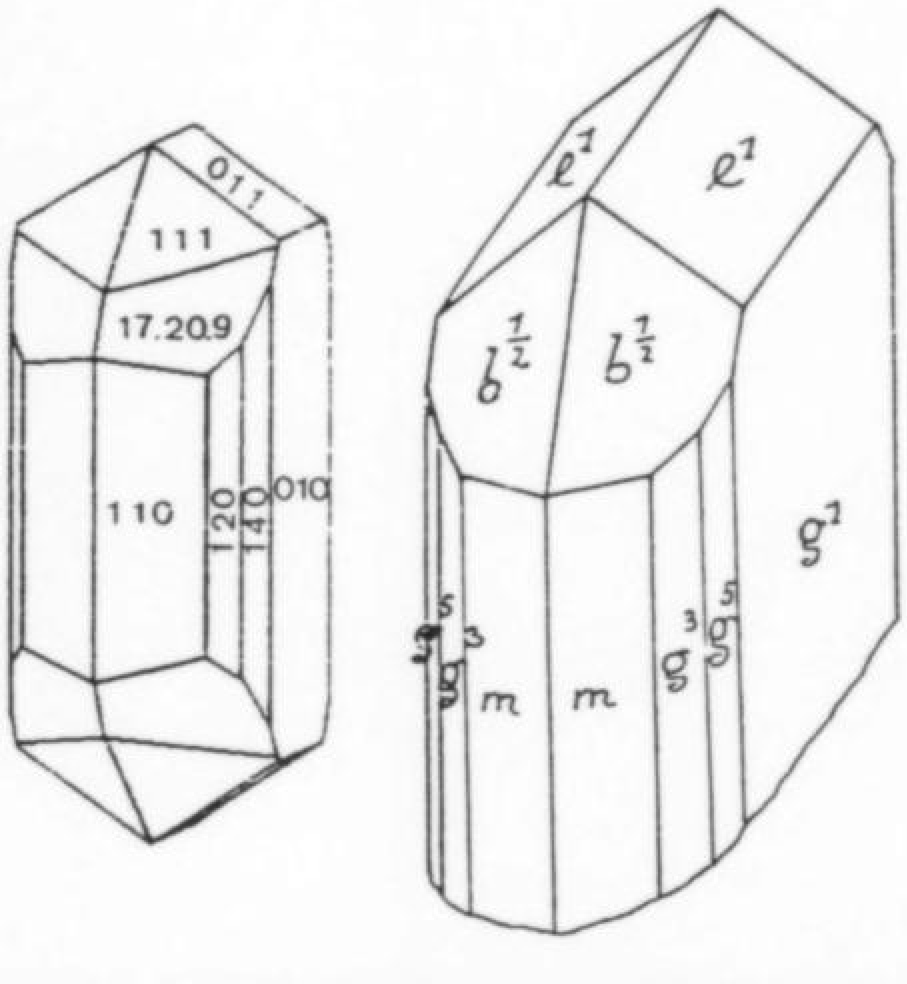


Figure 22. **Atacamite crystal drawings by Buttgenbach (1947) (right) and as modified by R. Van Dooren to emphasize the vicinal {17.20.9} faces.**

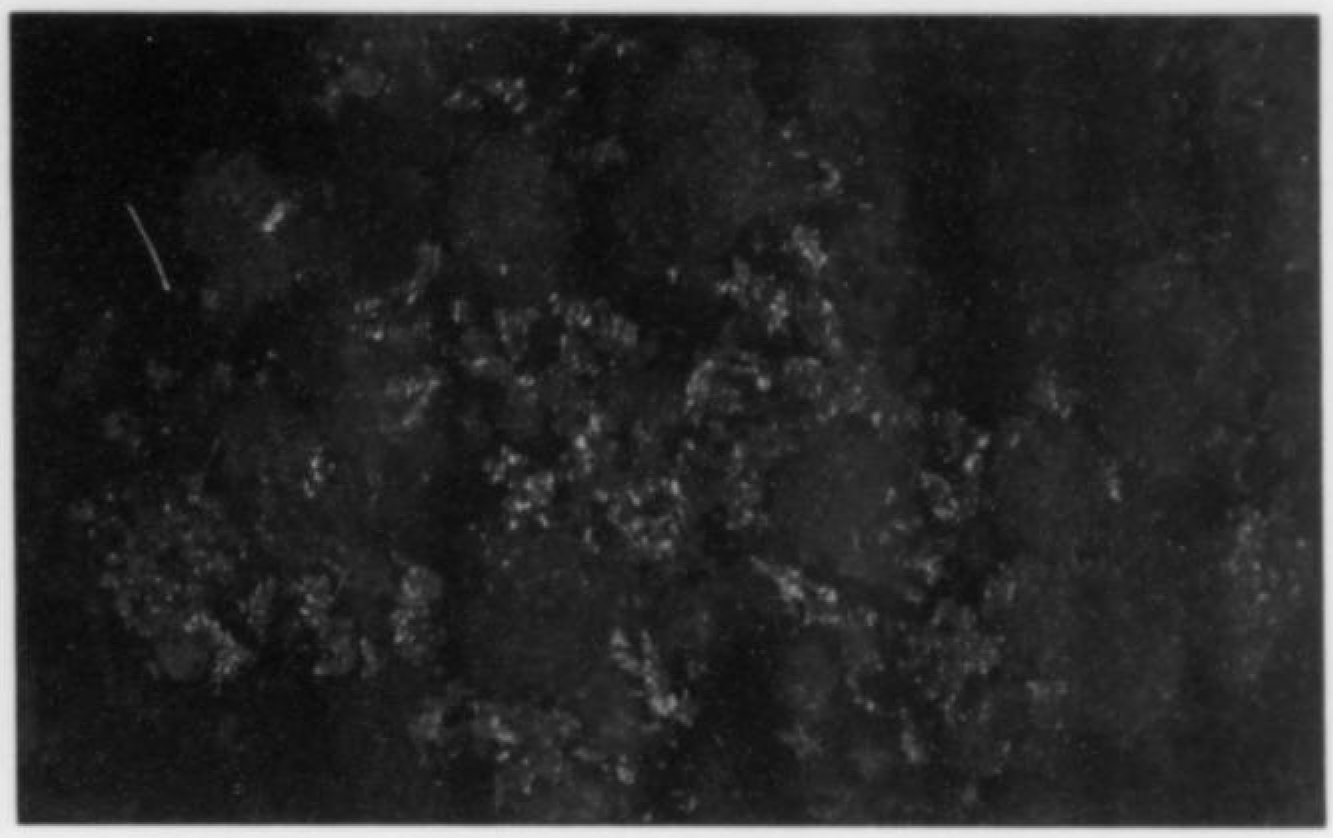


Figure 23. **Aurichalcite with hemimorphite and scales of native silver; M. Houssa collection; Lhoest photo.**

Figure 24. **Aurichalcite crystal sprays with hemimorphite on limonite, 4 cm across; Lhoest collection and photo.**

Figure 25. **Aurichalcite, 9 cm, hardened by an intimate intergrowth of microscopic hemimorphite; Lhoest collection and photo.**

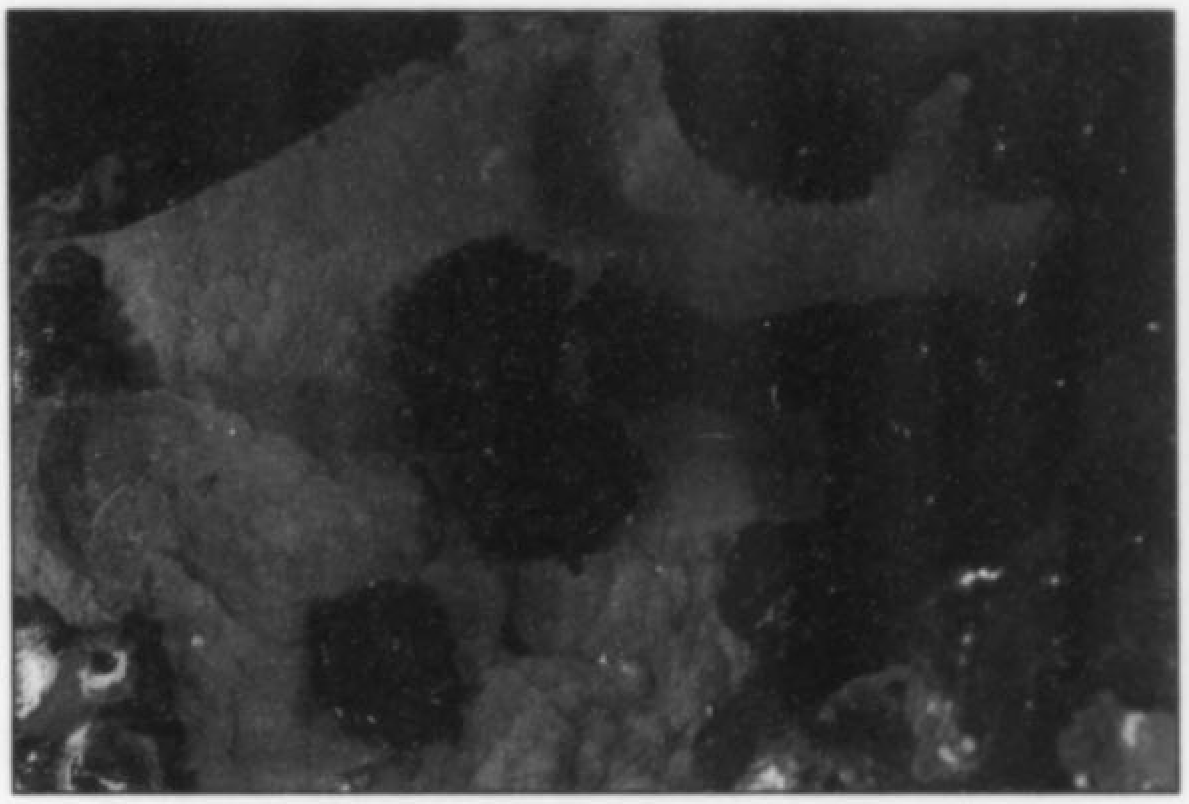


Figure 26. **Azurite rosettes on malachite, 4 cm across; F. Coune collection; Lhoest photo.**

Atacamite $Cu_2^{2+}Cl(OH)_3$

Atacamite has been known from Kipushi since 1928, in association with acicular cuprite. Buttgenbach noted the presence of the vicinal form *t*{17.20.9} on some specimens.

Aurichalcite $(Zn,Cu^{2+})_5(CO_3)_2(OH)_6$

Aurichalcite has been recognized from Kipushi since 1923, as tufts of small, acicular crystals in a vug (Buttgenbach, 1947). Buttgenbach also reported that aurichalcite inclusions can impart a green color to hemimorphite. He noted intergrown fibrous masses to 6 cm in thickness, with individual needles 3 to 8 mm.

Fibrous masses of aurichalcite to 10 cm thick were collected in the early days of mining; these asbestiform masses have in some cases been hardened by the intimately mixed presence of hemimorphite.

Aurichalcite is common in the near-surface oxidation zone. During the 1970's collectors recovered substantial numbers of specimens from the oxide dumps and from blocks pulled down from the piliars. Associations commonly include colorless hemimorphite, and hemimorphite crystal aggregates colored blue or green by aurichalcite inclusions (as radiating fibrous spheres and as uniform impregnations). Mammillary crusts and isolated hemispheres are also encountered.

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

Buttgenbach (1947) reported irregularly rounded azurite aggregates to 6 cm. Unlike malachite, azurite is rare in Katanga, Kipushi being one of the few occurrences. Even pseudomorphs of malachite after azurite are rare and especially prized by collectors. Crystals are generally not very sharp and are less than 1 cm in size. Azurite stalactites to about 1 cm were found during the early days of mining.

Betekhtinite $Cu_{10}(Fe,Pb)S_6$

Betekhtinite, first reported from Kipushi by Deutzmann (1961), is widespread in the lower bornite zone on level 850, as large masses and scattered groups of acicular, blackish gray crystals to 2 cm. Betekhtinite is also found as blebby masses and veinlets in bornite-rich ore. Tennantite may also be present, but the most typical associations besides bornite are chalcocite or galena (but not both). The compositions of these minerals suggest that betekhtinite + bornite cannot be in equilibrium with chalcocite and galena at the same time, a conclusion born out by observation (Devos *et al.*, 1974).

Figure 27. **Betekhtinite crystal aggregate, 1.5 cm; J. Pendeville collection; Lhoest photo.**

Bismuth Bi

Native bismuth has been found in isolated bodies at the margin of the deposit on the lower levels, along with complex bismuth sulfides. Trace amounts of bismuth have also been found in several sulfides, mainly tennantite and, to a lesser extent, sphalerite (Intiomale and Oosterbosch, 1974).

Bismuthinite Bi_2S_3

Bismuthinite was reported by Devos *et al.* (1974) in iron-rich ore of the Cu-I type (chalcopyrite, pyrite, arsenopyrite) on level 575.

Bornite Cu_5FeS_4

Massive primary bornite is the most abundant copper-bearing sulfide at Kipushi. It occurs as well-delineated zones in copper-rich ore, with a large extension in the upper levels (down to 400) and another one in the lower levels (around 850). From level 975 downward bornite disappears.

Crystals are rare, but many have probably escaped the attention of busy miners near the contact with the country-rock. Yet some good old-time specimens exist in collections as sharp rhombo-dodecahedrons with their faces superficially altered to malachite, exhibiting a lattice of striations due to the alternating growth of cube faces, and with visible remnants of chalcopyrite on the cleavages.

Massive bornite is bronze-colored on fresh cleavages, which rapidly take on the iridescent "pigeon's breast" shades before becoming definitely blue. Sometimes bornite does retain its original color, whether crystallized or not. But in the workings, the color of the cuts is almost always uniformly blue, probably due to multiple fissures caused by blasting in neighboring areas.

Primary bornite is the main carrier of silver, and can contain up to 2,600 ppm as a trace element (Intiomale and Oosterbosch, 1974). It occurs in contact with all other sulfides, except pyrite and arsenopyrite. Supergene bornite is also present, but contains no silver (Intiomale and Oosterbosch, 1974).

In his study of samples from level 500, Dimanche (1974) reported bornite with variations in the Cu:Fe ratio; this variability is easily explained by the complex structure of bornite with its numerous vacant sites (Pierce and Buseck, 1978). The crystal system of bornite is still a matter of debate (Fleischer and Mandarino, 1995; Pierce and Buseck, 1978), the temperature of formation being of importance.

It appears that bornites from various Katangan deposits exhibit their own characteristic colors in collections.

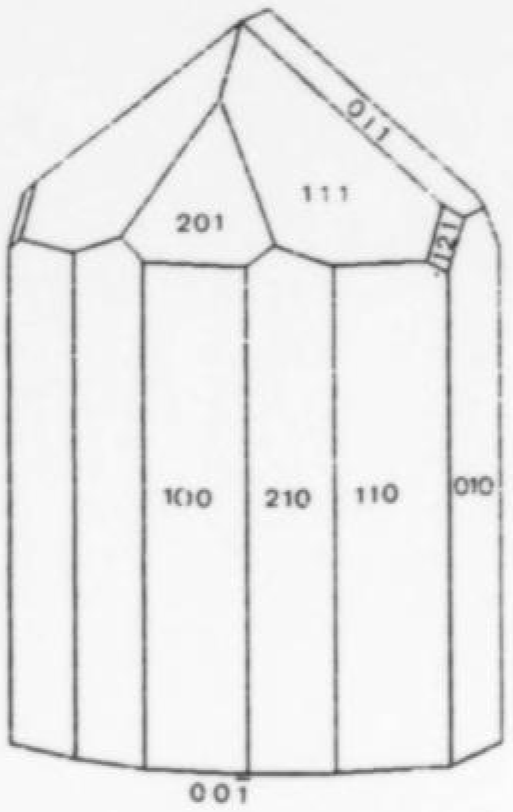


Figure 28. **Briartite crystal drawing based on a synthetic crystal (by R. Van Dooren, after Ottenburghs and Goethals, 1972).**

Briartite $Cu_2(Fe,Zn)GeS$

Briartite was described as a new species by Francotte *et al.* (1965), and named for Gaston Briart, a pioneer geologist at Kipushi. A preliminary description of grains in Tsumeb ore had appeared earlier in an unpublished report of Geier in 1955 (Geier and Otteman, 1972), to which the working name "mineral W" was given, but no more such grains were observed for years.

At Kipushi the mineral was first described by Francotte in an unpublished report of 1962 (Francotte *et al.*, 1965), and then by Ottenburghs (1964) in sphalerite from the appendicular pipes. For the original description, three specimens were used, plus a germanite from Tsumeb, and a renierite from Kipushi for comparison. Coincidentally, a briartite from Tsumeb was also included, which made Tsumeb a co-type locality.

Inclusions of briartite occur (in the Kipushi ore) in tennantite, chalcopyrite and sphalerite, but do not belong to the same paragenesis as renierite (Devos, 1973). The average size of inclusions is 0.1 to 0.3 mm but they can occasionally reach 2 mm. Their color is gray to bluish gray in natural light.

The tetragonal structure is related to that of sulfides with tetrahedral coordination, such as sphalerite, chalcopyrite, stannite and renierite. Chemically, briartite is the richest Ge-sulfide. It contains about 15% Fe and Zn, which can replace each other, resulting in Fe-rich and Zn-rich end-members, the former being the most abundant in Kipushi. A Ga-rich variety also probably exists (Devos *et al.*, 1974).

Ottenburghs and Goethals (1972) succeeded in synthesizing the phases and found that at 700°C there is a continuous solid solution between the two end-members. Above this temperature, synthetic briartite changes into an orthorhombic phase.

Briartite is a rare species of interest only to systematic collectors; no natural crystals have been found.

Brochantite $Cu_4^{2+}(SO_4)(OH)_6$

Brochantite has been known at Kipushi since 1924 (Buttgenbach, 1947). Crystals are acicular and of the typical green color, elongated along their c-axis, with a bevel termination composed of two {301} faces.

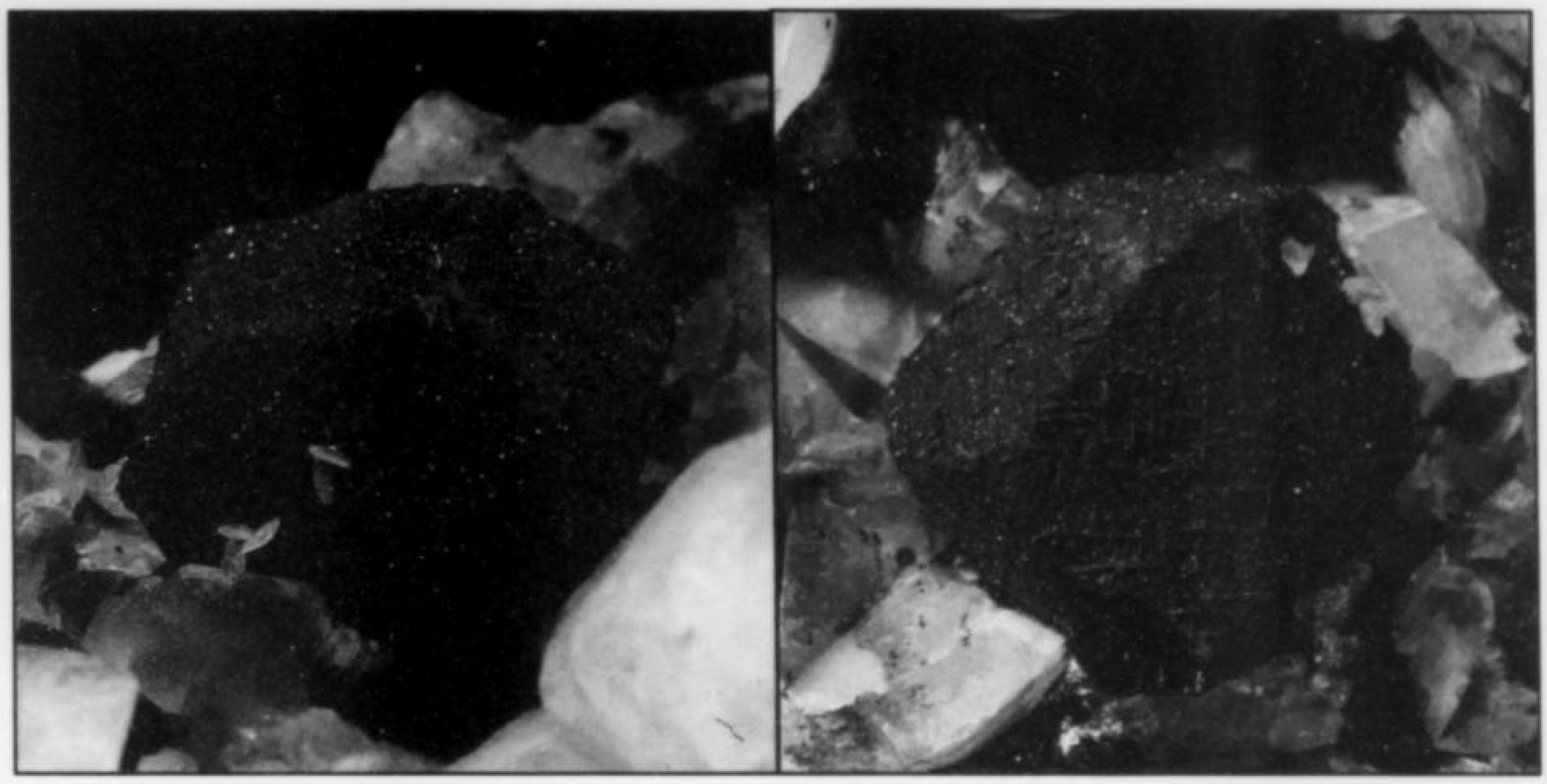


Figure 29. **Bornite (primary) crystals, 1.5 cm, coated with malachite, on dolomite; P. De Bondt collection; Lhoest photo.**

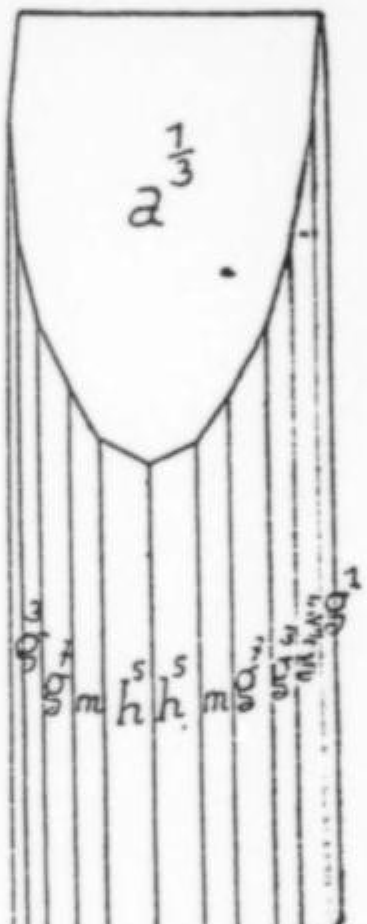


Figure 30. **Brochantite crystal drawing (Buttgenbach, 1947).**

Figure 31. **Bornite (secondary) crystal, 3 cm, in quartz/dolomite matrix; Lhoest collection and photo.**

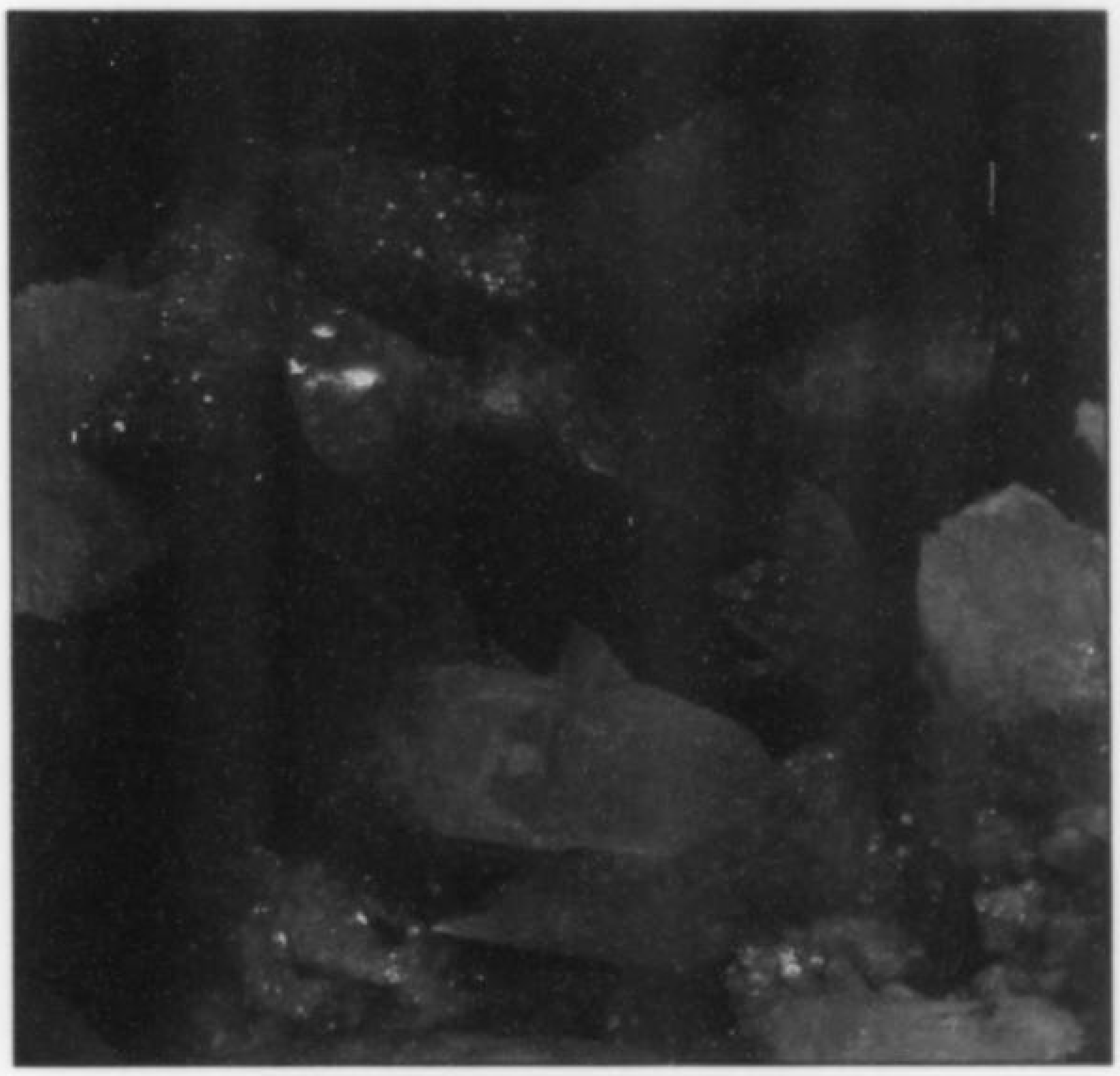


Figure 32. **Calcite crystals (of the "French fry" habit), 8 cm across; Lhoest collection and photo.**

Calcite $CaCO_3$

Calcite forms a noticeable part of the country-rock, where preparatory workings encountered walls and pockets lined with scalenohedrons to 6 cm. The constant association of (zincian) dolomite crystals on a matrix of carbonates covered by iron oxides indicates that the linings are secondary features. Specimens have always been difficult to remove intact because of the hardness of the matrix; limited blasting has usually been necessary.

Most calcite crystals are milky white, opaque to translucent, and commonly stained brown, orange or red by iron oxides, although others are colorless with a honey or lilac tinge.

Unusual habits have also been found, like Buttgenbach's steep positive rhombohedrons $\{40\bar{4}1\}$, with their lateral edges replaced by the negative scalenohedron $\{3.24.\overline{27}.71\}$. A cave produced elongated crystals referred to by collectors as "French fried" calcite. This is mainly due to a combination of the very sharp negative rhombohedron $\{0.11.\overline{11}.1\}$ passing over a curved zone to the acute negative rhombohedron $\{05\bar{5}1\}$, the termination being the negative rhombohedron $\{01\bar{1}2\}$ (not exceeding a few mm) altered by the positive rhombohedron $\{10\bar{1}1\}$. These latter two forms were observed by Buttgenbach as

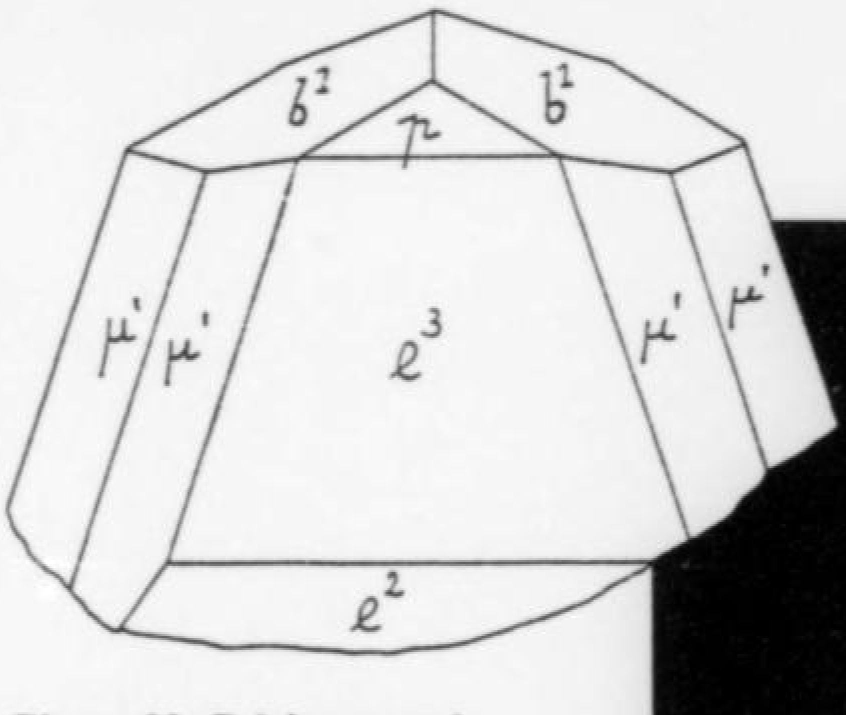


Figure 33. **Calcite crystal drawing (Buttgenbach, 1947).**

Figure 34. **Calcite crystal drawing showing the "French fry" habit, by R. Warin.**

crystal terminations. Originating from another pocket are the clusters of "calcite flowers," wherein the crystals, assembled as bunches, reach 1.5 cm. The predominating form here is the negative rhombohedron $\{05\bar{5}1\}$ with the simple termination $\{01\bar{1}2\}$.

Also typical of Kipushi are the encrustation pseudomorphs or molds of dolomite after calcite, empty or still filled with calcite. Several occurrences with different crystal habits of calcite and different color stainings of the molds exist in collections. The most remarkable are yellow-coated (probably by zincite) pyramids to 7 cm, the surface of the coating being covered with a later generation of small dolomite crystals and with a seeding of transparent hemimorphite crystals 2 to 3 mm in size. No cobaltoan calcite has been reported from Kipushi.

Carrollite $Cu(CO,Ni)_2S_4$

Carrollite is rare at Kipushi, crystals to 5 mm having only once been observed.

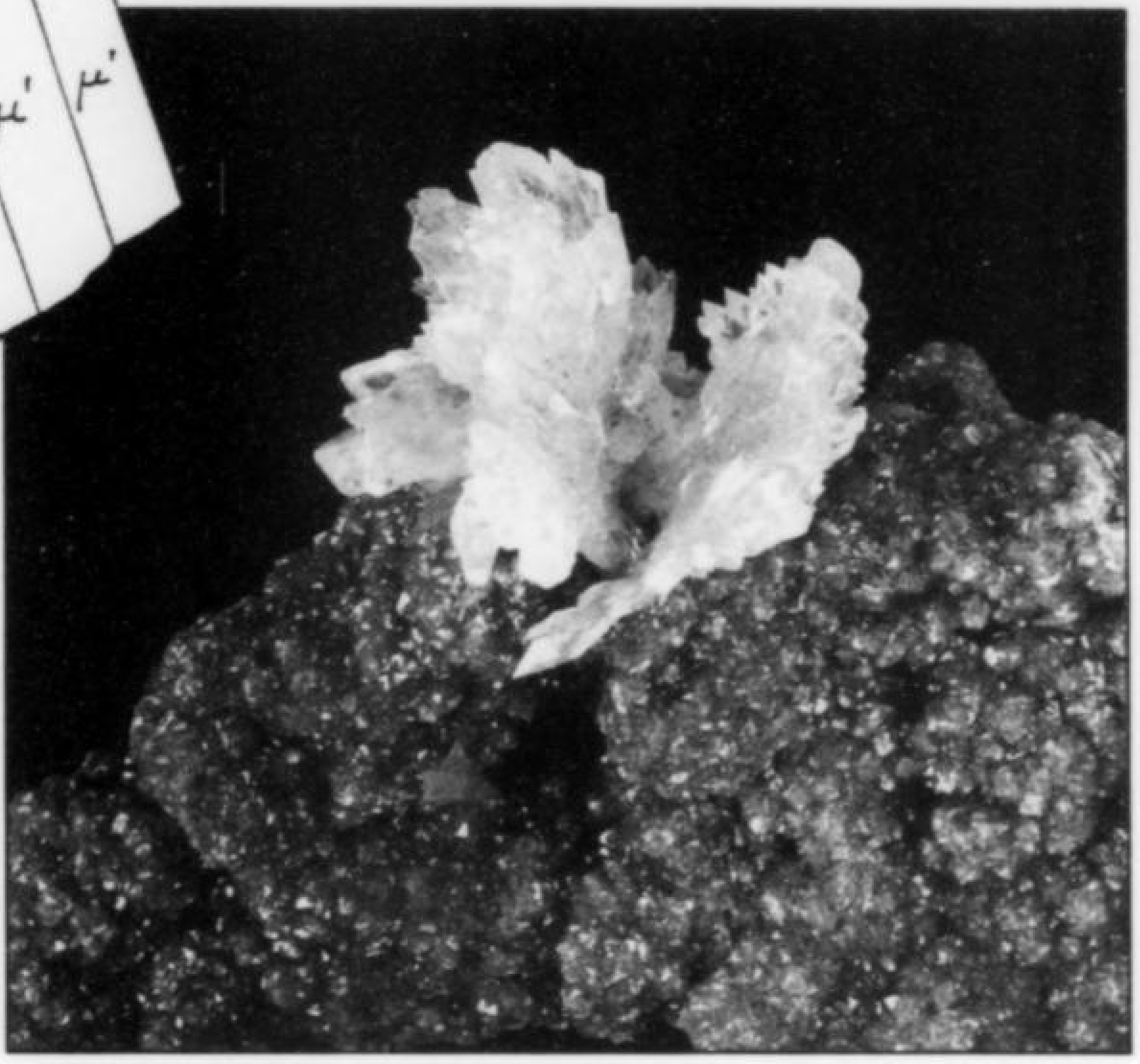
Cerussite $PbCO_3$

Cerussite occurs in limited areas of the oxidation zone. It was first described from Kipushi by Buttgenbach in 1923 (Buttgenbach, 1947) as sharp, milky white crystals, flattened on (010), with lustrous faces, isolated or assembled as trilling twins on (310), scattered on a carpet of malachite. According to Umba *et al.* (1977), crystals appear as sharp orthorhombic prisms to 1 cm, opaque or translucent white, with an adamantine luster and a complex habit, the prism being modified by several truncations of the edges and by multiple twinning.

It should be added that very often phantoms are delineated by growth lines parallel the lateral faces, with twinning clearly indicated by these lines and by re-entrant angles.

The best, original find came from a turret at level 50 in the old reconnaissance incline. During the late 1970's, when the incline was re-cut and re-timbered, more specimens were recovered. The pocket is not exhausted, but the place is very dangerous.

The association of malachite or pseudomalachite makes specimens aesthetically pleasing. Cerussite otherwise occurs quite dispersed. A veinlet of crystals on blue hemimorphite was once discovered, and pseudomorphs after cerussite have been observed on old-time vauquelinite specimens.



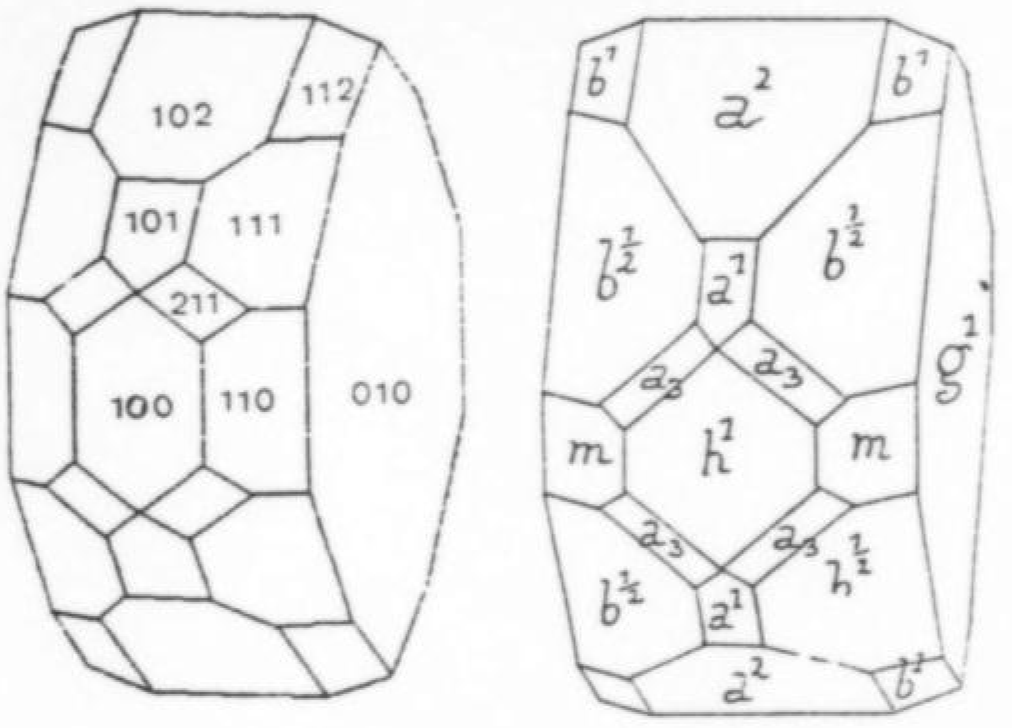


Figure 36. **Cerussite crystal drawing (by R. Van Dooren, left, after Buttgenbach, 1947, right).**

Chalcocite Cu_2S

No significant crystals of Kipushi chalcocite exist in collections, though both Buttgenbach (1947) and Umba *et al.* (1977) report the occurrence of elongated prisms. The mineral is mostly secondary, as masses in the oxides and as veinlets in other sulfides. Hypogene chalcocite was reported by Deutzmann (1961). Chalcocite is said by Devos *et al.* (1974) to coexist in equilibrium with betekhtinite.

Chalcopyrite $CuFeS_2$

Chalcopyrite is the second most abundant major copper sulfide. Large deformed crystals were reported by Buttgenbach (1947), but chalcopyrite most often occurs as massive, well-delineated bodies in the lower levels and as mixed ore with sphalerite and/or bornite in the higher levels. In copper-rich ore the zones of chalcopyrite and bornite are often independent from each other.

Being entirely primary, chalcopyrite forms part of two paragenetic sequences (Deutzmann, 1961):

Chalcopyrite I occurs in an iron-rich assemblage deposited at a rather high temperature. This chalcopyrite is cleaner and doesn't tarnish. It is accompanied by pyrite, arsenopyrite, some pyrrhotite, tennantite (corresponding to the Cu-I phase of Devos, 1973), dark, iron-rich sphalerite and some galena.

Chalcopyrite II occurs as golden yellow, rapidly tarnishing material associated with sphalerite II, cleaner and iron-poor but richer in elements like Cd and Co, with some galena. It is accompanied by tennantite, renierite, bornite, galena, betekhtinite and chalcocite. This sequence, deposited at a lower temperature, corresponds to the Cu-II type mineralization of Devos (1973).

Chalcopyrite can contain up to 0.56% Co in solid solution, and is an important carrier of this element (Intiomale and Oosterbosch, 1974).

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

Chrysocolla has been reported with veszelyite (Buttgenbach, 1947). Mammillary crusts of chrysocolla also underlie vauquelinite on old-time specimens. The vitreous chrysocolla is partly blue and partly gray-white, with an outlining banded structure. Like malachite, chrysocolla is not very significant from Kipushi, unlike in the Shaba Crescent.

Cobaltite CoAsS

Cobalt is an accessory element in Kipushi ore, cobaltite being the best represented species as grayish white masses with a metallic luster in chalcopyrite and/or bornite. Cobalt is present as a trace element in many sulfides besides chalcopyrite. In sphalerite, the cobalt content is particularly variable (Intiomale and Oosterbosch, 1974).

Copper Cu

Native copper occurs at the base of the oxidation zone, as masses and as poorly shaped crystals connected by a wire-like structure. At level 170, a tunnel crossed a pocket of concretionary smithsonite containing arborescent copper on a chalcocite matrix.

Figure 37. **Cuprite crystals showing elongation and right-angle bends, about 1 cm; Lhoest collection and photo.**

Cuprite Cu_2O

Few crystals of cuprite are known from Kipushi except as the acicular habit, in association with gangue and other secondary ore minerals. Acicular crystals to 1 cm, with right-angle bends, are known on some of the older specimens.

Dolomite $Ca,Mg(CO_3)_2$

Dolomite is the major component of the country rock at Kipushi. Twisted rhombs of the zinc-rich variety, informally called "zinco-calcite" by geologists (Umba *et al.*, 1977) and collectors, are opaque, milky white to beige or brownish, up to 8 mm in size, and are abundantly present on specimens with secondary minerals. Zinc-rich dolomite crystals occur isolated or aggregated, sometimes as stalactites with a core of goethite, and also as various kinds of twins and rosettes to about 1.2 cm in diameter.

The formation of zincian dolomite is easily explained by the similar ionic radii of zinc and magnesium and by the solubility of Zn ions, which are easily leached down by supergene fluids. On the other hand, cobaltoan dolomite, which is widespread in the Shaba Crescent (Umba *et al.*, 1977, describe *only* pink dolomite, but that was before the exploitation of Mashamba West), has not been reported at all from Kipushi (where the mineralization is post-tectonic).

Fluorapatite $Ca_5(PO_4)_3F$

Fluorapatite is a component of the country rock at Kipushi (Intiomale and Oosterbosch, 1974). Guillemin (1956) was of the opinion that phosphate leached from this mineral in the country rock was carried to the orebody by supergene fluids and accounts for the relative abundance there of secondary phosphate minerals.

Galena PbS

Galena is generally found as veinlets and small, brittle masses showing cubic cleavage, in or near the margins of all types of mineralization. Most of the lead at Kipushi was deposited as galena, and is present as barely a trace in other of sulfides. The deposition of galena seems linked to that of sphalerite in an early stage, as in the periphery of the off-shoots in the upper Kakontwe (eastern apophysis). Masuy (1938) reported replacement of galena by bornite. This author's view is that a great deal of galena went back into solution, and a second generation was then deposited as a halo around the copper-rich ore (Intiomale and Oosterbosch, 1974). Galena occurs in contact with almost all other sulfides and almost always appears younger. Small cubic crystals of galena have been reported since Thoreau (1928). Secondary galena was reported by Masuy (1938) in the overburden covering the Kakontwe.

Gallite $CuGaS_2$

Gallite was originally described as a new species by Strunz *et al.* (1958), who had studied samples from Tsumeb. A short time before publication, a similar occurrence was brought to their attention in samples from Kipushi, which thus became a co-type locality. The presence of gallium in germanite from Tsumeb has been known since 1922 (Strunz *et al.*, 1958). Gray grains and lamellae previously observed by several authors in germanite, renierite and other ore minerals were investigated by Strunz *et al.* (1958), who found primarily Cu and Ga in an atomic ratio of 1:1. The X-ray powder diffraction pattern was similar to that of chalcopyrite, which suggested that the formula might be $CuGaS_2$. The authors were successful in synthesizing this compound, which presented an identical X-ray powder pattern.

In ore from Kipushi, needles and grains of gallite occur in sphalerite and in chalcopyrite as exsolution structures. Gallite from Kipushi contains Fe which partially replaces Ga. Ga is also found as a trace element in chalcopyrite and briartite. (An incompletely characterized sulfide of Cu, Ga and Fe found here is gray-purple and contains up to 13% Ga (Devos *et al.*, 1974).) The average Ga content of Ge-rich ore from levels 725 to 775 is 0.25% (Intiomale and Oosterbosch, 1974); the distribution of gallium in ore parallels that of germanium (Devos *et al.*, 1974; Intiomale and Oosterbosch, 1974).

Germanite $Cu_{26}Fe_4Ge_4S_{32}$

Germanite is rare at Kipushi, even though it is the main Ge-bearing mineral at Tsumeb; according to the view of Viaene and Moreau

Figure 38. Cerussite twins to about 1 cm, on malachite; Lhoest collection and photo.

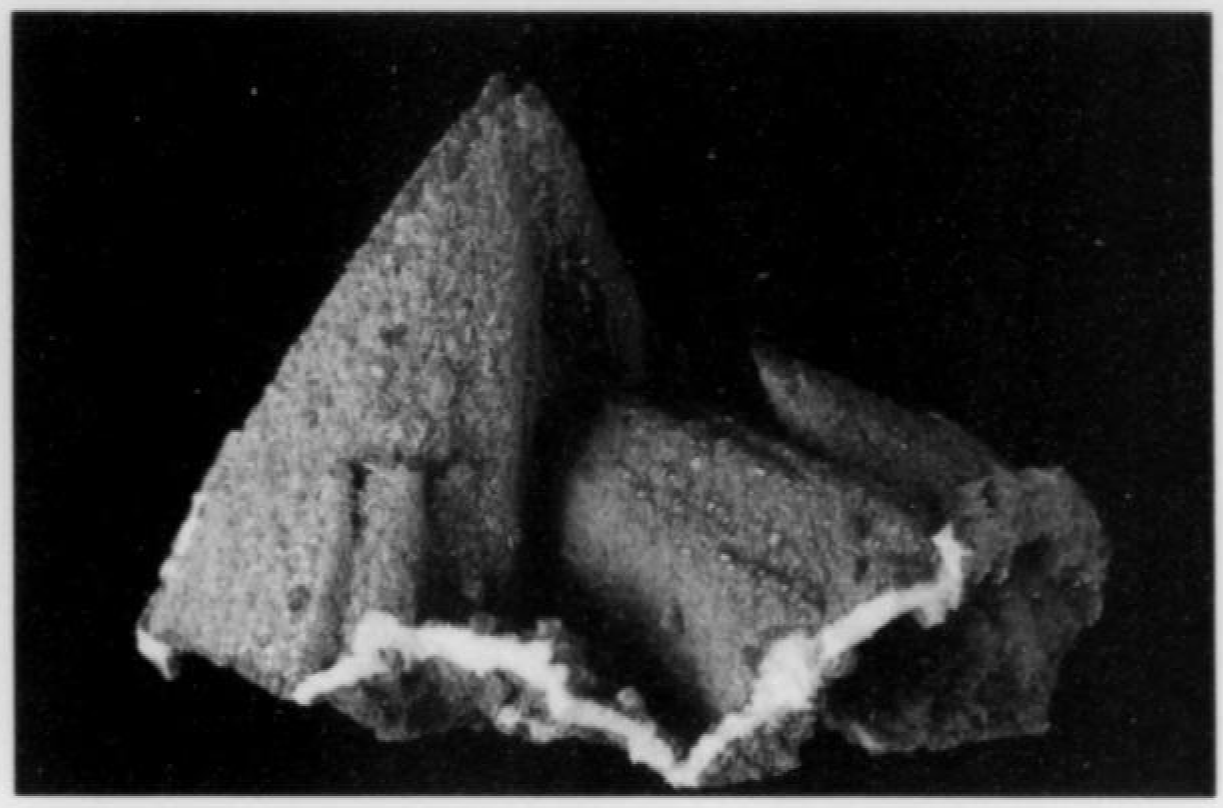


Figure 39. Dolomite molds of calcite crystals, 6 cm, colored yellow by greenockite (?) and showing microscopic hemimorphite crystals coating some faces; Lhoest collection and photo.

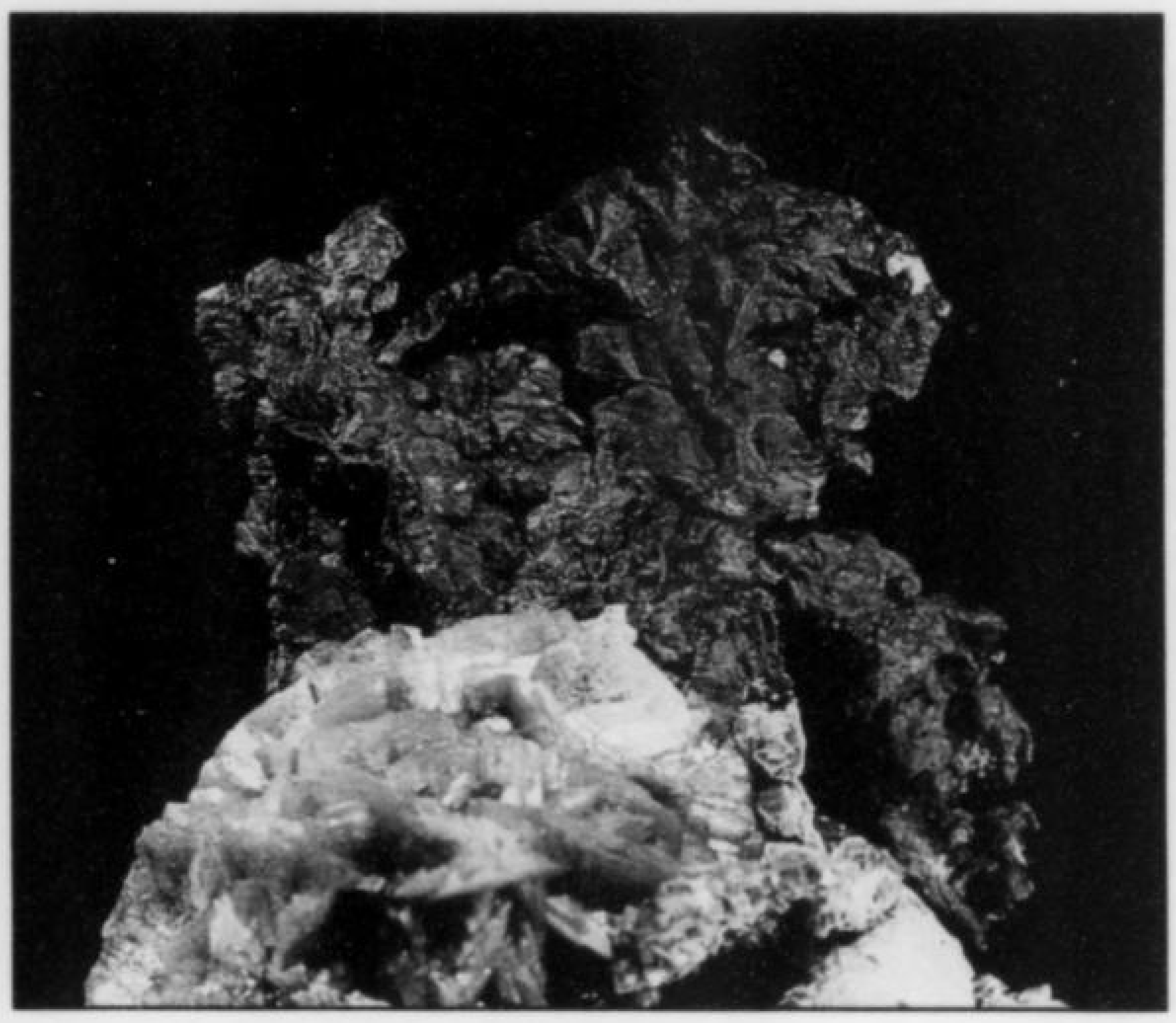


Figure 40. Copper crystal aggregate, 2 cm, on zincian dolomite; Lhoest collection and photo.

Figure 41. Cuprite in acicular crystals with gypsum, 3 cm across; M. Houssa collection; Lhoest photo.

Figure 42. Dolomite twin, 1.2 cm; F. Coune collection; Lhoest photo.

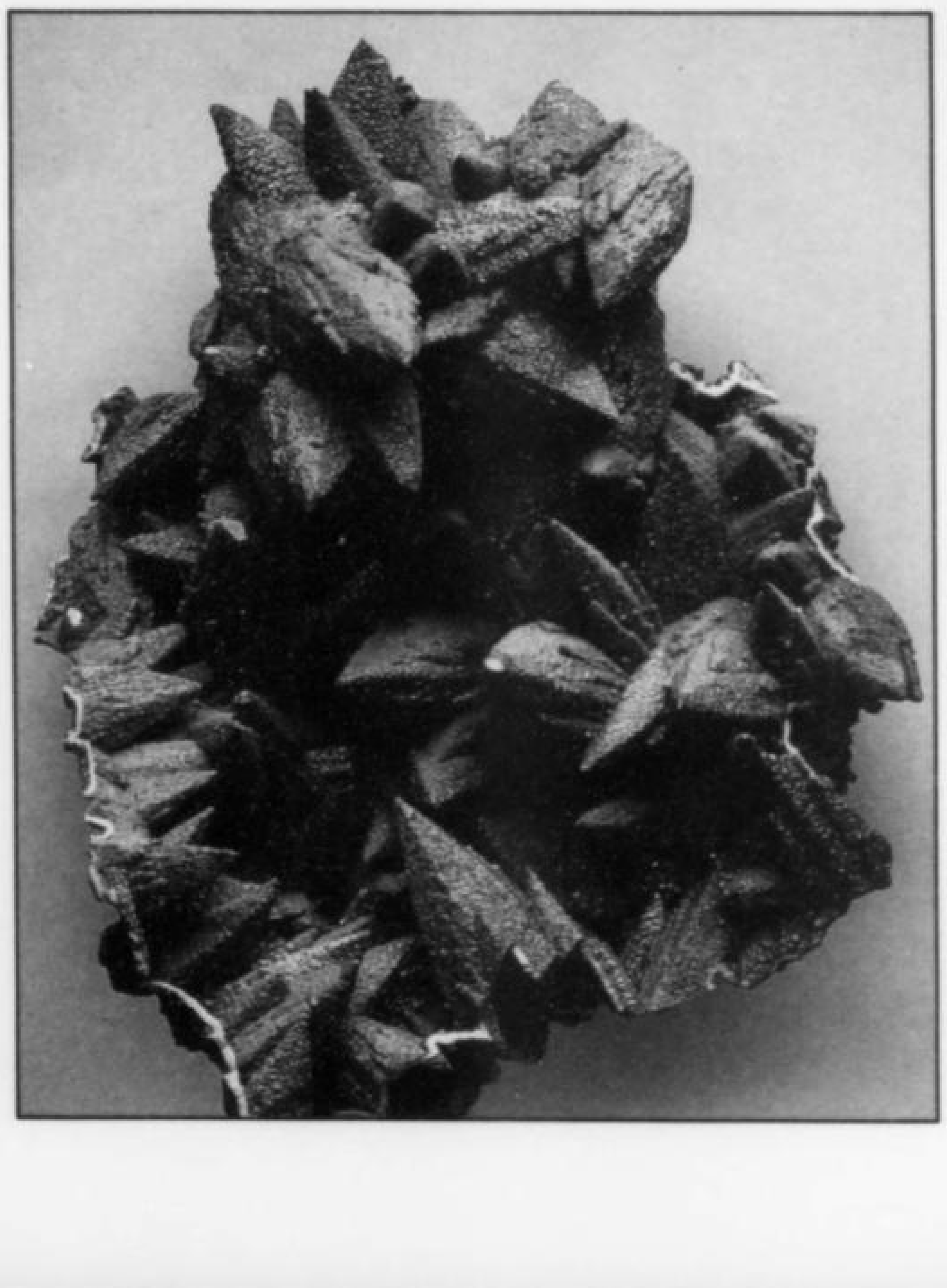


Figure 43. Dolomite molds of calcite crystals, colored yellow by greenockite (?), 23 cm; Lhoest collection and photo.

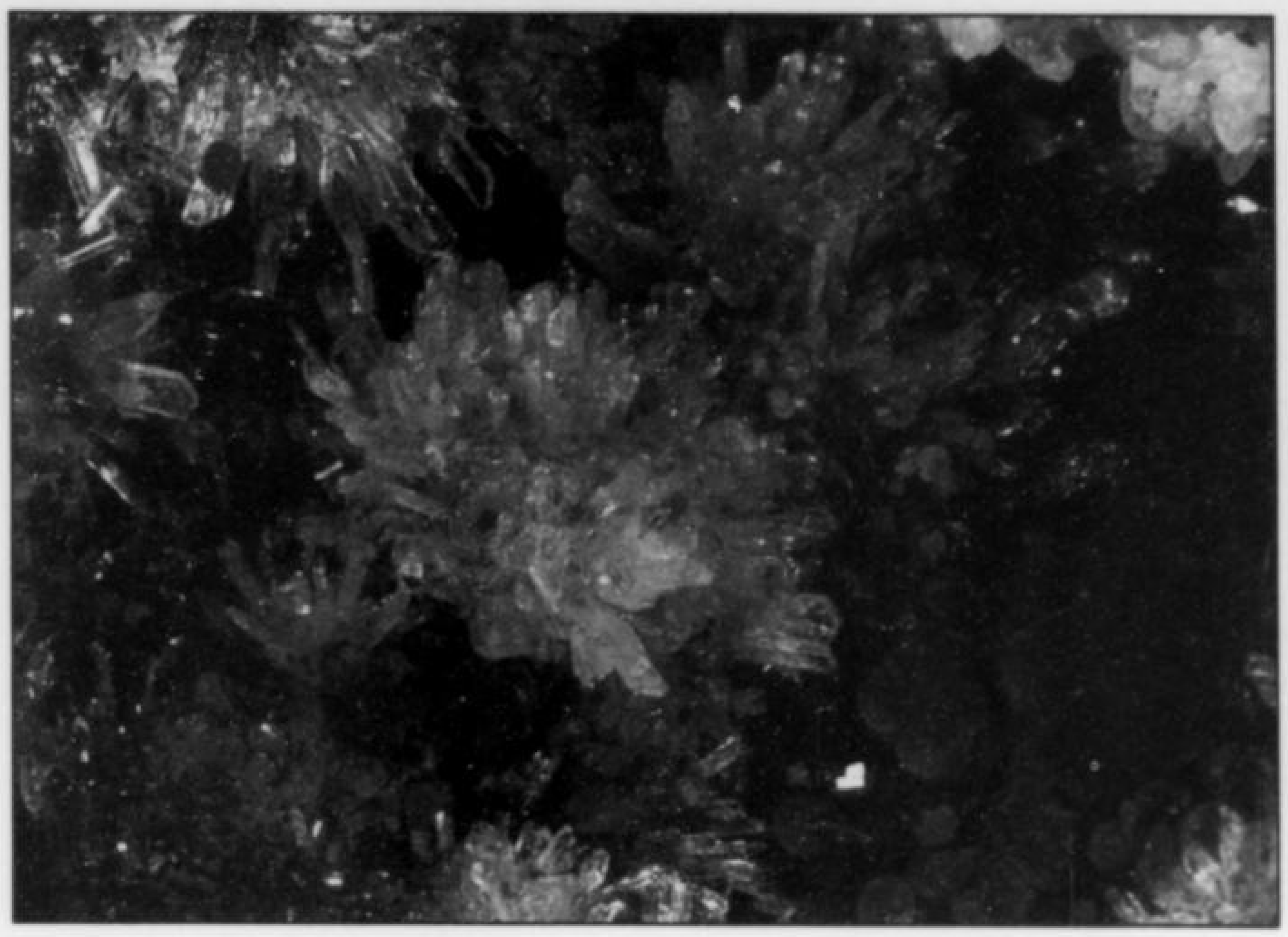


Figure 44. **Hemimorphite crystals with aurichalcite spheres, 3 cm across; Lhoest collection and photo.**

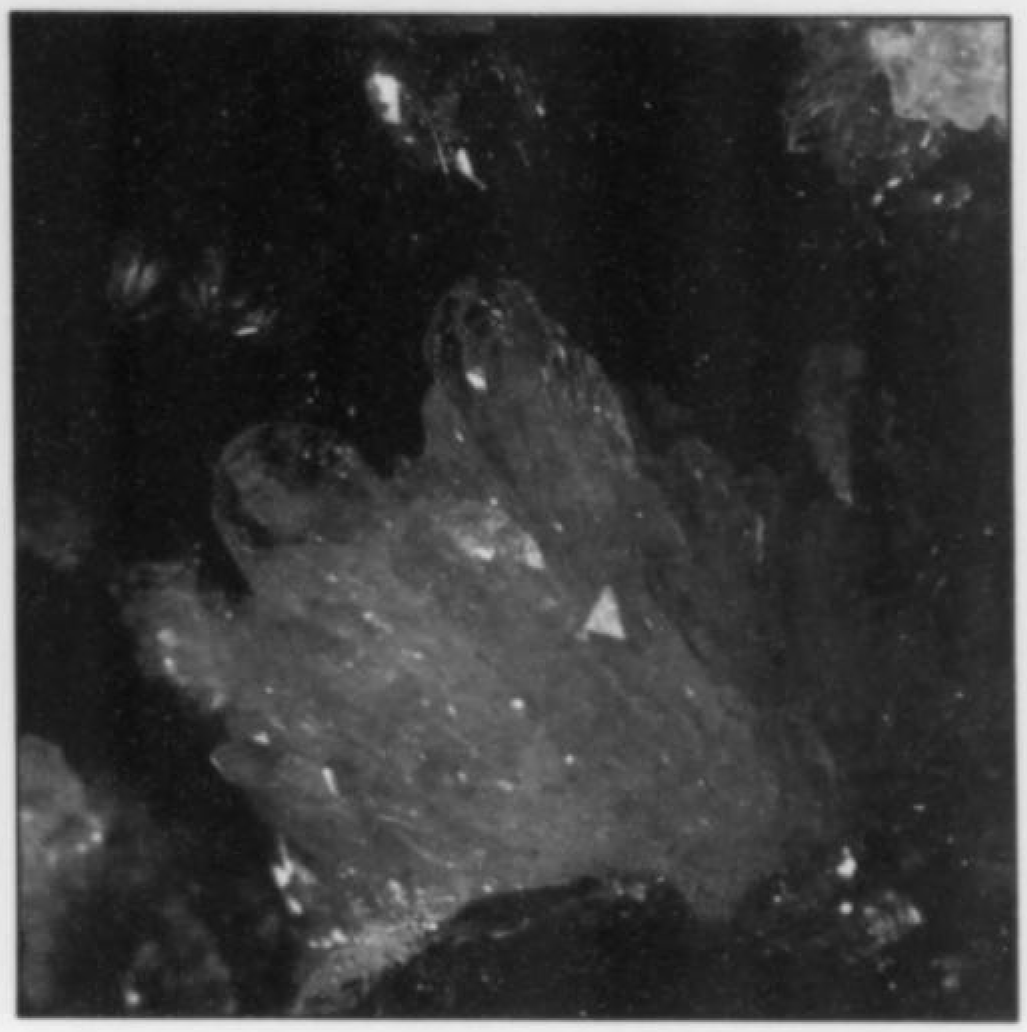


Figure 45. **Hemimorphite crystals colored blue by aurichalcite inclusions, 2.5 cm across; Lhoest collection and photo.**

Figure 46. **Hemimorphite in transparent crystals overlying blue aurichalcite on limonite, 2.5 cm across; Lhoest collection and photo.**

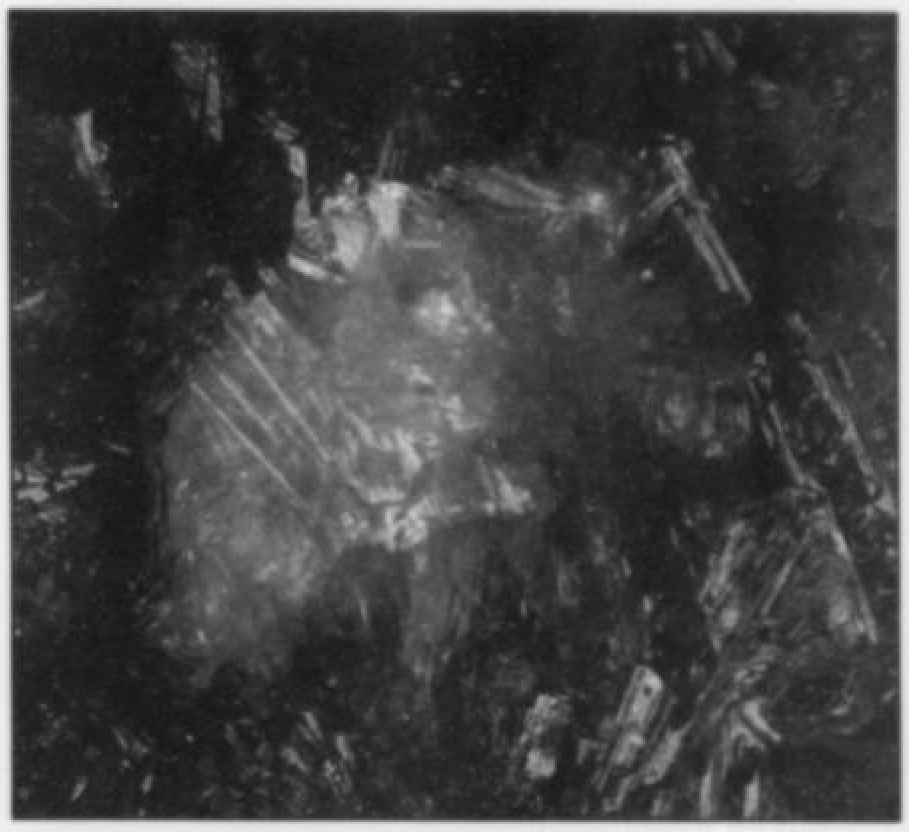
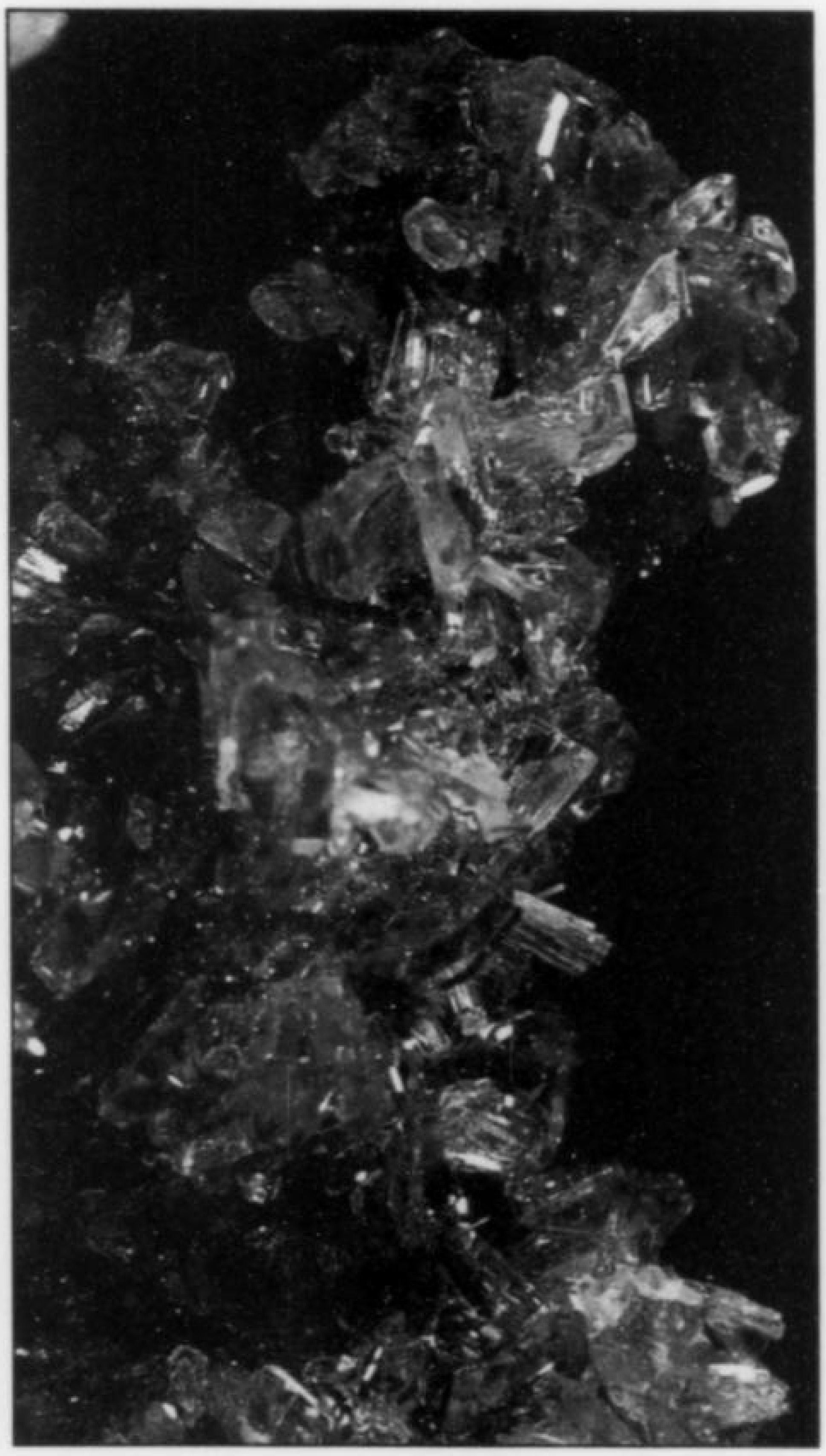


Figure 47. **Hemimorphite crystals with blue aurichalcite spheres, 2.5 cm across; Lhoest collection and photo.**



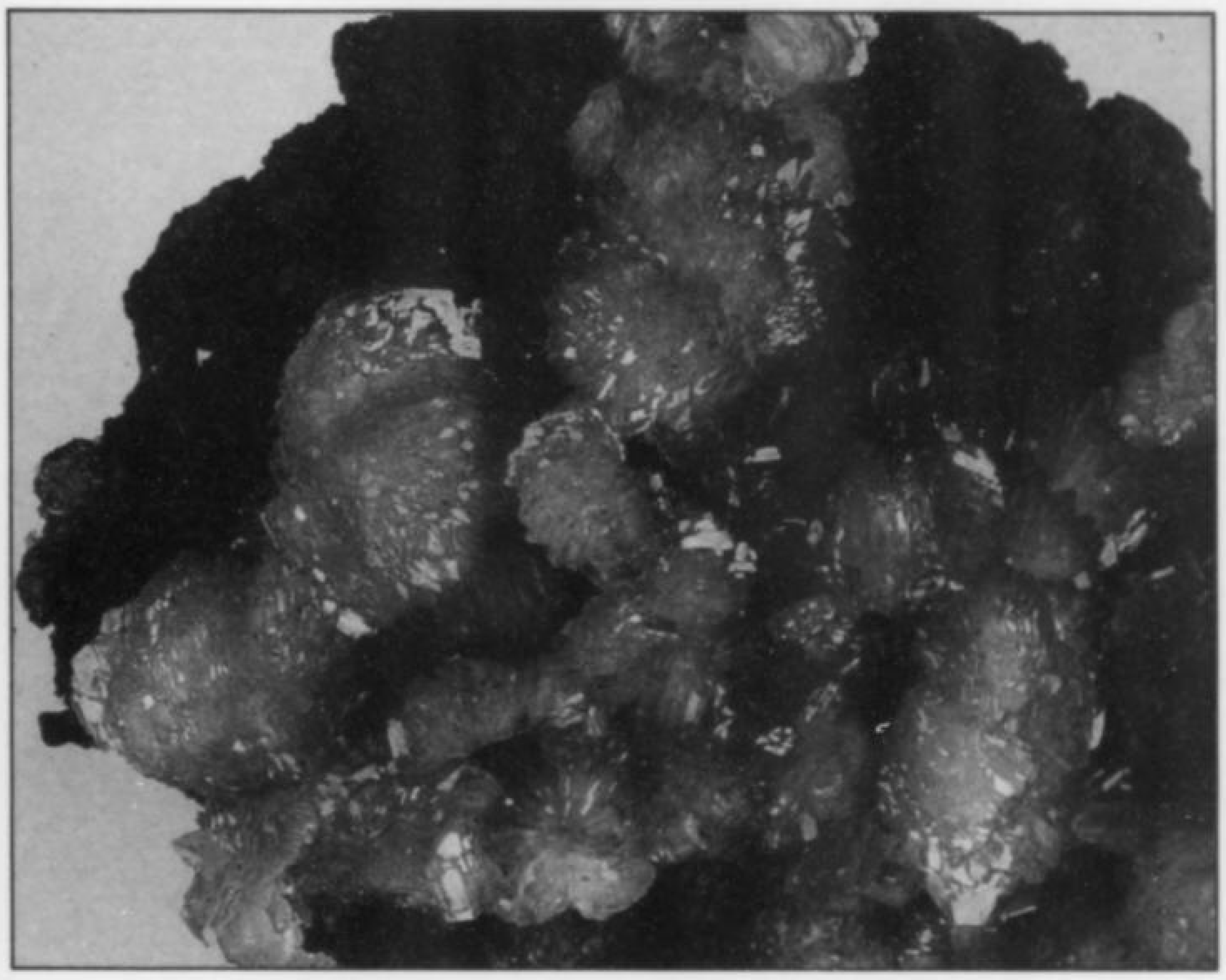


Figure 48. **Hemimorphite crystal clusters colored yellow by greenockite (?) inclusions, 7 cm; Lhoest collection and photo.**

(1968), this is because Kipushi is too iron-rich to allow the formation of much germanite, the Ge-sulfide with the lowest iron content. Devos *et al.* (1974) found germanite as an accessory species in both Ge-rich zones, their view being that germanite was deposited before renierite.

Goethite α-Fe^{3+}O(OH)

Iron oxi-hydroxides are abundant as a part of the matrix of most specimens containing secondary minerals. Pseudomorphs of limonite after pyrite are known from Kipushi, as from many places in Shaba. Radiating spherules of goethite are also common. Devos (1973) points out that goethite is present as supergene veinlets in all iron-rich types of mineralization.

Graphite C

Graphite is abundant and is sometimes found as large masses of the organically derived variety in the country rock and in gangue as well. Graphite from Kipushi contains structured remnants of "organites" (Devos, 1973).

Gypsum $CaSO_4 \cdot 2H_2O$

Gypsum as transparent needles to 2 cm is commonly associated with secondary minerals of the country rock. It also occurs in association with acicular cuprite on old-time specimens.

Halite NaCl

Halite has been reported as cubes inside fluid inclusions in quartz by Intiomale and Oosterbosch (1974).

Hematite α-Fe_2O_3

Hematite is a component of the country rock. Devos *et al.* (1974) report corrosion of hematite by chalcopyrite in ore of the Cu-I phase.

Hemimorphite $Zn_4Si_2O_7(OH)_2 \cdot H_2O$

Buttgenbach (1947) reported the occurrence of hemimorphite at Kipushi as early as 1923, in crystals reaching 1 cm or more in fan-shaped groups. The prisms are generally sharp, transparent, translucent or opaque, typically flattened, vertically striated on {010} and terminated by {001} and {101}. The latter faces are sometimes curved and are often variably (yet symmetrically) developed, giving a nearly triangular termination. The author also describes the heteropolar (opposite) extremity exhibiting another combination of forms. The rare twinning on (001) reported by Levy in 1843 from Moresnet, Belgium (Goldschmidt, 1913, and others), was not observed by Buttgenbach (1947) from Kipushi or Moresnet.

Hemimorphite crystals occur as the most widespread secondary mineral throughout the deposit and the neighboring country rock of the footwall. Specimens are plentiful in collections, presenting a good opportunity to examine their morphology. Sometimes, poorly shaped crystals present a lamellar structure with multi-grooved faces seemingly due to the juxtaposition of parallel individuals.

Hemimorphite crystals are most commonly white (when opaque) or colorless (when transparent), rarely also a transparent blue of the most appreciated variety. Coloring by aurichalcite or pseudomalachite inclusions makes crystals opaque, blue or green; crystals may also be colored yellow by (supposedly) zincite, black by sulfides (chalcocite) or red by iron oxides. Associations most often include aurichalcite and less often pseudomalachite.

The habit of hemimorphite crystals is not easy to discern. The lower

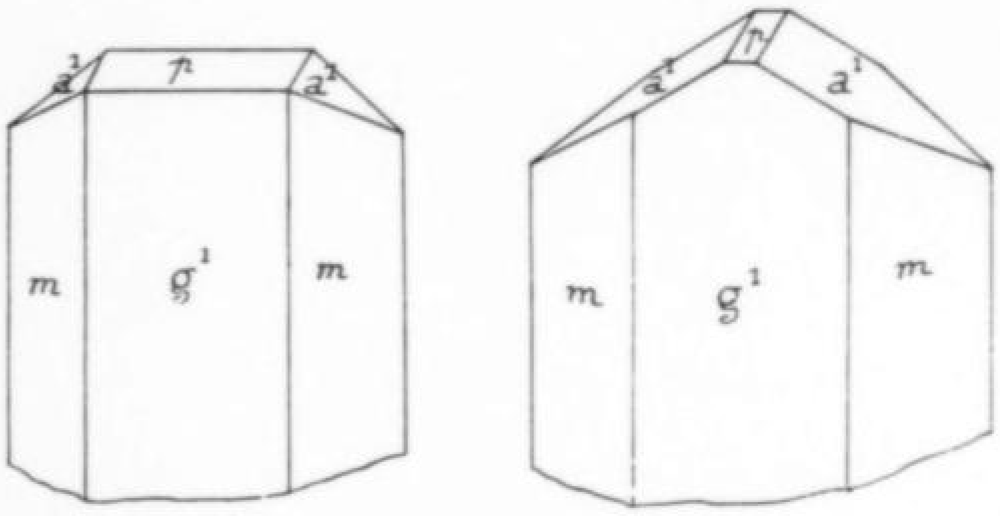


***Figure 49.* Hemimorphite crystal drawings (Buttgenbach, 1947).**

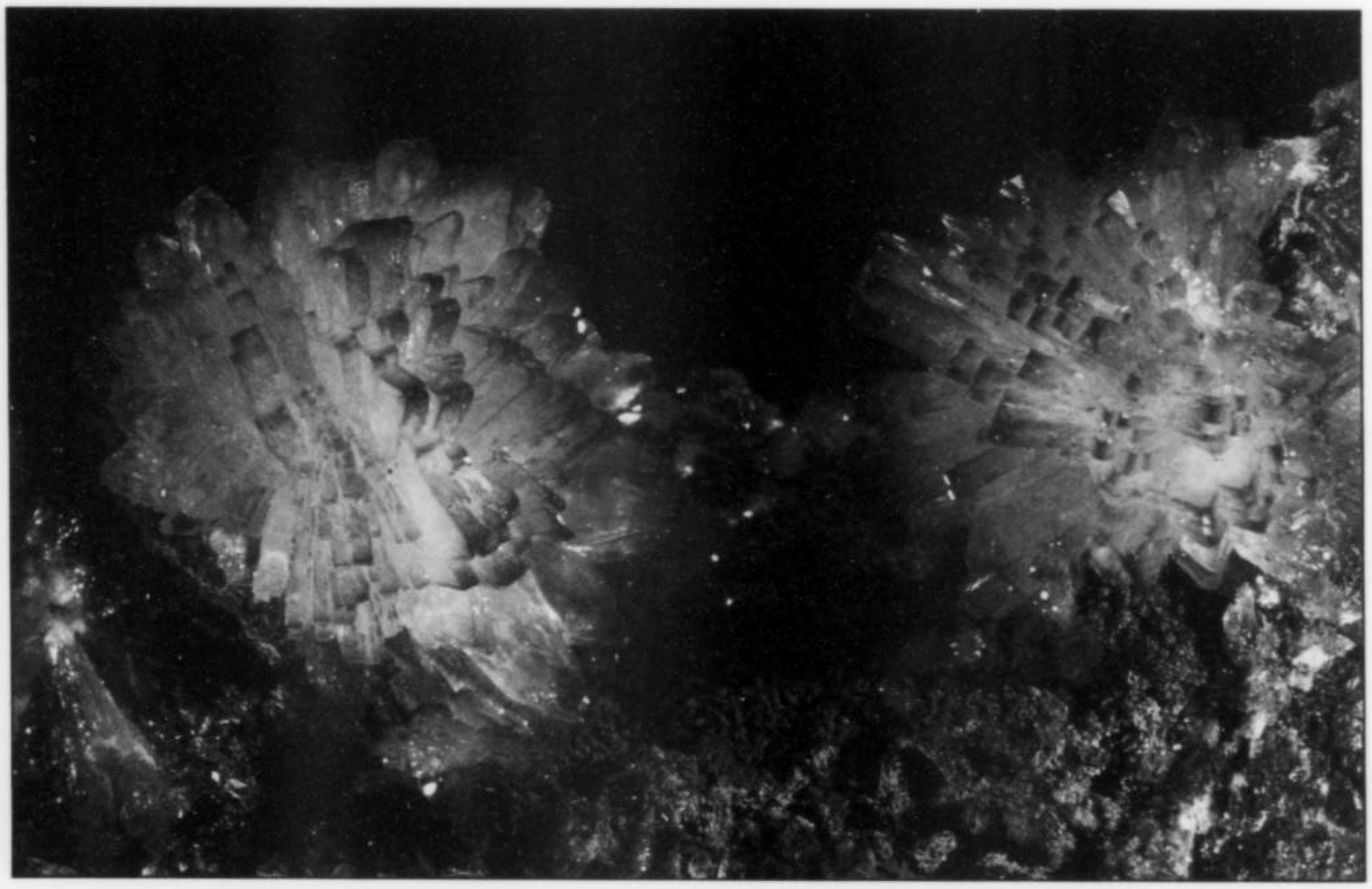


***Figure 50.* Hemimorphite crystals to 8 mm; Lhoest collection and photo.**

Figure 51. **Hemimorphite crystals to 1 cm; Lhoest collection and photo.**

termination, always implanted on matrix, is extremely rare. Crystals are clustered either as spherically divergent groups, as "paddle-wheels" (in sub-parallel planes), or as spherical aggregates or criss-crossed in druses, superposition being a severe hindrance to accurate observation.

The upper termination is variably shaped depending upon truncations, and it is not always possible to identify any of the visible faces. Re-entrant angles can occur in place of the pedion, and the {101} faces can sometimes be unequally developed, probably due to growth along parallel axes of two or more individuals.

Hydrozincite $Zn_5(CO_3)_2(OH)_6$

Hydrozincite occurs as earthy or microcrystalline coatings in cavities in smithsonite and as acicular material intermixed with aurichalcite.

Kipushite $(Cu_{2+},Zn)_5Zn(PO_4)_2(OH)_6 \cdot H_2O$

It is probably useful to recall that the original "kipushite" of Buttgenbach is different from the "kipushite" characterized later and currently accepted. In the early 1970's, the amateur who found the original material, later named "kipushite," on level 8m in the pillar, was actually searching for veszelyite, the famous old-time occurrence that every collector was then dreaming of finding. He found something blue, and was doubly successful because some crusts of microcrystalline veszelyite were indeed part of the assemblage recovered (personal communication of Dr. Defern of Geneva), though the overall blue color was mainly due to pseudomalachite. A fair number of pieces became available on the Belgian collector market, labeled "veszelyite." A thorough re-examination of the specimens subsequently revealed small, prismatic, emerald-green crystals of a new species, which was named "kipushite" by Piret *et al.* (1985). Since Buttgenbach's earlier "kipushite" had been discredited as identical with veszelyite (Zsivny, 1932), the name was free to be used for another well-characterized species, and the authors chose to propose it in order to immortalize in the mineral literature the name of a famous deposit. The original discoverer (who had in the meantime retired) collaborated with others researching the precise location of the find, and in 1988 and 1989 the remainder of the original kipushite pocket was emptied, and an appreciable new lot of specimens was recovered.

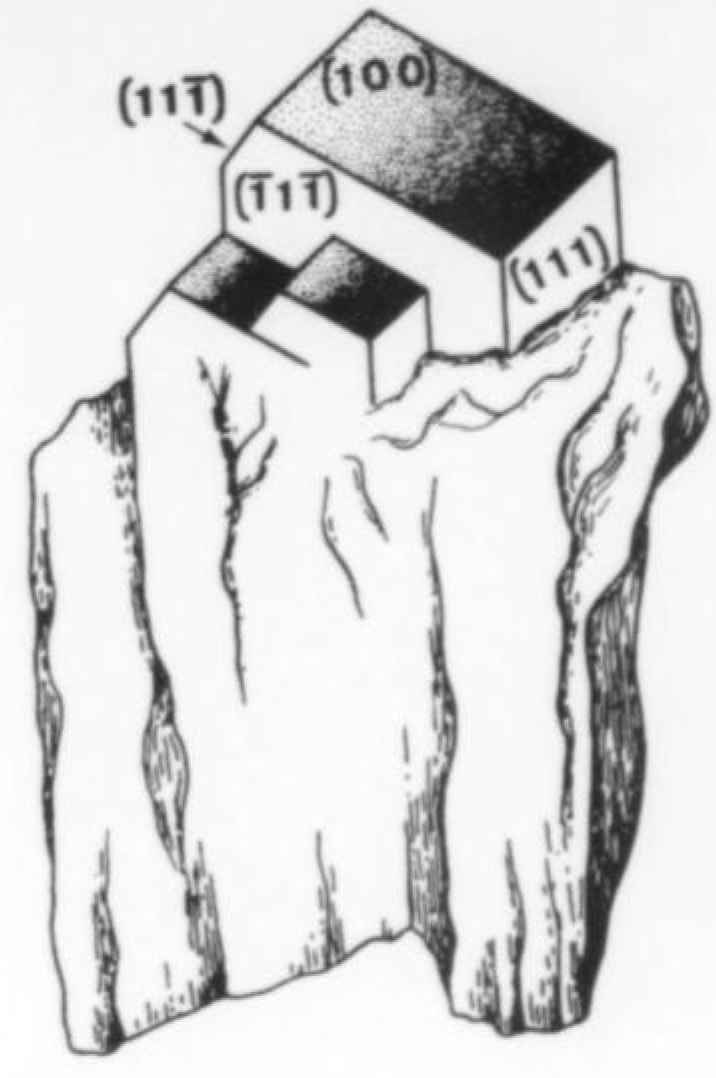


Figure 52. **Kipushite crystals to 3 mm in parallel growth (from Piret *et al.*, 1985).**

Crystals of kipushite are emerald-green with a pale blue streak, transparent to translucent, with a vitreous luster, and appear as isolated prisms, as slightly diverging aggregates, as radiating clusters to 5 mm, and as rosettes to 7 mm. The most common habit observed by Piret *et al.* (1985) from the original find is prisms {111} elongate along $[10\bar{1}]$ and terminated principally by {100}; individuals reach 1 to 2 mm and exceptionally 5 mm. (Another termination is visible in the SEM photograph shown here; the crystals are from the second lot collected.)

Judging from the original description and from observations of later-recovered specimens, the associations include pseudomalachite (as blue or green nodules), some malachite, hemimorphite, white prisms of pyromorphite, ultramarine-blue microcrystalline masses of veszelyite, yellow and olive-green crusts of vauquelinite, libethenite

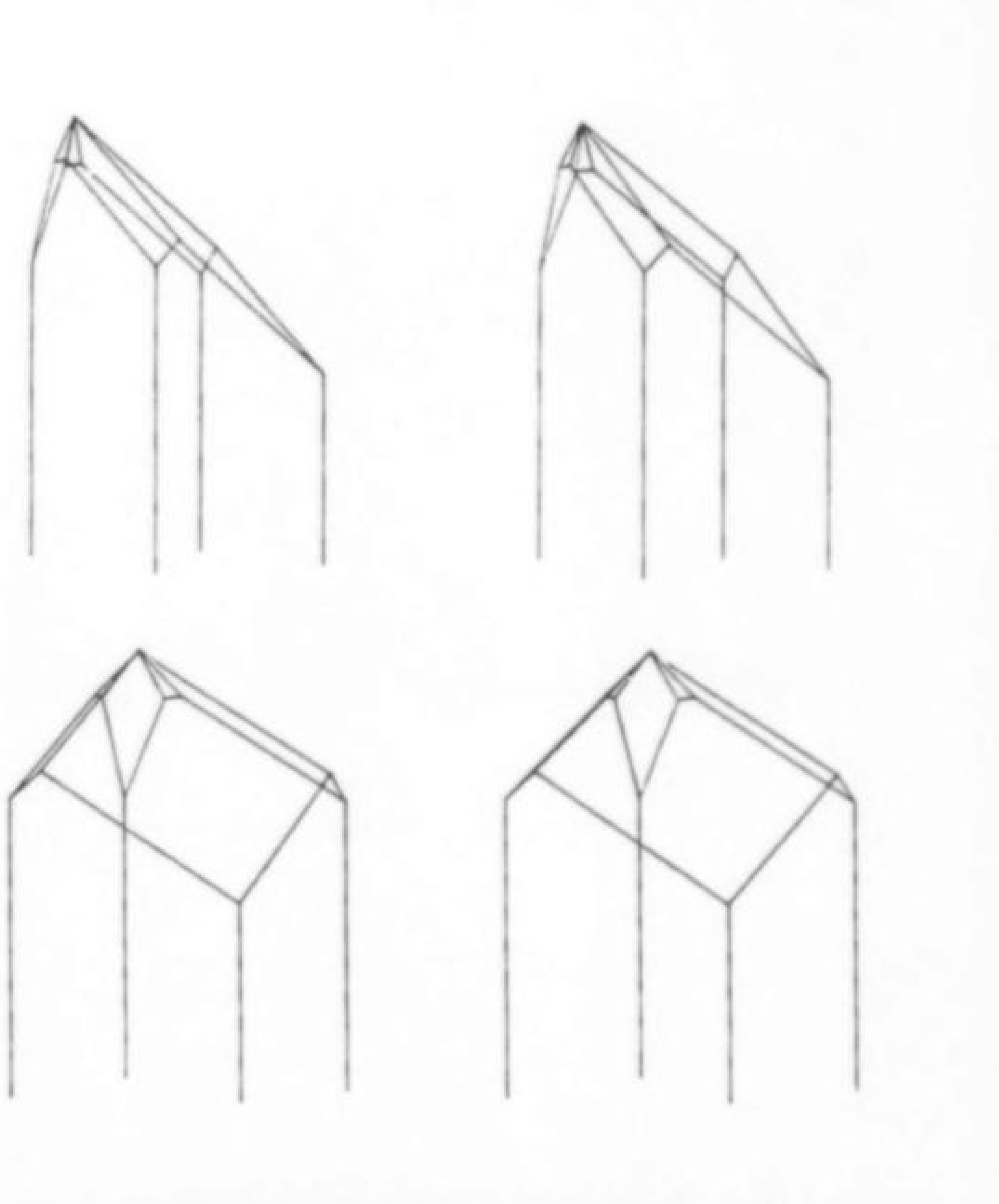


Figure 53. **Kipushite crystal drawings two stereoscopic views of the same crystal showing lateral {111}, large diamond-shaped {100}, kite-shaped $\{\bar{1}0\bar{2}\}$, and also $\{1\bar{1}\bar{1}\}$, $\{11\bar{1}\}$, $\{01\bar{2}\}$, and $\{0\bar{1}2\}$ (from Piret *et. al.*, 1985).**

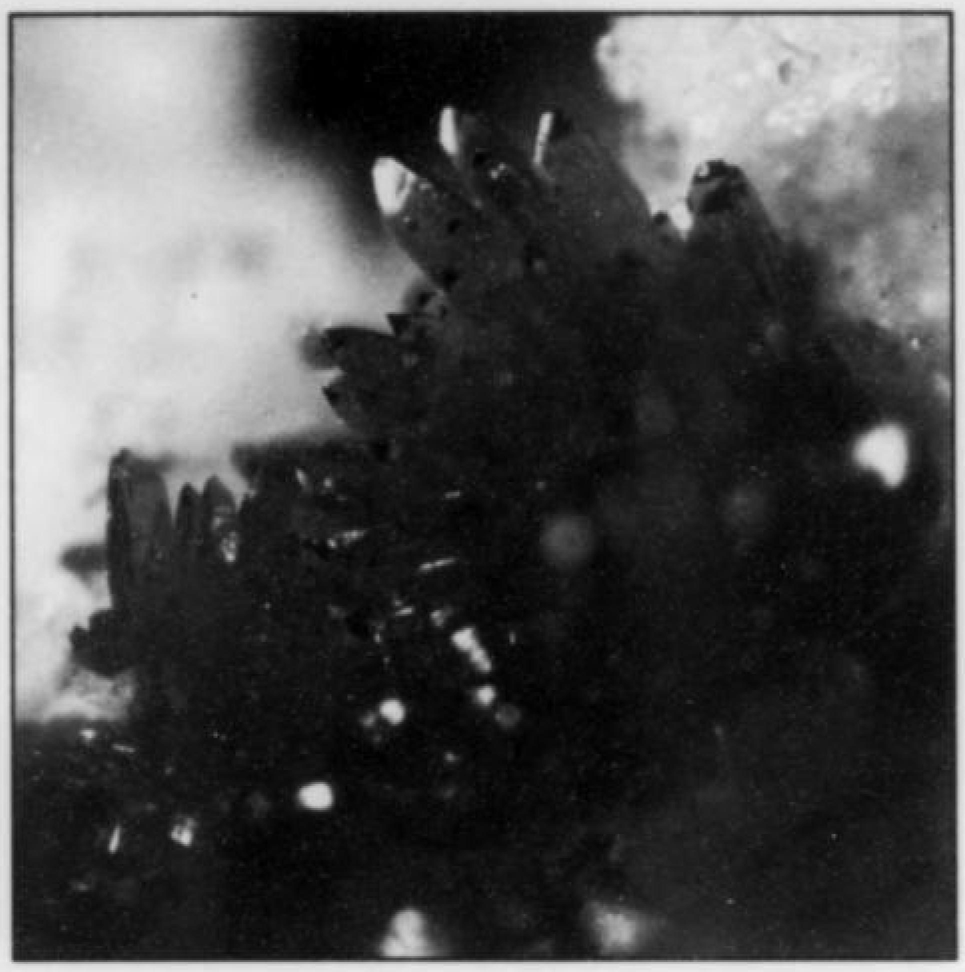


Figure 54. **Kipushite crystal clusters, 3 mm; J. Pendeville collection; Lhoest photo.**

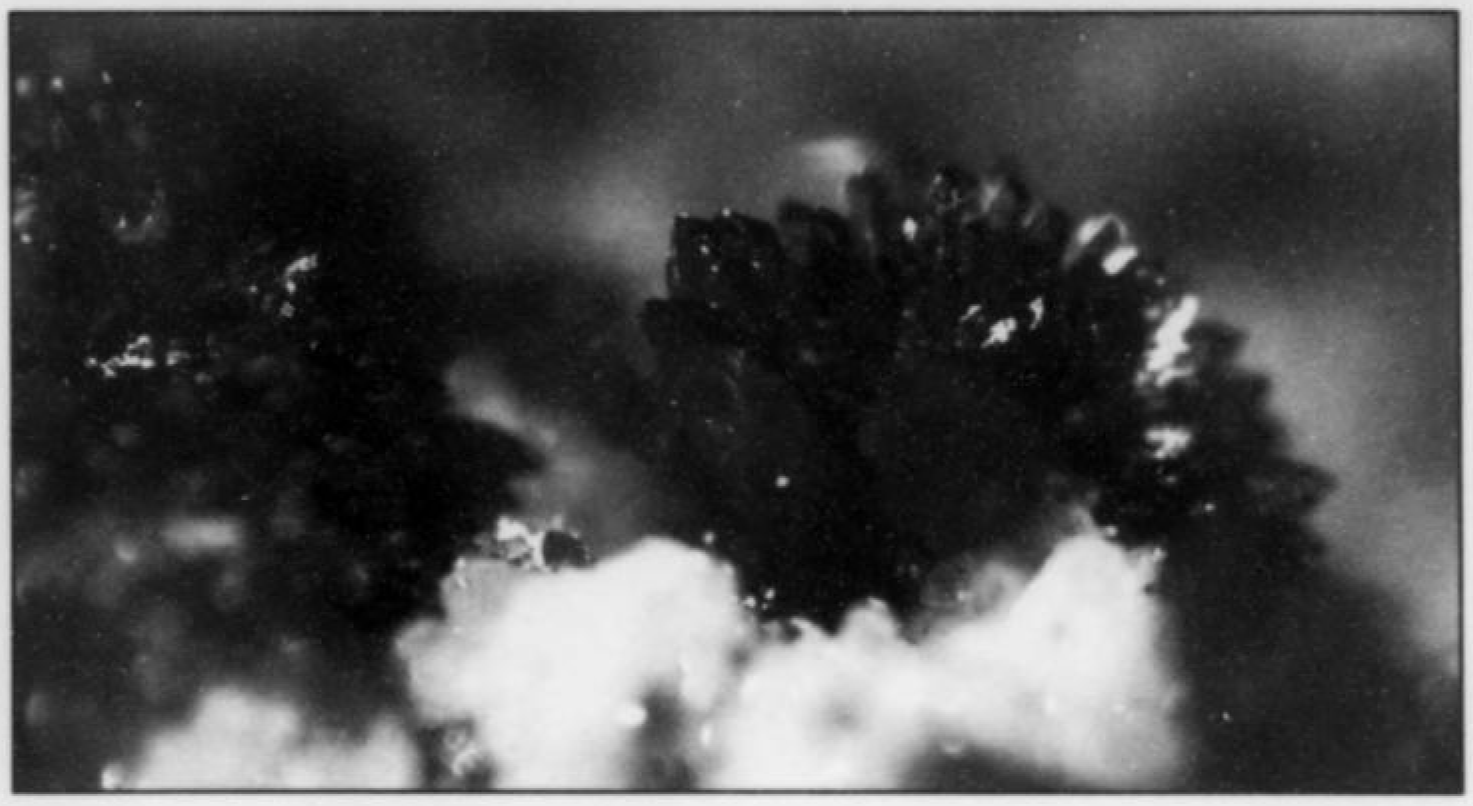


Figure 55. **Kipushite crystal cluster, 2 mm; J. Pendeville collection; Lhoest photo.**

(as acicular clusters, as small nodules with a radiating internal structure and also as equant to short prismatic crystals to 3 mm isolated on matrix), green pseudomorphs of reichenbachite after kipushite, quartz, and iron oxides.

Kipushite is isostructural with philipsburgite. As with veszelyite, the Cu:Zn ratio is variable due to a complex structure composed of alternating sheets which are different in each species (Piret *et al.*, 1985).

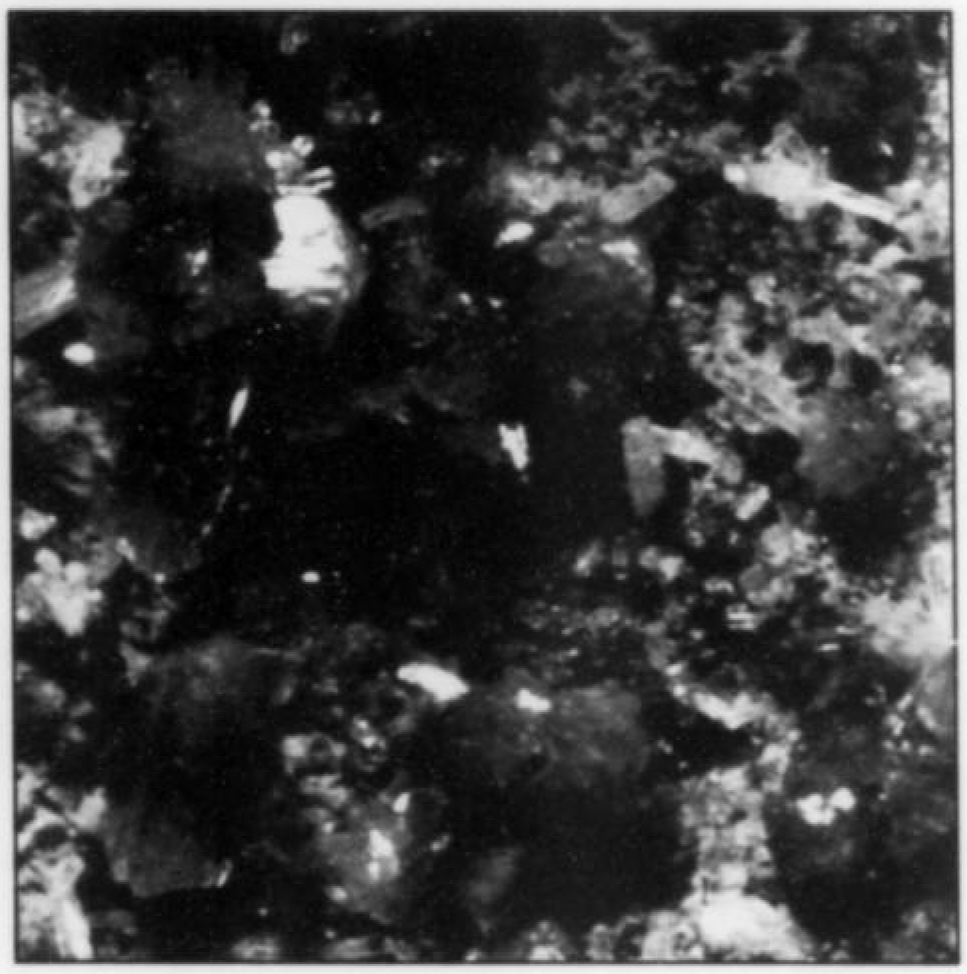


Figure 56. **Libethenite crystals to 1 mm from the kipushite pocket; J. Pendeville collection; Lhoest photo.**

Libethenite $Cu_2^{2+}(PO_4)(OH)$

Libethenite from Kipushi, for many years listed only in unpublished reports, was described for the first time in the literature as part of the kipushite assemblage (Piret *et al.*, 1985), as acicular clusters. Crystals in the second lot of specimens from the pocket are gray-green or bluish with gray-whitish extremities due to incipient alteration, while the nodules are olive-green in color.

More material will probably come out when operations at depth have ceased and more intensive recovery in upper levels is attempted. The recovery of more good unaltered crystals would be of great interest in clarifying the mystery of the zincian variety of libethenite, to which three papers have already been devoted: The first one (the probable source of the confusion) is Mennell's historical paper of 1920: "Rare zinc-copper minerals from the Rhodesian Broken Hill mine . . . ." Mennell's principal "rare minerals" were undetermined grayish copper phosphates which could not be collected free from parahopeite admixture (copper is very scarce in Broken Hill ore, and therefore greenish and bluish traces stand out). Much less abundant was the well-crystallized ultramarine-blue zinc-copper phosphate which was not positively identified as veszelyite. Guillemin (1956) published an extensive review of copper phosphates, during the preparation of which he had produced many syntheses and so obtained a zincian libethenite, with an X-ray powder pattern "different from that of normal libethenite." Guillemin had performed an X-ray diffraction analysis of the specimen from Broken Hill in the collections of the Ecole des Mines (labeled veszelyite) and found the pattern "identical to that of synthetical zincian libethenite." In 1980 Notebaart and Korowski reported the discovery at Broken Hill of greenish blue globules (smaller than 2 mm) and encrustations in tarbuttite ore. This material yielded a powder diffraction pattern "identical to that of normal libethenite, but microchemical tests indicate the presence of both zinc and copper." So the problem remains unresolved until better specimens can be recovered for research.

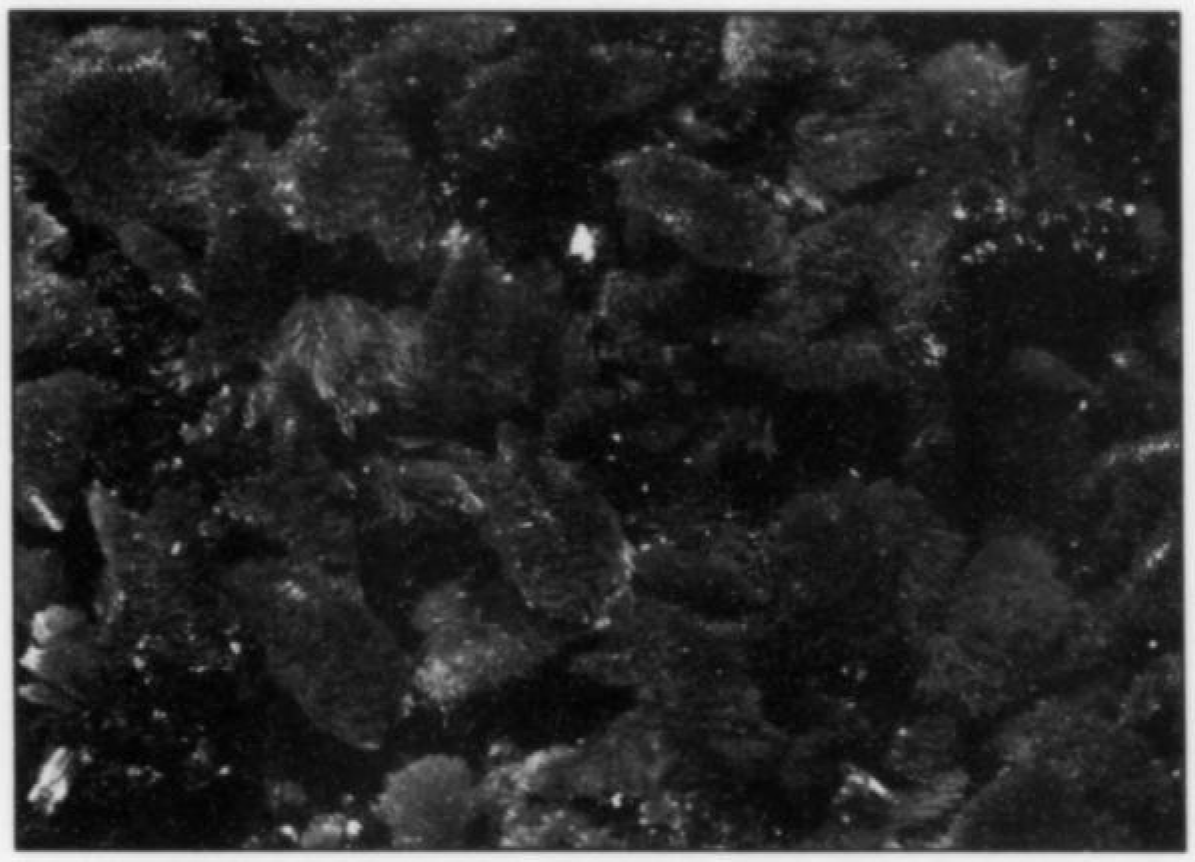


Figure 57. **Malachite crystal sprays, 4 cm across; Lhoest collection and photo.**

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

Malachite has only been reported from Kipushi since 1931, as minute crystals (Buttgenbach, 1947). It is also listed as a member of the kipushite assemblage (Piret *et al.*, 1985), as pale earthy coatings.

Figure 58. **Malachite pseudomorphs to 8 mm after azurite, with a thin, pale blue coating of second-generation azurite; Lhoest collection and photo.**

Figure 59. **Pyromorphite in barrel-shaped crystals to 5 mm; Lhoest collection and photo.**

Occasionally, it is found as bunches of fibers to 5 mm and as crystals to 3 mm. Compact sprays of fibers to 7 cm were once recovered from depth. Crusts of mammillary malachite are found as a matrix for other secondary minerals like cerussite and pyromorphite, but the banded botryoidal malachite so common in the Shaba Crescent is not found at Kipushi.

Massicot PbO

Massicot appears as a yellow dusting widespread in fissures in the gangue, particularly near the cerussite turret.

Molybdenite MoS_2

This accessory species is remarkable because of its high rhenium content, up to 3% (Capitant *et al.*, 1963). An incompletely characterized mineral containing at least 20% to 30% rhenium was reported by Capitant *et al.* (1963), and a pure rhenium sulfide has recently been described from Russia (see the "What's new in minerals?" report elsewhere in this issue).

Pseudomalachite $Cu_5^{2+}(PO_4)_2(OH)_4$

Pseudomalachite is quite abundant in the oxidation zone, and often underlies other secondary species. Banded crusts to 2 cm of a dark green to bluish green color are known. When found as translucent nodules, as in the kipushite assemblage, pseudomalachite appears either green or blue.

Pyrite FeS_2

Pyrite is one of the two earliest sulfides at Kipushi. Framboids (raspberry-like micro-aggregates) and simple crystal habits, commonly with slightly corroded faces, are common in the country rock, whereas in the ore, crystal remnants are scarcer than those of arsenopyrite. Good crystals seem to occur only in association with siderite, which played the role of a protective barrier against supergene alteration. A few specimens recently purchased in Tucson are composed of lustrous crystals to 1 cm with concave faces, their habit being the dominant octahedron slightly modified by the pyritohedron and the diploid. One side shows mainly supergene alteration and one side shows intact crystals, the transition lined by goethite needles which form domes (perpendicular to the needles) in some places. One curiosity consists of a combination of early and late modifications: a pyrite crystal wherein an aggregate of siderite crystals (developed probably as a recrystallization of the gangue mineral at the time of deposition of the primary sulfide) is covered by a dome of goethite. The sheaths of pyrite surrounding the sphalerite lenses are of a later generation (Ottenburghs, 1964).

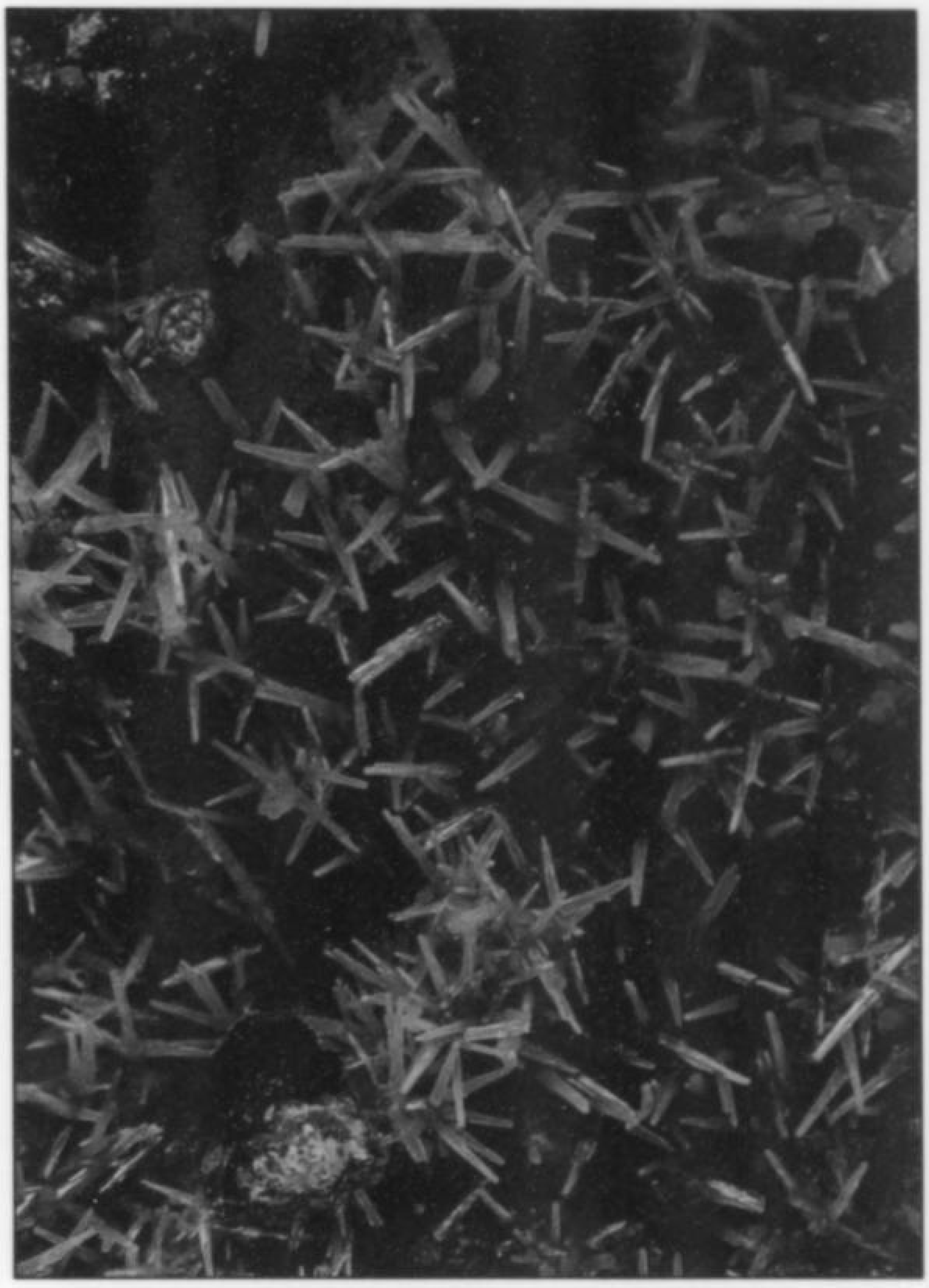


Figure 60. **Pyromorphite needles on malachite, 4 cm across; Lhoest collection and photo.**

Pyromorphite $Pb_5(PO_4)_3Cl$

Pyromorphite has been known at Kipushi since 1924 (Buttgenbach, 1947). A vein of similar crystals was found by collectors during the mid-1970's *in situ* in the pillar; the crystals are straw-yellow, opaque with a resinous luster, and up to 7 mm long. They are positioned obliquely on a carpet of bluish pseudomalachite covering a layer of a black oxide (probably heterogenite), as isolated hexagonal prisms, terminated by {001} and modified by {101}. The faces are longitudinally striated, giving the appearance that each crystal is formed by a group of subparallel smaller prisms, not all reaching the extremities. Crystals thus appear much thicker in the middle, like a barrel. Some are aggregated in divergent groups without perfect spherolithic disposition. Larger, stubby, hexagonal dipyramids of the same color and truncated by {001} have been recovered from a block of goethite.

Quartz SiO_2

Quartz is the third most common component of the country rock (20%), and probably constitutes the bulk of the gangue, as it was not replaced by sulfides like the carbonates were. Good specimens come from the preparatory workings, as zoned, clearly amethystine crystals associated with (zincian) dolomite. Crystals are doubly terminated and slightly twisted longitudinally, with a multiple second termination due to growth along parallel axes. Amethyst crystals from Kipushi are very distinctive.

Reichenbachite $Cu_5^{2+}(PO_4)_2(OH)_4$

The discovery of reichenbachite can be attributed to the perseverance of collectors in emptying the kipushite pocket. Kipushite crystals can occur pure, or only partially replaced, while others are complete pseudomorphs of reichenbachite after kipushite (M. Deliens, personal communication). Dull, opaque crystals commonly occur as rosettes to 7 mm on a carpet of pseudomalachite.

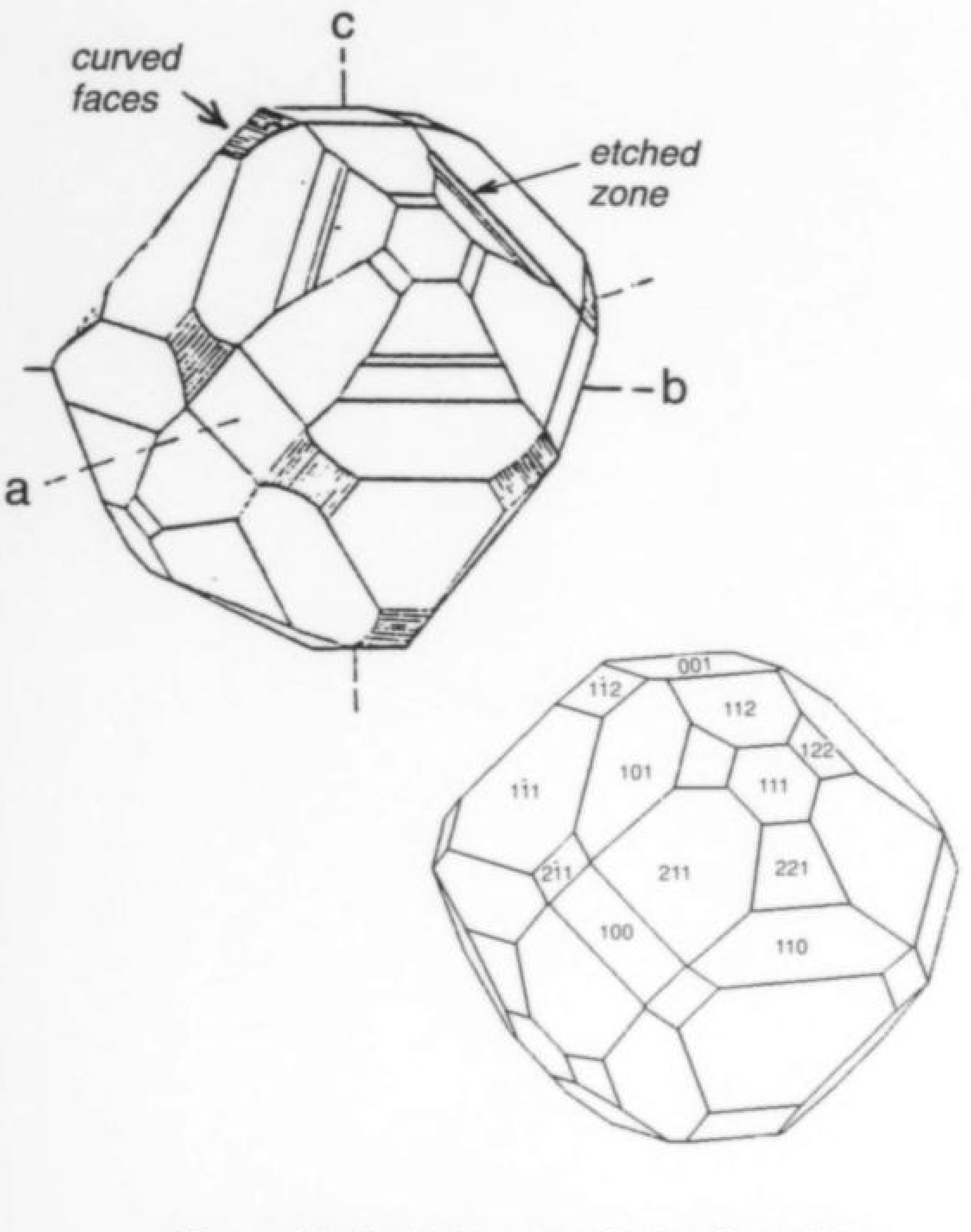


Figure 61. **Renierite crystal drawings (Vaes, 1948, unindexed; R. Van Dooren, indexed).**

Renierite $(Cu,Zn)_{11}(Ge,As)_2Fe_4S_{16}$

The occurrence of renierite was first observed by Thoreau (1928), who called it "orange bornite." In polished sections and cleavages, however, renierite is easily differentiated from bornite through the retention of its original (somewhat darker) bronze color. The description as a new species (Vaes, 1948) named it in honor of the Belgian geologist A. Renier. Eight analyses performed in the Central Laboratory of Likasi gave remarkably consistent results.

Renierite is widespread at Kipushi as small, round inclusions disseminated in primary bornite, and as massive bodies in two Ge-rich zones linked with the two boundaries of primary bornite. These are located in the upper levels, from 275 to 400, and in the lower levels from 725 to 775. From level 850 downwards, renierite inclusions become scarce and are completely absent under level 975, as is primary bornite. Renierite also occurs very sporadically in the traces of chalcopyrite and tennantite present in the iron-rich sphalerite pipes (Ottenburghs, 1964), although never in the sphalerite itself.

Germanium occurs as a trace element in many common sulfides (Intiomale and Oosterbosch, 1974). Deutzmann (1961) reported a secondary germanium ore mineral replacing renierite, which exhibits a yellow-olive tinge under the microscope.

Renierite from Kipushi is magnetic, making it easy to obtain a pure product for investigation, and facilitating industrial recovery from copper concentrates. The degree of magnetism is variable from one sample to the next, and is related to the crystal structure rather than the iron content.

Vaes (1948) described renierite as cubic. However, it is definitely tetragonal pseudoisometric, and is related to the sphalerite structure (Bernstein, 1986). Massive renierite contains abundant vugs lined with small crystals to 1.5 mm (Vaes, 1948). In our specimens, crystal faces appear like tiles of a roof when examined under the binocular microscope. SEM photographs are good for more precise visualization.

The exact formula of renierite remained in dispute for many years. Bernstein (1986) found that the mineral is a unique example of an extensive solid solution series between zincian and arsenian end-members, through the coupled substitution of Zn^{2+} + Ge^{4+} for Cu^{1+} + As^{5+} (each pair totaling a 6+ charge).

During the early 1970's, the demand for germanium was high on the international market. The rich zones were exploited, and ore was sent in barrels by plane to Europe after manual sorting according to the typical color of renierite, the richest Ge-containing sulfide (14%). Renierite accounted for 99% of the germanium production (Ottenburghs, 1964), totaling about 125 tons.

Siderite $Fe^{2+}CO_3$

Siderite appears regularly in unpublished systematic lists, though attractive, valuable crystals are not represented in collections. The recent recovery of the curious specimens of pyrite, siderite and goethite have filled this deficiency to some extent.

Silver Ag

Silver was deposited as a trace element in primary bornite and, to a lesser extent, in tennantite and betekhtinite (Intiomale and Oosterbosch, 1974). Silver occurs mostly as grayish stains on chalcocite masses, good specimens being rare. Yet some noteworthy old-time pieces are known, like those with specks of silver spread on an aggregate of blue hemimorphite on a matrix of massive aurichalcite, and also in brittle assemblages of metallic silver-white "oak leaves" with a skeletal framework.

Smithsonite $ZnCO_3$

The occurrence of smithsonite at Kipushi is not mentioned in the literature before 1931, and is merely cited by Buttgenbach (1947) without any physical description. Crystals are indeed rare; the most spectacular occurrences are banded concretionary or stalactitic masses in the footwall cavities, which are suitable for lapidary work.

At level 100, the workings are cut by a roughly cylindrical offshoot about 60 cm in diameter consisting of a core of massive chalcocite surrounded by a sheath of smithsonite crystals. Otherwise, crystals have been found only sparingly in supergene pockets, in ore sometimes recovered from a block in the dumps. The crystals, reaching to 3

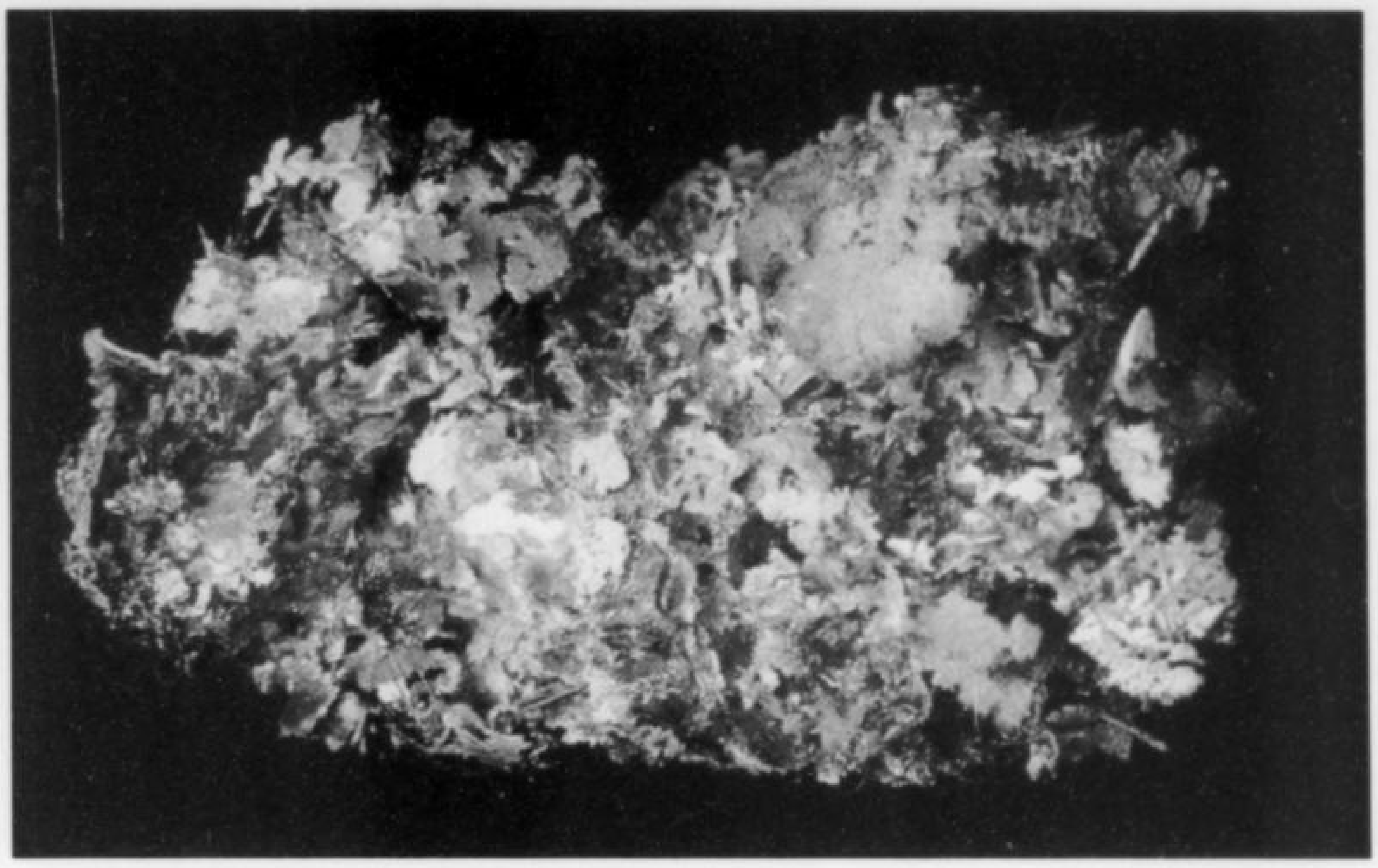


Figure 62. **Silver leaves in a 3-cm aggregate; R. Vandenbussche collection; Lhoest photo.**

mm, are opaque or rarely translucent, and mostly grayish or beige; they become attractive when colored green or blue. The crystal habit resembles rice grains with visible longitudinal striations reflecting the underlying rhombohedral structure. Sometimes external growths of rhombs form pleasing figures delineating stages of the crystal growth or, with enough imagination, Hauy's solid.

Sphalerite (Zn,Fe)S

Sphalerite (which constitutes 50% of the ore) is nearly always massive with a cubic cleavage; the banded variety is very rare, as are significant crystals. An isolated, poorly shaped old-time crystal 10 cm long was once seen; crystals to 2 cm of the green variety on a dolomitic matrix have also been found.

Sphalerite belongs to two paragenetic sequences (Deutzmann, 1961), an iron-rich assemblage well-represented in the appendicular pipes, and a later-deposited iron-poor variety which is richer in trace elements like Cd and Co. The average content of Cd is 0.05%, and the content of Co is variable, from 20 to 820 ppm (Intiomale and Oosterbosch, 1974). The color of the iron-poor sphalerite varies from colorless to yellow to pale brown. A typical occurrence at Kipushi is the green variety (supposed to be copper-rich). It does indeed contain some copper (Intiomale and Oosterbosch, 1974), and also cobalt. Hoffman and Henn (1984) found that the green color is, in fact, due to trace cobalt in the amount of about 840 ppm. Fritsch and Rossman (1987) have since confirmed that the green color of sphalerite is due to cobalt.

Stromeyerite AgCuS

Stromeyerite is the sole silver sulfide at Kipushi, and seems always to be secondary (Deutzmann, 1961; Devos *et al.*, 1974).

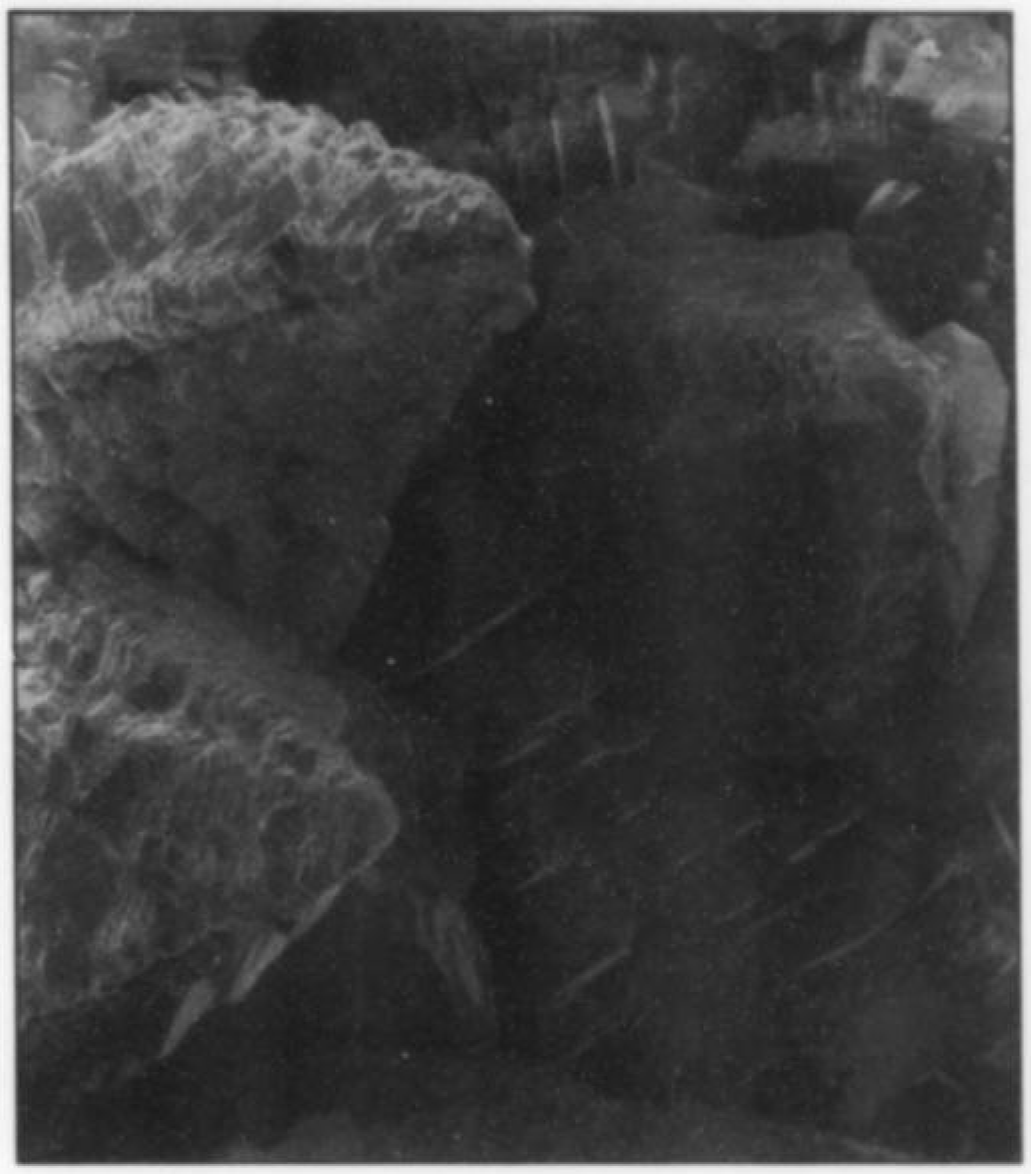
Tennantite $(Cu,Ag,Fe,Zn)_{12}As_4S_{13}$

Tennantite, reported by Thoreau (1928) as "tetrahedrite," is widespread in most types of ore as gray-whitish masses or veins with a metallic luster. Umba *et al.* (1977) reported crystals to 1 cm, and showed a photograph of a specimen from the Mineralogical Museum of the geological staff in Likasi. The official formula of tennantite was changed recently through the addition of Ag (Fleischer and Mandarino, 1995), which is interesting to correlate with the presence of silver as a trace element reported by Intiomale and Oosterbosch (1974).

Tsumebite $Pb_2Cu(PO_4)(SO_4)(OH)$

Tsumebite is probably not as rare at Tsumeb as initially thought (Pinch and Wilson, 1977). Yet phosphates are scarce in Tsumeb, represented mostly by the rare tsumebite and some pyromorphite (Guillemin, 1956). In contrast, phosphates are quite abundant at Kipushi, where tsumebite has been recognized on a single specimen in the Tervuren Museum (M. Deliens, personal communication). During the 1960's and 1970's (and even the 1980's), collectors in Katanga were accustomed to searching for relatively large specimens and were not inclined to save such tiny crystallizations, especially among so many greenish occurrences. Tsumebite therefore, probably occurs more commonly than supposed in Kipushi too.

Figure 63. **Smithsonite crystals, 0.1 mm, showing stacked-rhombohedron habit. Lhoest collection and SEM photo.**



Tungstenite WS_2

Tungstenite was reported by Moh (1973) in ore from level 280, as oriented lamellae in chalcocite, with minor renierite. Devos *et al.* (1974) report that tungstenite lamellae are always present near germanite, having probably been deposited when renierite replaced germanite, considering that renierite does not accept W in its structure as germanite does.

Turquoise $Cu^{2+}Al_6(PO_4)_4(OH)_8 \cdot 4H_2O$

An extensive occurrence of turquoise is reported by Intiomale and Oosterbosch (1974) in the overburden covering the Kakontwe.

Vauquelinite $Pb_2Cu^{2+}(CrO_4)(PO_4)(OH)$

In addition to its type locality in the Urals, vauquelinite has also been reported from a fair number of other localities, among which is

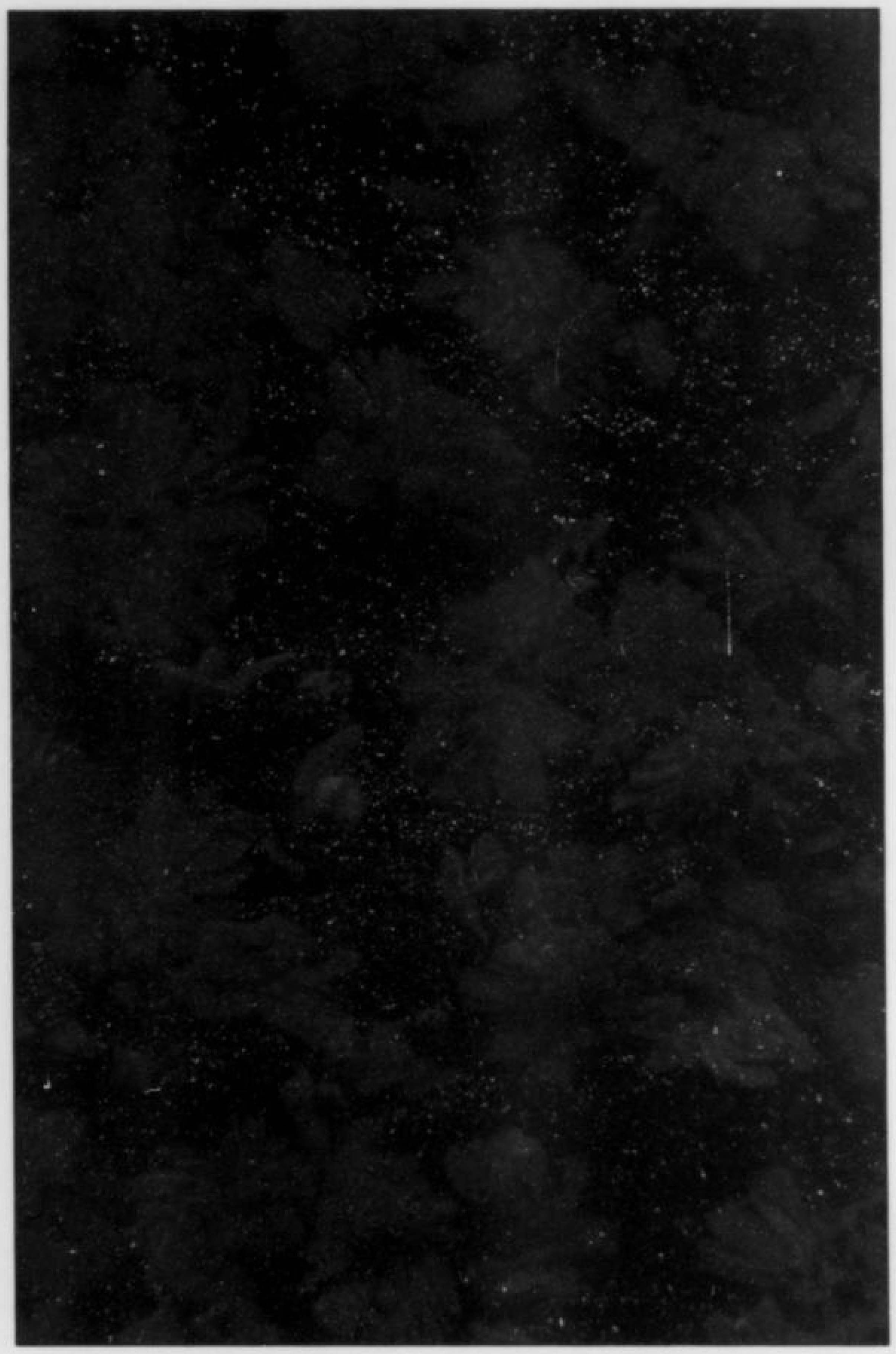
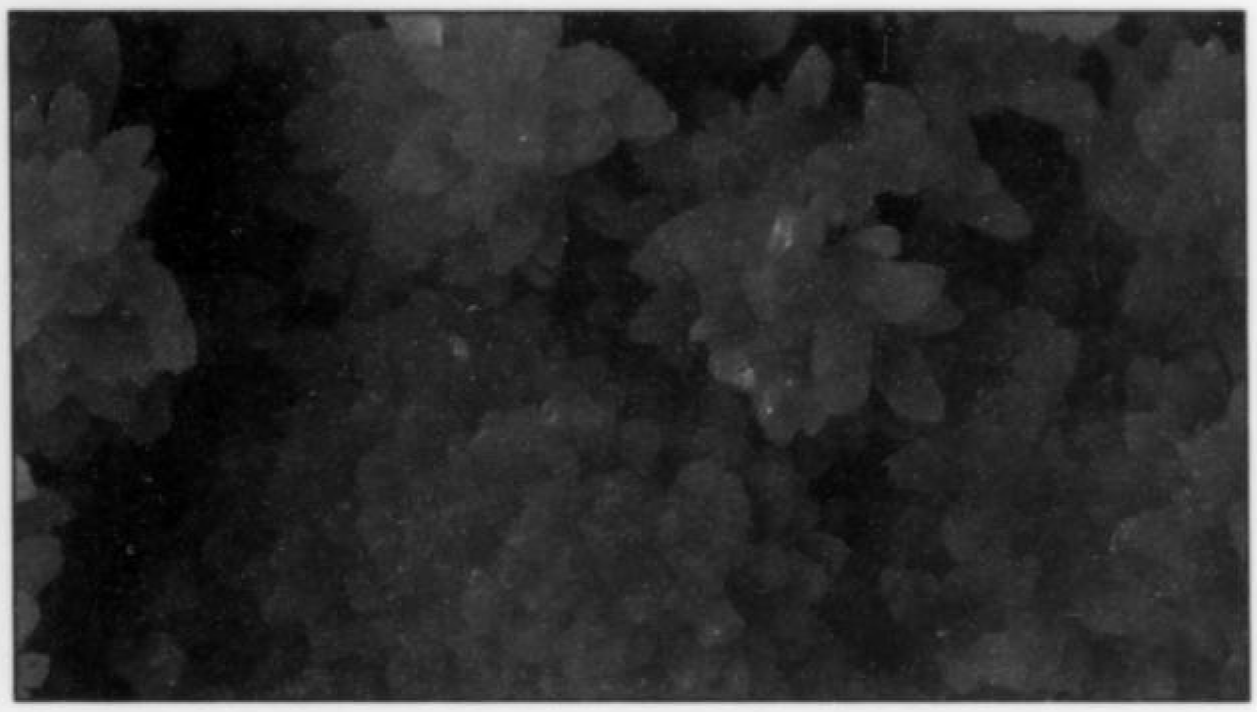


***Figure 64.* Smithsonite crystals to 2 mm on chalcopyrite, goethite and quartz; Lhoest collection and photo.**

***Figure 65.* Reichenbachite pseudomorphs after kipushite, 4 cm across; Lhoest collection and photo.**

***Figure 66.* Smithsonite in blue-green "rice grain" crystals, 3 cm across; R. Vandenbussche collection; Lhoest photo.**



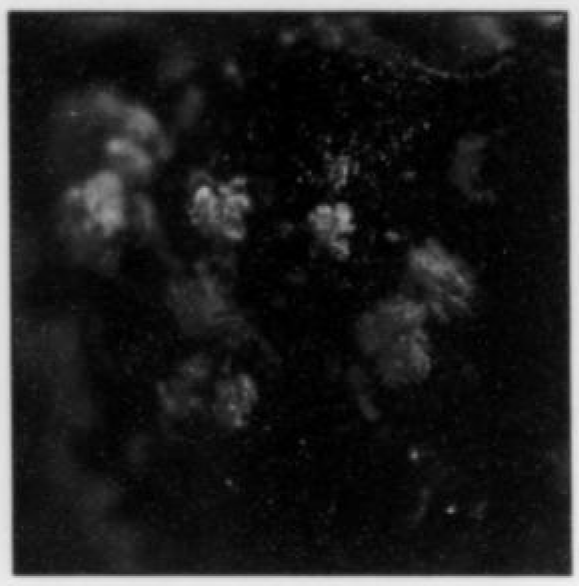


***Figure 67.* Vauquelinite crystal clusters, 0.2 mm; F. Coune collection; Lhoest photo.**

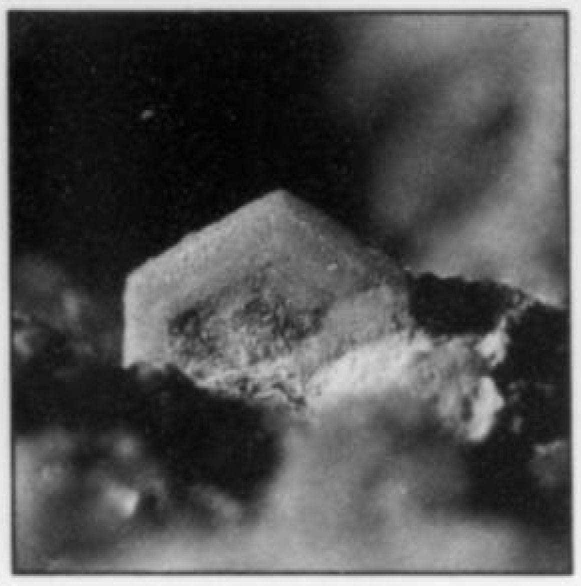


***Figure 68.* Vauquelinite pseudomorph after cerussite, 0.7 mm; R. Van Dooren collection; Lhoest photo.**

Musonoi in the western Kolwezi klippe. In specimens from Kipushi the canary-yellow color is striking, and even misleading if taken as analogous to uranium occurrences in Luiswishi and in Shinkolobwe (Gauthier *et al.*, 1989). Autunite is erroneously quoted in early internal reports; but in fact there is no radioactivity at all in the primary ore. Even the pioneer collectors had specimens confiscated from their cases and disallowed at the official control checks before delivery of exportation permits, on the assumption they were radioactive.

The earliest report of yellow vauquelinite from Kipushi is in the kipushite assemblage (Piret *et al.*, 1985). On the specimens of pyromorphite from the pillar, tiny, opaque, canary-yellow plates, generally isolated and lying flat between the layers of pseudomalachite and black oxides, are present rather abundantly. Sometimes the tiny plates appear assembled as clusters resembling a rose.

Old-time specimens in collections consist of rough yellow clods to 2 mm and yellowish plates to 3 mm of vauquelinite pseudomorphs, probably after cerussite, scattered on a matrix of mammillary chrysocolla, with fibrous malachite complementing the association. The yellow mineral has been identified as vauquelinite on both the recently collected and the old-time specimens (courtesy of Zelimir Gabelica of Namur, Belgium).

Veszelyite $(Cu^{2+},Zn)_3(PO_4)(OH)_3\cdot 2H_2O$

Kipushi is one of the historical localities for the occurrence of veszelyite, a mineral name with an amusing history. The type-material was described from a locality in Transylvania in two papers of 1874 and 1880 (quoted in Zsivny, 1932), with an inaccurate As content of about 10% and a greenish blue tinge (supposedly due to the presence of As). Some 50 years later, two additional descriptions were published by Mennell (1920) and by Japanese authors in 1922 (quoted in Zsivny, 1932). Mennell (1920) described an ultramarine-blue well-crystallized mineral of which only about 1 gram was collected. The author considered that it could be veszelyite, yet the crystal habit was

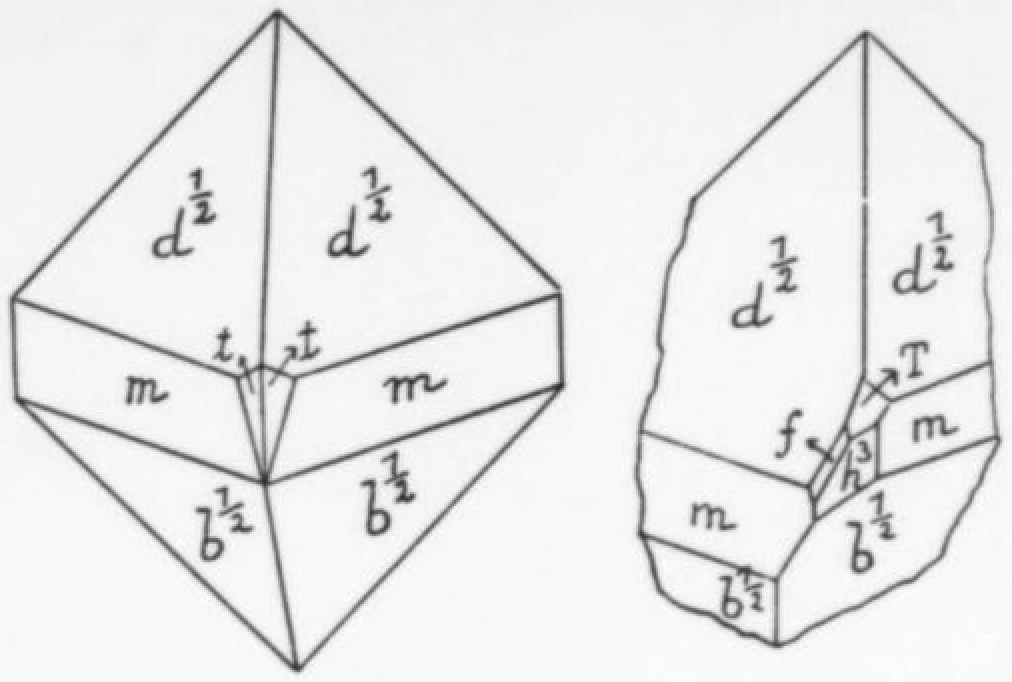


Figure 69. **Veszelyite crystal drawings (Mennell, 1920; Buttgenbach, 1947, oriented differently).**

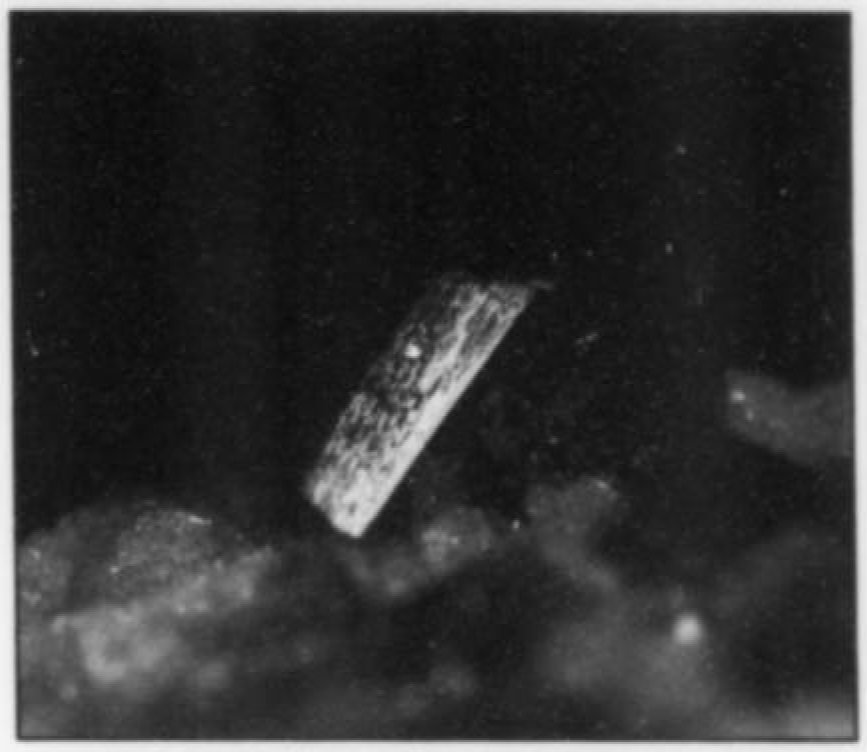


Figure 70. **Veszelyite crystal, 3 mm; Lhoest collection and photo.**

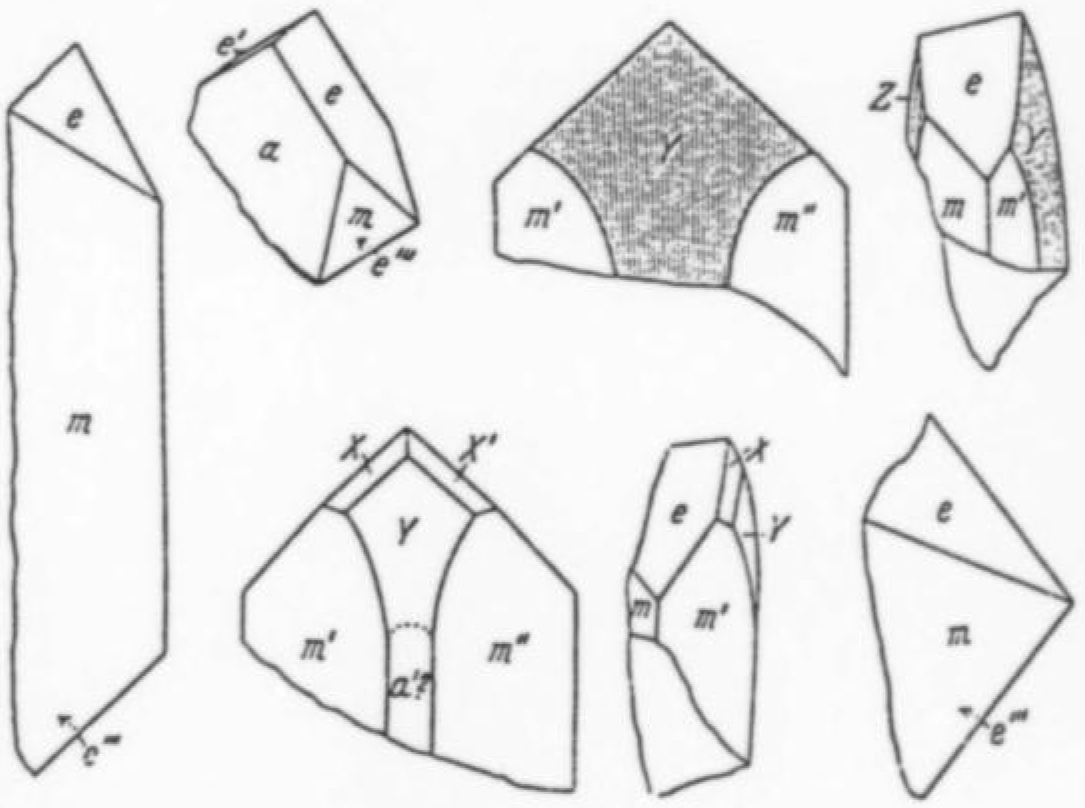


Figure 71. **Veszelyite crystal drawings (from Mennell, 1920, and Zsivny, 1932). Note the unidentified curved faces Y and Z.**

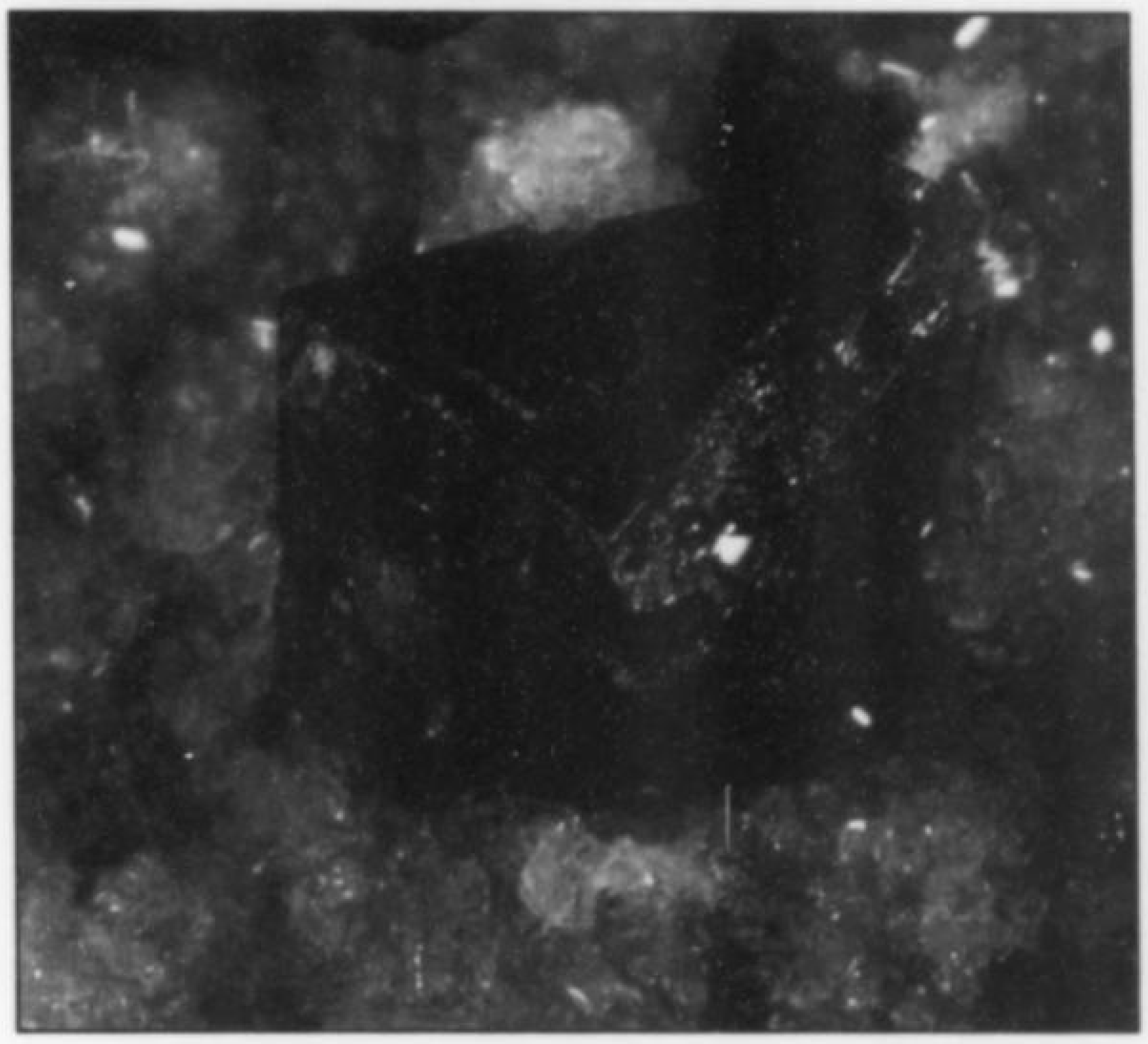


Figure 73. **Veszelyite crystal, 2 mm, on blue hemimorphite; Lhoest collection and photo.**

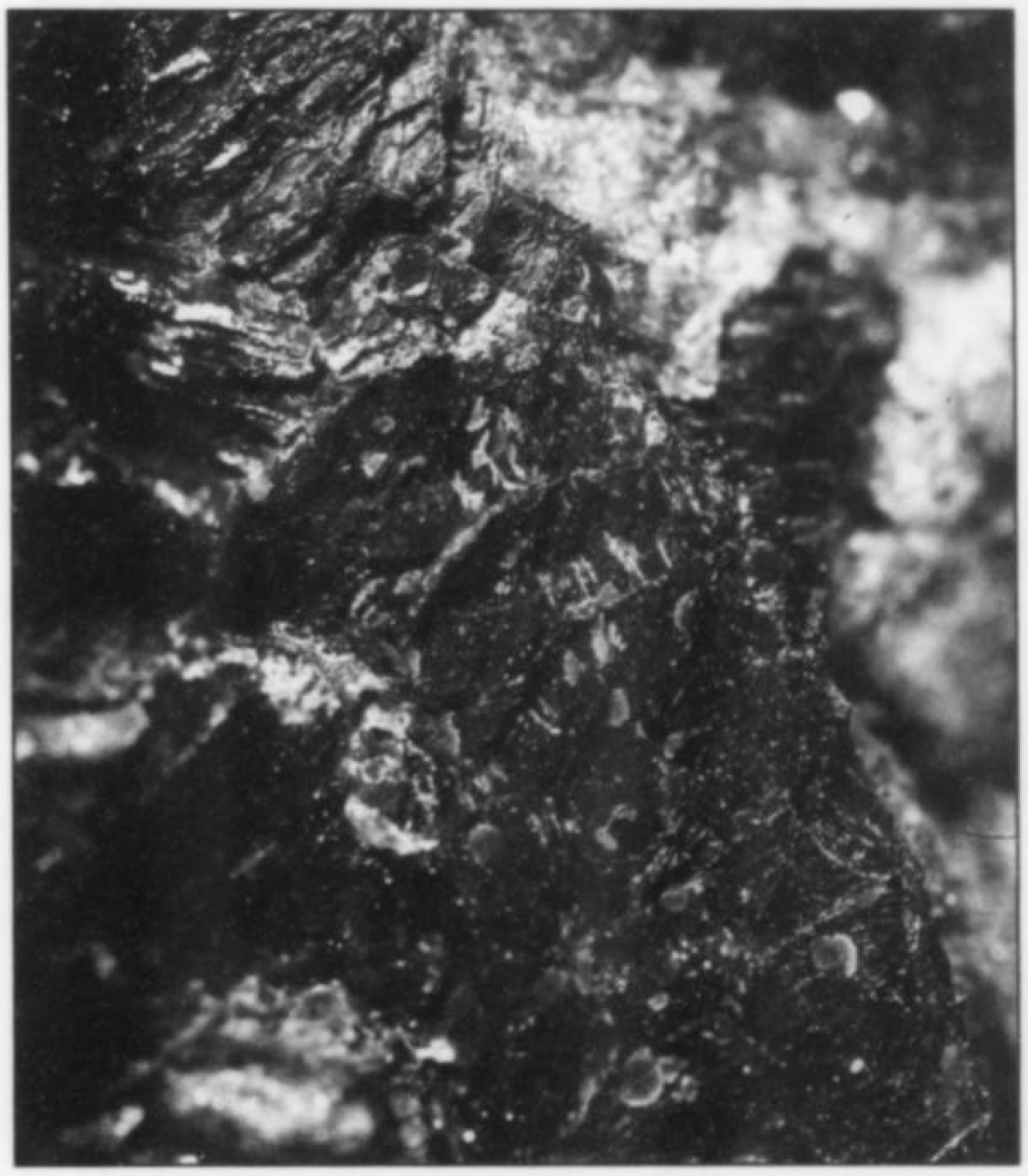


Figure 72. **Zincite cluster of lamellar crystals, 1.2 cm; F. Coune collection; Lhoest photo.**

quite particular, with a large (typical) "orthopinacoid" {100} which had not been observed in the original veszelyite. Above all, the new mineral contained no As. The Japanese authors described "arakawaite," which they soon considered identical with "Broken Hill's veszelyite," considering that both contained no As (quoted in Zsivny, 1932) and were blue.

Buttgenbach (1947) then described "kipushite" in 1926. The occurrence at level 100 was first reached by exploratory workings and later (in 1932) by an exploitation tunnel. According to legend, crystals abundantly covered the walls in a large area, representing the largest find of the best crystals then known. These were very sharp, from 3 to 7 mm in size (and in rare cases up to 1 cm), opaque and of a deep blue color with azure-blue translucent areas.

The name "kipushite" was a working name chosen to please executives of the U.M.H.K. who had suggested it. Buttgenbach retained the working name, probably for too long, yet not without reason. He had identified immediately "his mineral" with the ultramarine-blue "unnamed" species of Mennell, which he also called "kipushite," and stated that it was probably identical with "arakawaite" if it could be ascertained that the latter contained no As at all; all of these minerals (including veszelyite) would be members of an isomor-

Table 1. **Minerals reported from the Kipushi mine. (Species for which Kipushi is the type locality are given in bold.)**

Elements	
Bismuth	Bi
Copper	Cu
Graphite	C
Silver	Ag
Sulfides & Sulfosalts	
Aikinite	$PbCuBiS_3$
Arsenopyrite	$FeAsS$
Betekhtinite	$Cu_{10}(Fe,Pb)S_6$
Bismuthinite	Bi_2S_3
Bornite	Cu_5FeS_4
Briartite	$Cu_2(Fe,Zn)GeS_4$
Carrollite	$Cu(Co,Ni)_2S_4$
Chalcocite	Cu_2S
Chalcopyrite	$CuFeS_2$
Cobaltite	$CoAsS$
Cosalite	$Pb_2Bi_2S_5$
Covellite	CuS
Digenite	Cu_9S_5
Emplectite	$CuBiS_2$
Enargite	Cu_3AsS_4
Galena	PbS
Gallite	$CuGaS_2$
Germanite	$Cu_{26}Fe_4Ge_4S_{32}$
Idaite	Cu_3FeS_4 (?)
Linnaeite	$Co^{2+}Co_2^{3+}S_4$
Marcasite	FeS_2
Mawsonite	$Cu_6Fe_2^{3+}Sn^{4+}S_8$
Molybdenite	MoS_2
Pyrite	FeS_2
Pyrrhotite	$Fe_{1-x}S$
Renierite	$(Cu,Zn)_{11}(Ge,As)_2Fe_4S_{16}$
Sphalerite	$(Zn,Fe)S$
Stannite	Cu_2FeSnS_4
Stromeyerite	$AgCuS$
Sulvanite	Cu_3VS_4
Tennantite	$(Cu,Ag,Fe,Zn)_{12}As_4S_{13}$
Tetradymite	Bi_2Te_2S
Tetrahedrite	$(Cu,Fe)_{12}Sb_4S_{13}$
Tungstenite	WS_2
Valleriite	$4(Fe,Cu)S\cdot 3(Mg,Al)(OH)_2$
Wittichenite	Cu_3BiS_3
Wurtzite	$(Zn,Fe)S$
Chlorides	
Atacamite	$Cu_2^{2+}Cl(OH)_3$
Fluorides	
Fluorapatite	$Ca_5(PO_4)_3F$
Fluorite	CaF_2
Oxides	
Cuprite	Cu_2O
Goethite	$\alpha FeO(OH)$
Hematite	αFe_2O_3
Heterogenite	$Co^{3+}O(OH)$
Magnetite	$Fe^{2+}Fe_2^{3+}O_4$
Massicot	PbO
Pyrolusite	$Mn^{4+}O_2$
Tenorite	CuO
Zincite	$(Zn,Mn^{2+})O$
Carbonates	
Aurichalcite	$(Zn,Cu^{2+})_5(CO_3)_2(OH)_6$
Azurite	$Cu_3^{2+}(CO_3)_2(OH)_2$
Bismutite	$Bi_2(CO_3)O_2$
Calcite	$CaCO_3$
Cerussite	$PbCO_3$
Dolomite	$CaMg(CO_3)_2$
Hydrozincite	$Zn_5(CO_3)_2(OH)_6$
Malachite	$Cu_2^{2+}(CO_3)(OH)_2$
Rosasite	$(Cu^{2+},Zn)_2(CO_3)(OH)_2$
Siderite	$Fe^{2+}CO_3$
Smithsonite	$ZnCO_3$
Silicates	
Actinolite-tremolite	$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$
Albite	$NaAlSi_3O_8$
Chrysocolla	$(Cu^{2+},Al)_2H_2Si_2O_5(OH)_4\cdot nH_2O$
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$
Hemimorphite	$Zn_4Si_2O_7(OH)_2\cdot H_2O$
Muscovite	$KAl_2(SiAl)O_{10}(OH,F)_2$
Palygorskite	$(Mg,Al)_2Si_4O_{10}(0H)\cdot 4H_2O$
Phlogopite	$KMg_3Si_3Al_{10}(F,OH)_2$
Quartz	SiO_2
Riebeckite	$Na_2(Fe^{2+},Mg)_3Fe_2^{3+}Si_8O_{22}(OH)_2$
Talc	$Mg_3Si_4O_{10}(OH)_2$
Willemite	Zn_2SiO_4
Phosphates	
Fluorapatite	$Ca_5(PO_4)_3F$
Kipushite	$(Cu^{2+},Zn)_5Zn(PO_4)_2(OH)_6\cdot H_2O$
Libethenite	$Cu_2^{2+}(PO_4)(OH)$
Pseudomalachite	$Cu_5^{2+}(PO_4)_2(OH)_4$
Pyromorphite	$Pb_5(PO_4)_3Cl$
Reichenbachite	$Cu_5^{2+}(PO_4)_2(OH)_4$
Tsumebite	$Pb_2Cu(PO_4)(SO_4)(OH)$
Turquoise	$Cu^{2+}Al_6(PO_4)_4(OH)_8\cdot 4H_2O$
Vauquelinite	$Pb_2Cu^{2+}(CrO_4)(PO_4)(OH)$
Veszelyite	$(Cu^{2+},Zn)_3(PO_4)(OH)_3\cdot 2H_2O$
Vivianite	$Fe_3^{2+}(PO_4)_2\cdot 8H_2O$
Arsenates	
Adamite	$Zn_2(AsO_4)(OH)$
Beudantite	$PbFe_3^{3+}(AsO_4)(SO_4(OH)_6$
Conichalcite	$CaCu^{2+}(AsO_4)(OH)$
Vanadates	
Descloizite	$PbZn(VO_4)(OH)$
Vanadinite	$Pb_5(VO_4)_3Cl$
Tungstates	
Scheelite	$CaWO_4$
Sulfates	
Anglesite	$PbSO_4$
Barite	$BaSO_4$
Beaverite	$Pb(Cu^{2+},Fe^{3+},Al)_3(SO_4)_2(OH)_6$
Beudantite	$PbFe_3^{3+}(AsO_4)(SO_4)(OH)_6$
Brochantite	$Cu_4^{2+}(SO_4)(OH)_6$
Devilline	$CaCu_4^{2+}(SO_4)_2(OH)_6\cdot 3H_2O$
Goslarite	$ZnSO_4\cdot 7H_2O$
Gypsum	$CaSO_4\cdot 2H_2O$
Tsumebite	$Pb_2Cu(PO_4)(SO_4)(OH)$
Chromates	
Vauquelinite	$Pb_2Cu^{2+}(CrO_4)(PO_4)(OH)$
Molybdates	
Wulfenite	$PbMoO_4$

phous series. Recognition of the morphological identity of the varieties with veszelyite must be credited to Buttgenbach.

Zsivny (1932) carefully reinvestigated the type-material (morphologically, optically and chemically), and compared his results with data from the literature concerning the varieties. He proposed discreditation of "kipushite" because the type material contained no As, the name veszelyite having chronological priority.

Finally, Guillemin (1956) discovered that veszelyite from Broken Hill was actually a zincian libethenite. Generally veszelyite crystals are short and prismatic (with the recent exception of the incredible crystals from the Black Pine mine, Montana; Waisman, 1992). From Kipushi, the habit is pseudo-octahedral, composed of a combination of the forms {110} and {011}. Moreover, Kipushi crystals typically show a complete absence of the pinacoid {100} and the presence of an often well-developed "belt-like" truncation indexed as {$\bar{1}$21} according to international standards of crystal positioning (Zsivny, 1932). It is positioned similar to {$\bar{5}$94} and {$\bar{2}$53}, which had been observed rarely by Zsivny as small single faces. Yet Buttgenbach retained his handsome vertical orientation in order to better show the typical truncation, and probably also because he could not easily accept that his "kipushite" was not a new species.

Associations include mostly blue hemimorphite and accessorily aurichalcite with some chrysocolla. Otherwise, veszelyite occurs sparingly; it has been reported as part of the kipushite assemblage, and as poorly shaped small crystals on an old-time specimen with massive aurichalcite and hemimorphite.

Chemically, veszelyite is remarkable because of its variable Cu:Zn ratio, a feature related to its structure consisting of two kinds of sheets (Piret *et al*., 1985).

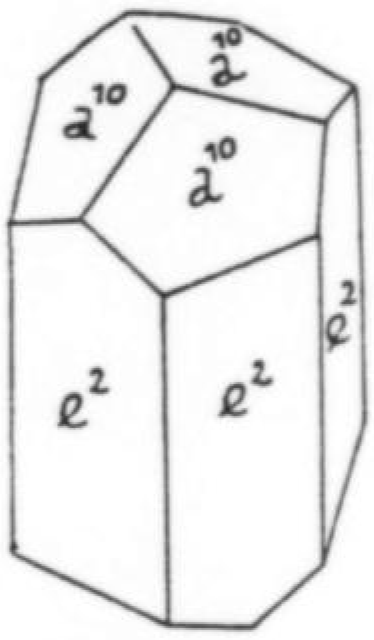


***Figure 74*. Willemite crystal drawing (Buttgenbach, 1947).**

Willemite Zn_2SiO_4

Willemite is rare and was not observed at Kipushi by early investigators. Umba *et al*. (1977) report short, whitish yellow hexagonal prisms to 1 mm, terminated with a {334} rhombohedron face. One old-time specimen consists of a dark sphalerite crystal group partially covered by aggregates of small, pale brown, poorly shaped willemite crystals.

Wurtzite $(Zn,Fe)S$

An occurrence of sphalerite-after-wurtzite pseudomorphs was reported by Deutzmann (1961).

Zincite $(Zn,Mn^{2+})O$

In the oxidation zone, zincite is widespread as brownish yellow earthy fillings. A more limited occurrence is as reddish mammillary crusts underlying aurichalcite in some specimens. One good old-time specimen consists of very brittle, micaceous, transparent plates of a dark red color, with hexagonal terminations, on a matrix of green sphalerite and chalcocite.

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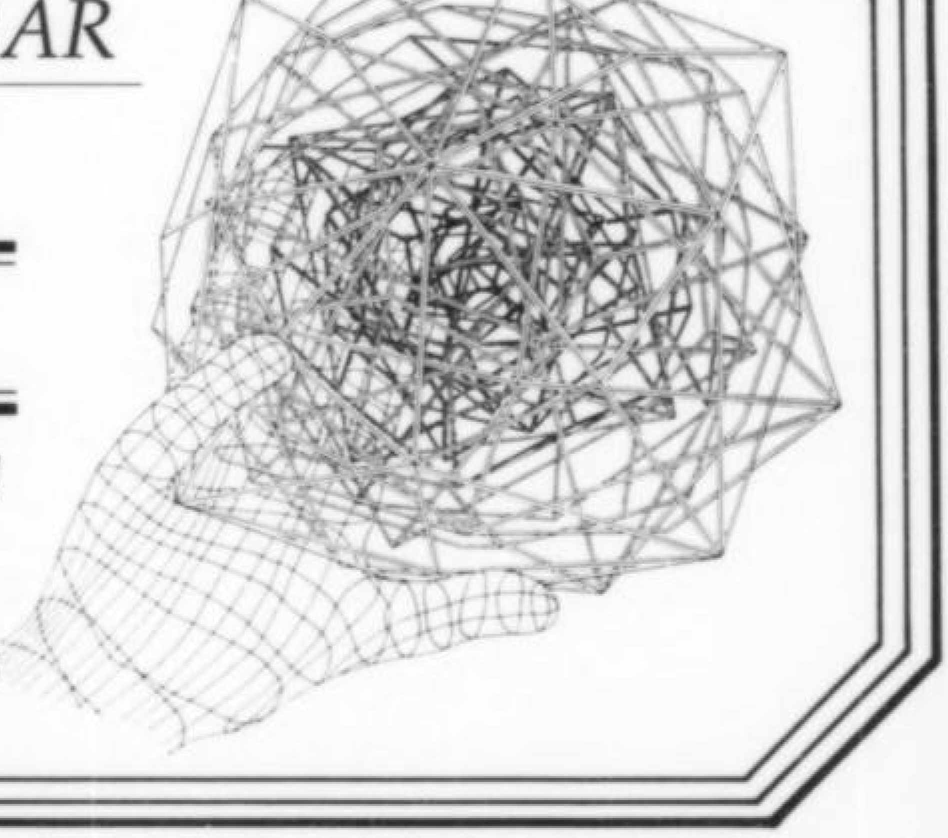

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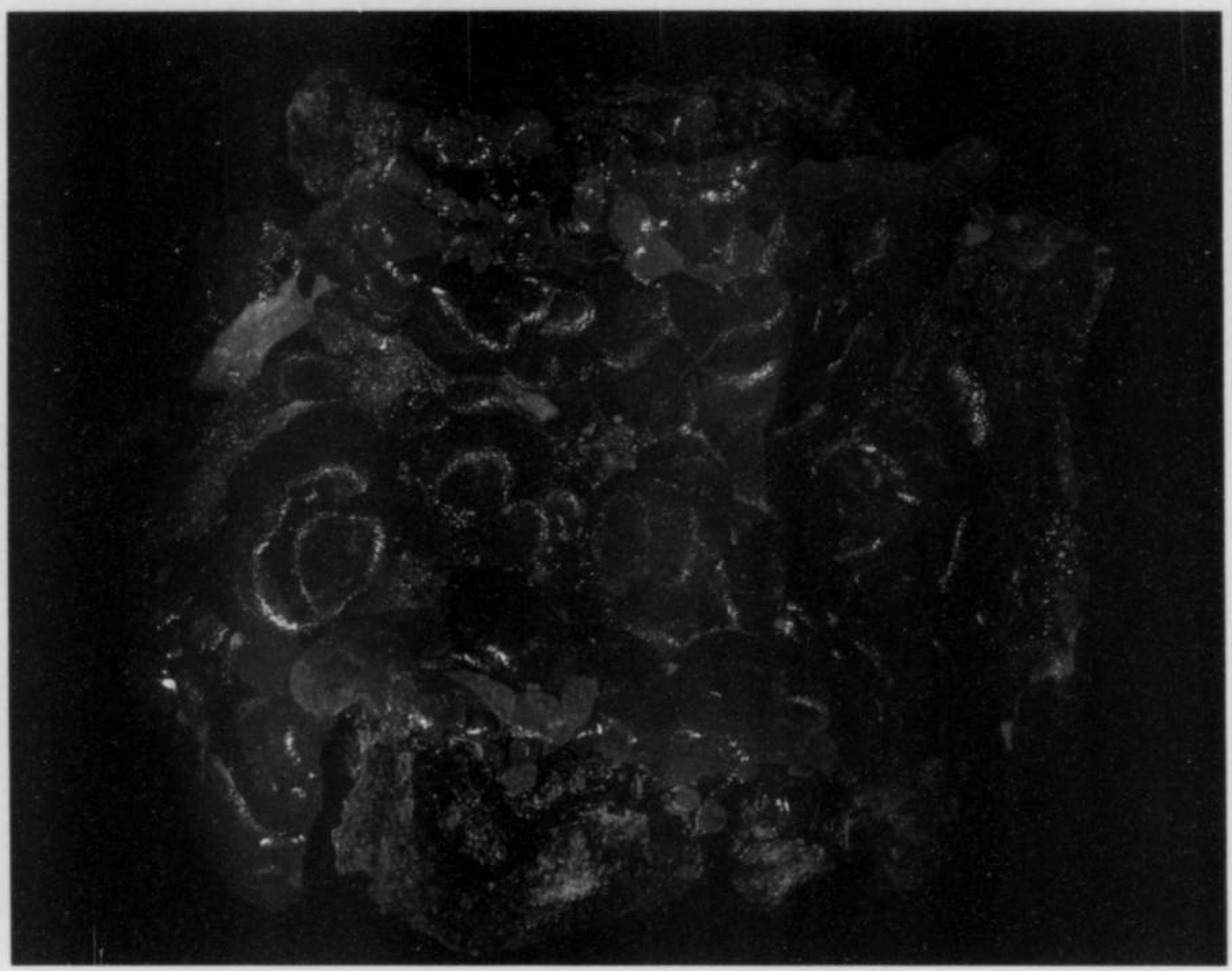

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THE BOLIVIAN DEATH SWITCH

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In October 1993 my friend, Gary Moss of San Francisco, was going to do some consulting work for the new giant copper mine of Escondida in northern Chile. Concurrently another friend, Dr. Alfredo Petrov, of Cochabamba, Bolivia, wrote me a letter proposing a trip to visit a number of seldom visited mines in southern Bolivia. He outlined a juicy itinerary. I forwarded the letter to Gary, who immediately contacted Alfredo and asked about the possibility of him going on the trip. The proposed departure date was only a few weeks after my return from Siberia and I was vacillating about going or putting it off till next year. Gary pushed me over the edge and I told him, "Not without me you don't"; it was just too juicy a trip to pass up.

The plan was to meet Alfredo in Cochabamba and spend two days there arranging logistics and getting used to the altitude before heading up to the altiplano and south to the even higher mines. Cochabamba, located in a semi arid mountainous region, is the third largest city in Bolivia, at an altitude of about 8,000 feet. We arrived on schedule and Alfredo met us at the airport in his beat up Volkswagen, which introduced us to a whole new dimension in the meaning of the word, dilapidated. On a hill outside of town. Cochabamba has just built the largest concrete Christo (statue of Christ) in the world. They made it one meter taller than the one in Rio de Janeiro, Brazil, reasoning that it would steal away some of the tourist trade from Rio.

The economic situation in Bolivia is grim but stable and slowly getting better. The new president of Bolivia speaks Spanish with an awful American accent, because he was raised in the United States. He has managed to bring inflation to almost zero, and the Bolivian peso is now stable and traded openly against the US dollar. The new administration is trying to institute a whole new series of reforms from open trade with Peru to expelling corrupt officials from government. In Cochabamba on TV we saw a Bolivian supreme court justice accepting a $5,000 bribe; caught on tape! The new president has required that the mines pay their way and has even gone so far as to abolish the bureau of mines. The state-run mining company, COMIBOL, which at one time had 65,000 employees, is but a shadow of its former self. COMIBOL still maintains a caretaker role at many of the country's mines, but most of the deposits have been completely or partially given over to the miners to run. Most are run as collectives, but they are having a hard time because the pumps have failed at many mines and they cannot afford to buy new ones. In some cases they cannot even pay for electricity to run the pumps. Many mines have flooded to the level of the lowest adits and the collectives are then limited to mining only the upper levels.

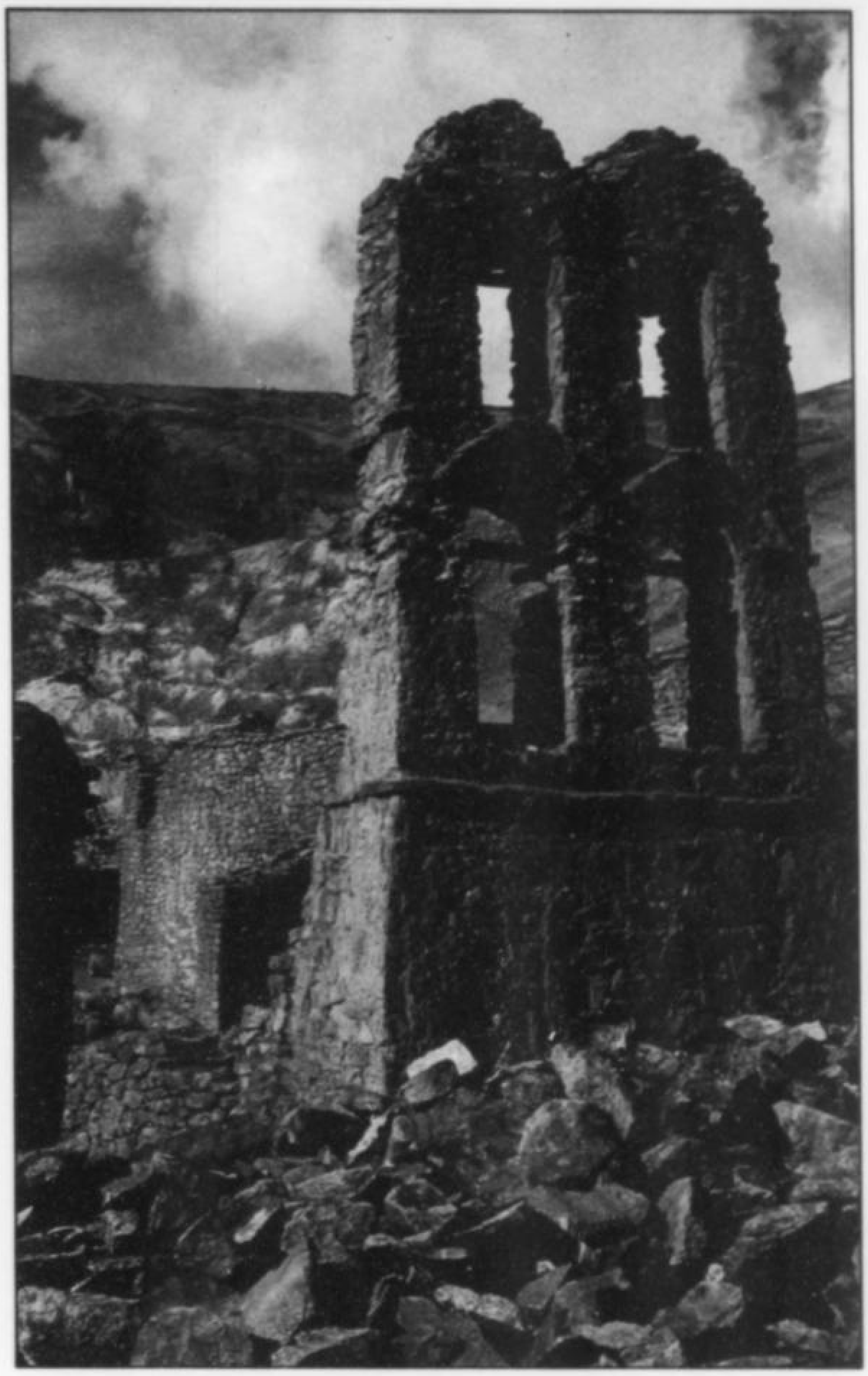
Figure 1. **Ghost town of Colquechaca, Bolivia. *Colquechaca* means "Silver Bridge"; a sign over the road into town proclaims the camp to be the Ruby Silver Capitol of the World.**

Bolivia is the only country in South America where Indians still form the majority of the population. Amazingly, before 1982 they were excluded from riding buses because the majority did not possess the necessary government identification cards. Most of the miners are Indian or of Indian extraction and the government has always been afraid of them. They have a long history of militant activity. Many mining camps have statues depicting miners with broken chains still hanging from their wrists, brandishing a pick in one hand and a rifle in the other. In the early days the Spanish were not gentle with the Indians. Many stories are told of how thousands of them were marched into the mines, never to see daylight again, and of deep shafts filled with huge piles of bones. Now, many of the miners who cannot make a living in the mines are moving to Santa Cruz and the jungle in hope of finding a better life. Santa Cruz is now the second largest town in Bolivia and it is projected to soon pass La Paz in population.

For $100 a day we rented a moderately new, flashy, 4-wheel-drive Toyota we speculated had been the property of some drug runner. We found that changing money was not a problem because most people preferred to be paid in U.S. dollars. This was true even in remote mining camps. Our biggest problem in this regard was obtaining the

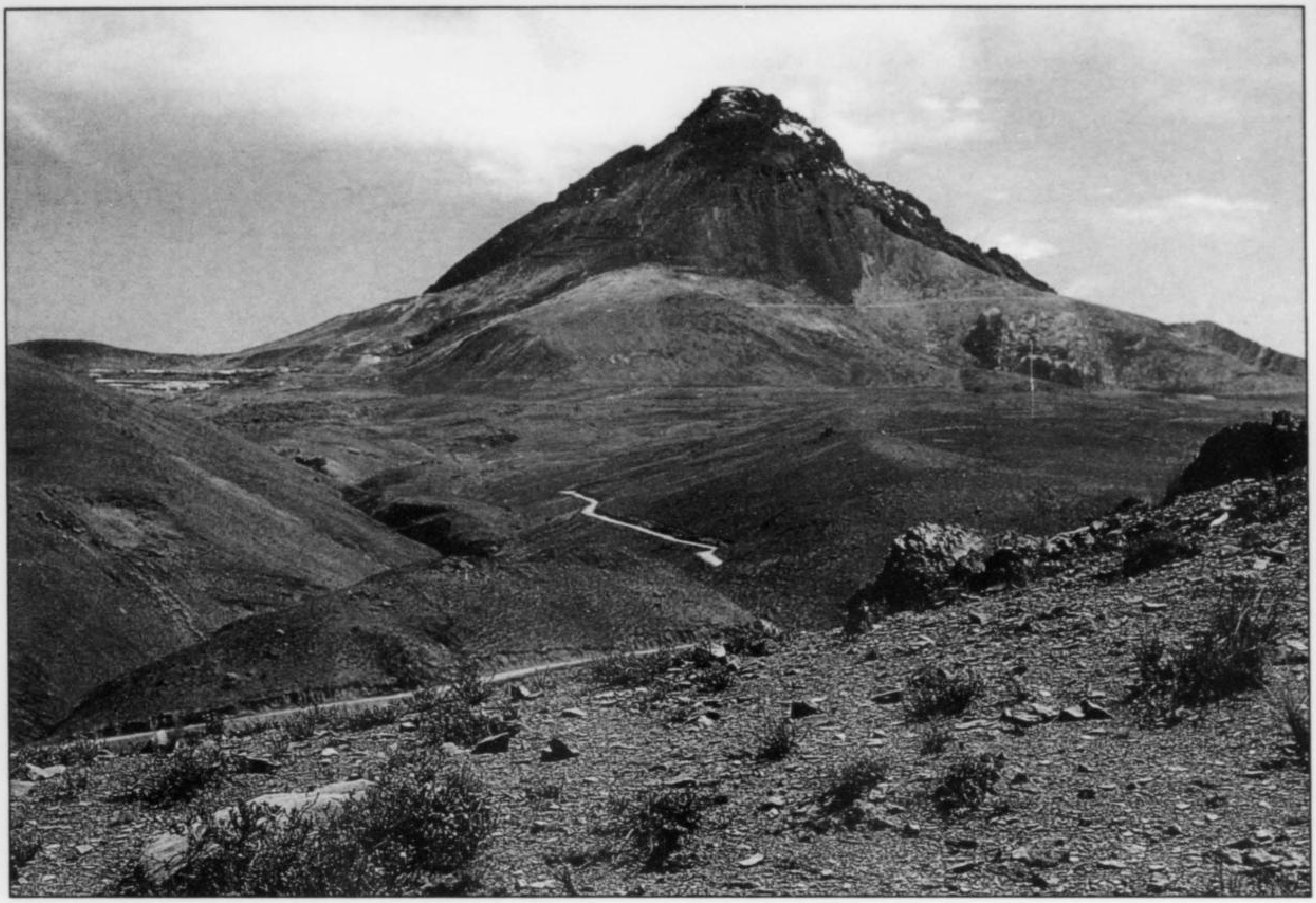

***Figure 2.* The volcanic stock at Tasna, Bolivia, perhaps the world's greatest concentration of bismuth.**

small Bolivian peso notes we needed to make small purchases of food and small lots of specimens. By offering a 10% premium to the merchants for small bills, we were largely able to solve that problem. We bought two cases of bottled water, loaded up on groceries, and headed off to seek fame and fortune.

Oruro was our first stop. At the San Jose mine, acid-rich mine water running from one of the adits had carved a small gulch in some of the mine dumps and hillsides. Small gypsum crystals lined the sides and bottom of the stream. The mines were mostly closed and, except for the efforts of the collectivos, they would be entirely defunct. In 1975 I had visited the Itos and San Jose mines and had been able to buy a few specimens, but now found nothing to buy.

Leaving paved roads behind, we headed south with a full tank of gas, not knowing when we could buy more. The road more or less followed the railway tracks, which was obviously intended to be the primary means of transportation. The roads became progressively worse, and the maps we had were rudimentary and full of errors. We often had to make a guess at which fork to take and often little villages we passed through were not shown. We frequently encountered roads with deep sand and dust and it was not uncommon for us to be running in front of a 100-foot-high rooster-tail of dust, doing our best to keep ahead of it. All was well if we could, but frequently we would pass a truck coming the other way, had a strong tail wind, or had to slow to avoid some terrible washout or boulders in the road. Then the dust would catch up with us and there would be a flurry of up window rolling, gasping, and complaining about the lack of skill of the current driver. Remarks like, "You know, if you had tried a little harder you could have hit that really big hole," and "If driving ability were gas you wouldn't have enough to run an ant's motor scooter around the inside of a Cheerio," etc., were common.

We eventually came in sight of the Salar de Uyuni, which is advertised as the largest Salar in the world. This one is extraordinarily flat, white and smooth, and in places is about 100 miles across. There are places here with a substantial lithium content, which has not been exploited because of Bolivia's recent political problems and the resulting conditions hostile to business. It will take some years of a stable government and economy to tempt investors to again take a chance on doing business in Bolivia. At the southern end of the Salar de Uyuni we came at sunset to the little town of Uyuni.

In good weather and at sunset it was a rather pleasant little town. Like many little towns the main business district lined both sides of the railway track. Because of a general railway strike, there had not been a train in two weeks. The gas station was closed and would theoretically open in the morning at 8 a.m. Next we found a little hotel in which to stay and, after our first day of intensive dust eating, a shower was high on the list of our concerns. None of the rooms had their own bathroom, but the communal bathroom down the hall did have a shower and, even more surprising, hot water.

Hot water was provided by a Brazilian-style water heater and proved to be typical of all the showers we encountered. These water heaters look like the starship Enterprise stuck on a pipe coming out of the wall. Heavy duty 220 volt, mostly insulated wires, also come out of the wall and are attached to the shower head. Bare wire is usually visible somewhere in this lash up and the wires are often wound around the metal water pipe. Water temperature is controlled by a single knob that regulates the flow of cold water to the shower head.

As soon as water passes through the shower head, the current kicks on and resistance wires do their best to flash boil the water. The more you open the tap, the cooler the water.

Experience in Brazil with these shower heads had, at various times, yielded surprises all the way from nasty, piercing little shocks when trying to adjust the water flow to being stunned and knocked on one's butt while trying to change the settings on the shower head itself. Here in Bolivia, adding to the apprehension of using the shower, was a rather large forked, throw switch whose ominous, long, naked, red metal bars were just waiting to fry any careless, fumbling fingers. They had only a tiny plastic knob attached to them, which you had to throw to activate the system. You can imagine, having finished your shower, standing there warm, wet, a little soapy, i.e. the perfect conductor, contemplating if you really wanted to try and turn off the system.

At the end of a hard day, when we had located a potential (haw haw) hotel, the first thing that one of us would do would be to check out the bathroom for potential hot water. Upon returning he would immediately be quizzed about the facilities and the answer would almost always be, "Another Bolivian death switch." Incredible as it may seem, we found more hot water in southern Bolivia than we did in Siberia.

In Uyuni we filled our tank and a five-gallon plastic container with gas and headed south trailing a big plume of dust. Fumes from our leaking plastic gas can, and the inaccurate maps were constant irritations. In addition we were constantly worried about when and if we could find more gasoline. At each village we asked if gas was available and were told no, but it was at the next village which also had no gas, etc.

All was not gloom and doom because the weather was great with a beautiful blue sky, and the altiplano (13,000 to 14,000 feet) offered grand vistas of mountains and the plains which were punctuated with small clusters of low adobe huts with thatched roofs and an occasional llama heard grazing on the sparse vegetation. Alfredo, always a fountain of the most interesting facts, told us that the population of the altiplano during the time of the Incas was substantially higher than it was today.

Often in towns or mining camps people would approach us wanting a ride. Driving through villages and even in remote places on the altiplano, people would try and flag us down for a ride. In one mining camp I came out of a miner's house and found an old Indian chap sitting in the back seat. He had really made himself comfortable, sitting in the exact center of the seat with a blanket draped over his lap to keep his hands and legs warm. I assumed he just wanted a ride back to the center of the camp. Upon arriving at the center of the camp he didn't get out. We ask the old fellow what he wanted. He wanted to catch a ride to Uyuni. We told him that we were going to Atocha. He said that destination was OK as well. After a while we felt that the country was filled with people who wanted to go someplace else, any place else, and our vehicle was the transportation of choice.

No matter how far we thought we were from civilization we would find people riding bicycles and freshly painted political slogans on rocks and walls, from the most recent election. Once we stopped to examine an abandoned quarry and some crumbling ruins near the railway tracks. The tracks disappeared into the horizon in both directions, but here came a guy on a bicycle, carefully peddling along a smooth four-inch-wide path that had obviously been used for years by other bicycles.

For years I had observed the overwhelming popularity of soccer in South America, but here in Southern Bolivia basketball appeared to rival it as the sport of choice. Almost every village had a sad looking soccer field, but also you would find a basketball court with a drooping, netless, rusted hoop. In the small village stores there even appeared to be more basketballs for sale than soccer balls.

Finally, approaching Atocha, we wound down into a canyon and then into a river bed laced with rivulets of water. In the trackless portions, we had to guess where the road was and were thankful for the 4-wheel drive. Eventually we encountered the reassuring railway running along one bank and, after scrambling over protruding rock formations in the bottom of the canyon, maneuvering around boulders, and turning up another canyon past a substantial graveyard, we spotted the little town of Atocha perched on the bank of the river. We drove through a final garbage-filled pool, up the bank, and into the town. We found an adequate little hotel on the town square just off the railway tracks that had doorways about five feet high and another Bolivian death switch in the bathroom. Our next order of business was to go looking for gas. Everyone we talked to said the gas station was up the river. We drove to the end of town without seeing the gas station and still people told us to go up the canyon. We drove down the bank into the river bottom and continued north, making our own road in most places. Finally all the houses disappeared and still there was no sign of a gas station. A fellow on a bicycle told us to go up river still farther. Finally in the distance, in the middle of nowhere, we spotted what looked like storage tanks. As we splashed closer we could see tire

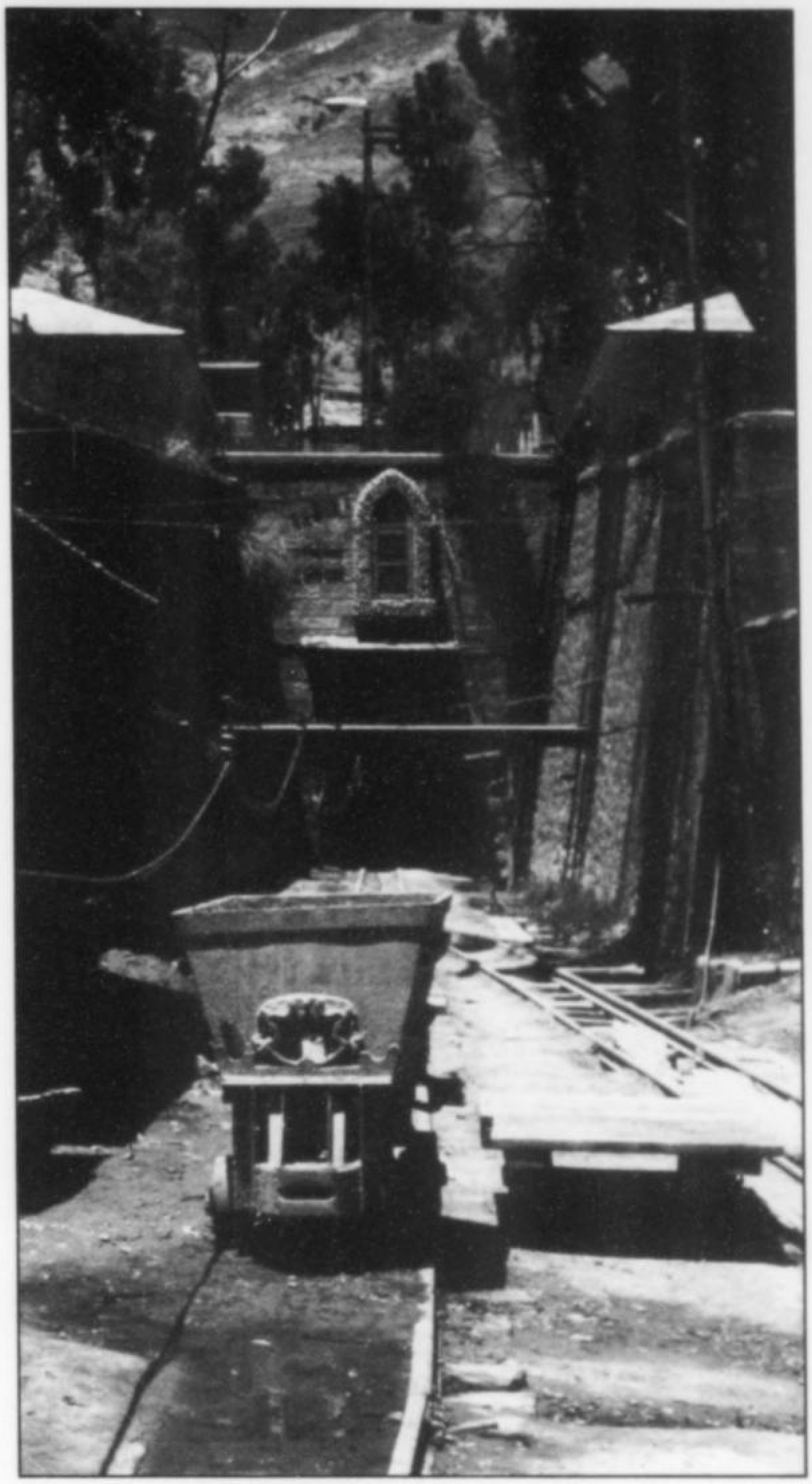

Figure 3. **The entrance to the Siglo XX ("20th Century") mine at Llallagua; this famous mine is now closed.**

Figure 4. **Alluvial workings at Llallagua.**

Figure 5. **Pyrite crystal group, from Tasna.**

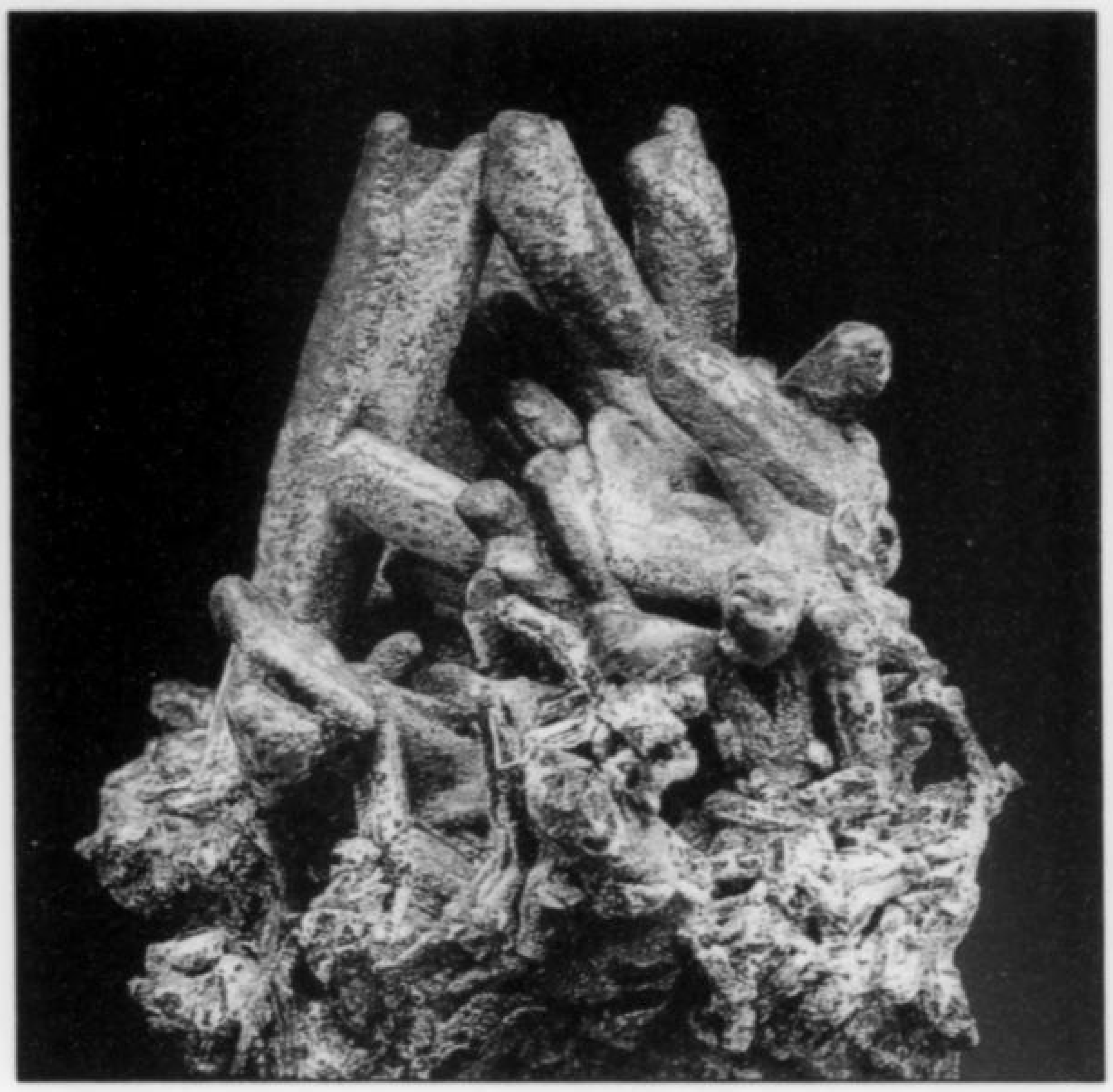

Figure 6. **Bismuthinite crystals (pyrite coated) from Tasna.**

tracks climbing the bank. We followed and sure enough as soon as we climbed the bank there was a storage depot, which actually had two electrically driven gas pumps. They were closed, however, and we were told to come back the following morning. Surprisingly, the cost of the gas was about the same as it was in Oruro or Cochabamba.

The next day we decided to visit the mines at Tasna which, according to Ahlfeld, is one of the world's greatest bismuth deposits. From the altiplano we climbed steadily; after more than an hour of steady climbing toward a mountain that looked somewhat like a reclining elephant, we reached the mines. The upper levels of the mine were worked by a cooperative like most of the other mines we visited; and they were currently involved in a dispute with COMIBOL over the cost of electricity that was supplied to them. At first we were greeted with suspicion, but soon we were able to buy some specimens from the many children who flocked around our car. The tension eased and soon their mothers were bringing specimens for us to buy as well. The problem was that almost all of the material was terrible trash, ranging from massive pyrite to water tumbled pieces of stream tin. We bought a few specimens of damaged siderite, pyrite and wolframite that showed promise. It became evident that to get any quantity of good

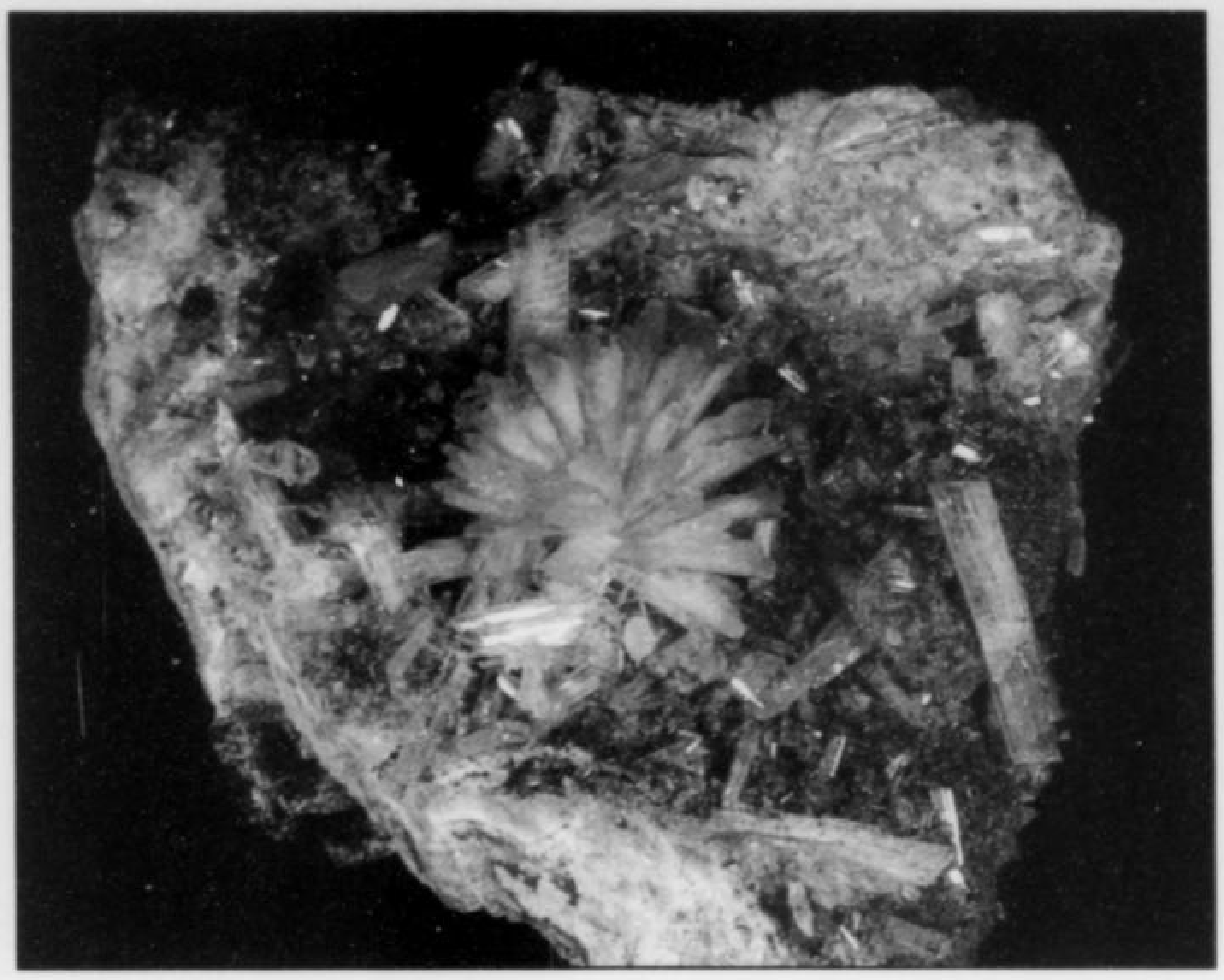

Figure 7. **Paravauxite with childrenite, 6.5 cm across, from Llallagua; Mark Bandy collection.**

Figure 8. **Vivianite with ludlamite crystals from Huanuni.**

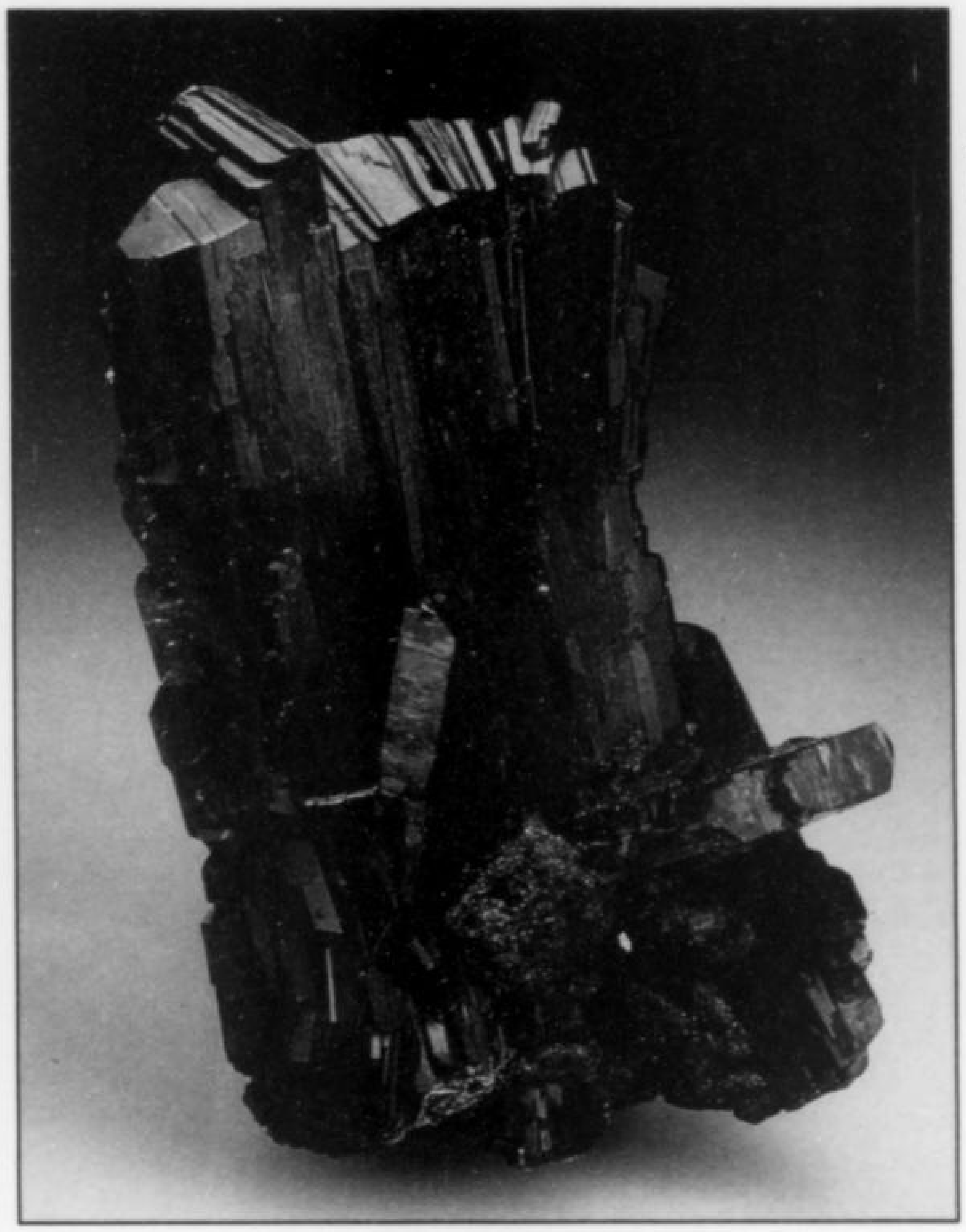

Figure 9. **Vivianite crystals on drusy pyrite from Morococala.**

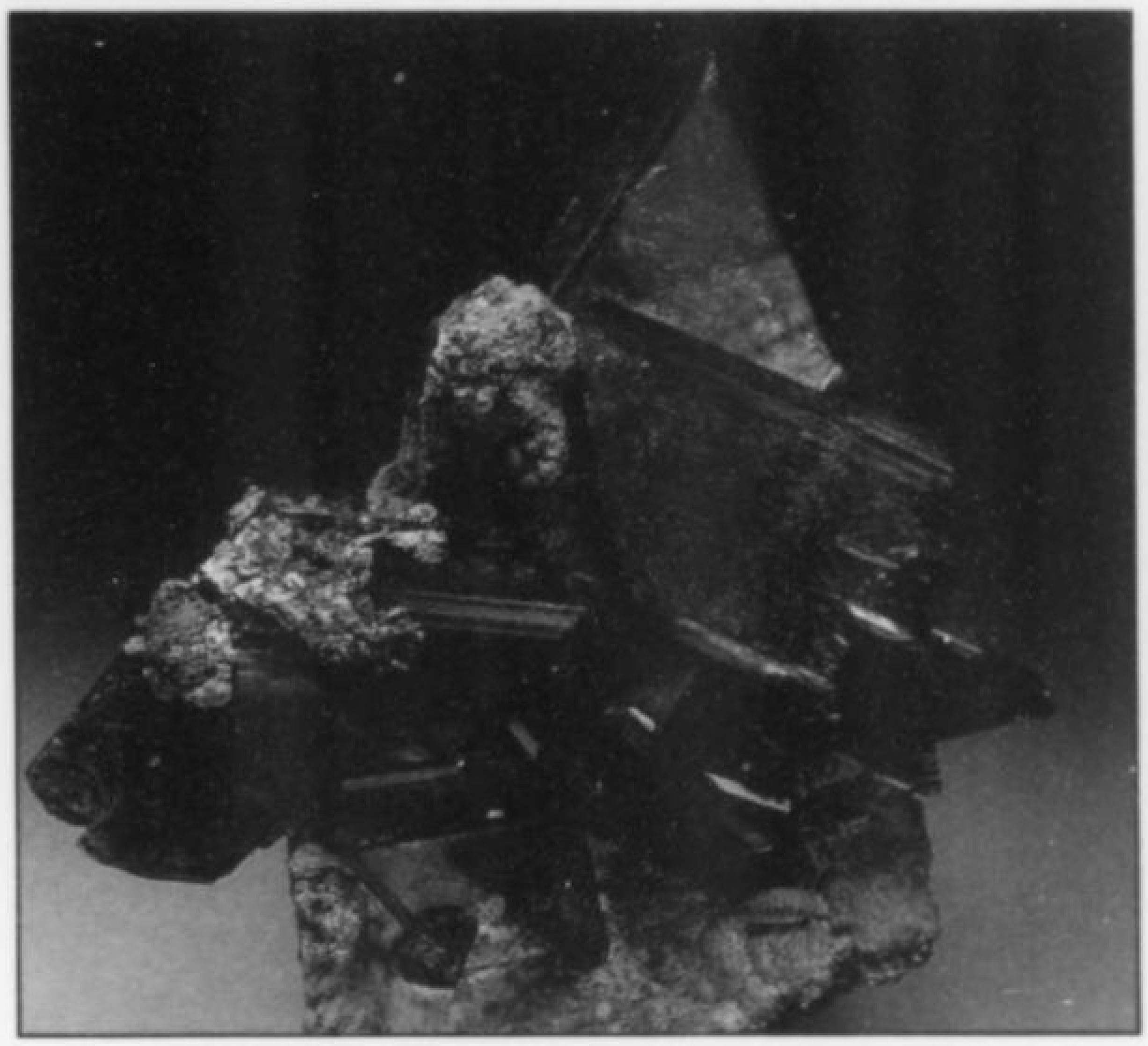

Figure 10. **Vivianite crystals on limonite and pyrite from Morococala.**

specimens from there, you would have to make many buying trips there to encourage the miners to carefully collect and preserve specimens. No one had any idea about wrapping specimens in paper to protect them. In fact, there was very little paper in the camp that one could use to wrap specimens. Another problem was that, during the day, most of the men were working in the mine and did not return home till near sunset. To deal effectively with the miners, you would have to wait till Saturday, or better yet, Sunday, or spend the night at more than 15,000 feet.

The best we could do was visit about one mining camp a day. Another day was spent in the mining camp of Chorolque. It was the highest I had ever been (18,000 + ft.). It was late spring and there were still traces of snow at some of the mine portals. In some of the mines frozen waterfalls had to be blasted out and removed to keep the tunnels open. Amazingly enough, the miners frequently rode bicycles between the mines and camp. Our reception here was nearly hostile, and we were immediately hustled to the offices of our cooperative, where we were asked what our business there was. A video camera was immediately produced and we were asked to explain again what we wanted. They said they had a local TV station and would like to broadcast the tape. Alfredo did his best to explain what we wanted while I showed a few specimens we had and showed how to wrap them up in newspaper. Alfredo explained how specimens are like flowers and if you wanted to give a flower to your sweetheart you would be careful not to step on it or damage it before you gave it to her. We hoped that the tape would be played on local TV, but suspected that, as much as anything else, they just wanted a record of exactly what we looked like. We saw few specimens in the camp worth having. There were a few interesting hollow cassiterite? stalactites however and we felt this mine too had potential but were reluctant to try and spend the night at 18,000 feet. In spite of lengthy explanations of the kinds of things we were looking for, people kept trying to sell us massive cassiterite.

We spent a day driving around some of the mines near Atocha; like Animas, and everywhere there were large, partially abandoned mining camps and abandoned mills, with huge tailing dumps poisoning the streams that trickled down the canyons. In Atocha, one night while eating dinner, we were approached by a man with a tape recorder who said he represented the local radio station. He also wanted an interview about who we were and why we were in town. Again, Alfredo did his best to explain how we wanted to buy mineral specimens and how they should be protected.

We finally realized that in the time we had left we could only scratch the surface of the mines in the district, and it would be better to move on to other districts and at least get a quick overview rather than spend all our time in one place. We managed to drive from Atocha to Potosi in one day, arriving at 10 p.m. The next day we found out that protesting railway workers had blockaded the roads into and out of town at midnight for a 24-hour period. We found ourselves in a blockaded city with all the gas stations and many businesses and government buildings closed for the day. In some ways it was ideal, because traffic was very light in the city and it was easy to get around.

Potosi is perhaps the most famous mining camp in the world. Back in the 1600's it was the largest city in the western hemisphere and had a population of about 250,000, a large number of churches, riding clubs, ballet companies etc. It's population is now only about 125,000 but at 13,500 feet has the distinction of being the highest large city in the world, substantially higher than Lhasa, Tibet. The city sits on the flank of Cerro Rico (Rich Mountain), that produced many fortunes of silver and allowed Spain to create all kinds of mischief in Europe. Today the only large mine that is operating is the Mina Unificada and it is so poverty stricken that it has taken up offering mine tours for tourists. The balance of the mines are being mined by small collectivos. On some of the city streets that lead directly to the mines, at the edge of town, are small shops that openly sell dynamite, blasting caps and fuse, all stacked neatly on the sidewalk in front of the stores.

Alfredo introduced us to a man he knew, who had decided that running around searching for mineral specimens was a better way to make a living than teaching school. He had a tabletop covered with grungy pyrite and siderite specimens and a poor lot of vivianites. I bought the lot and told him that I was buying it more to encourage him in the business than any other reason. He did not believe me till I started to throw the worst of the siderite and pyrite out on his patio and told him I couldn't afford to pay the freight back to the USA on such junk. This dealer had been trying to find specimens of phosphophyllite for a number of years without success. He had even advertised in the local newspaper, but miners had brought him every manner of blue and green rubbish they could find, but no phosphophyllite.

Gary badly wanted to visit the El Dragón mine, not far from Potosi, to see if he could find any of the rare selenium minerals that it was famous for. Time did not permit us to do this, but our runner said that visiting the mine would be useless because the portal had caved and there was absolutely nothing on the dump. He said, however, that he knew the owner of the mine and that the owner had about 100 kg of the mostly pure vein material, predominately krutaite, which he would be glad to sell for $70 per kg. We ordered 5 kg, carefully instructing him to look for material with tiny vugs with well-formed crystals, especially any colorful crystals which were likely to be the even rarer secondary selenium minerals. Our runner finally brought us the material late at night. Some Germans had told the mine owner that the material was dangerous and, thinking that it was radioactive, he had buried it in his courtyard. He could not remember where it was buried and had to hire two miners to excavate. They found the material but destroyed his patio in the process.

We were finally able to buy gasoline and drove on to Llallagua, where the police and the owner of the hotel told us that we should not park our car in front of the hotel, but in a locked parking garage. Even though the front of the hotel was not more than 100 feet from a police station, they worried that radical miners might put a stick of dynamite in it. There was a lot of unrest in town caused by the closure of the Siglo XX mine by COMIBOL. COMIBOL still had a caretaker staff watching many of the old mine buildings and mills but collectivos were intensively working many of the upper levels. Since the mill had been shut down, the miners had to make their own concentrates. Sunday afternoon we saw hundreds of men working to crush ore by hand, and using various kinds of primitive water-driven devices to separate the heavy cassiterite concentrates from the lighter host rock. Driving up one of the winding roads through one of the camps and the hundreds of primitive small concentrating facilities we felt a real tension in the air and had the feeling that some small incident could set off a real riot.

We were not able to buy a single specimen in Llallagua. Llallagua is a fairly large city and it is hard to find the miners. We thought it could be done, but it would take several days to find the miners who might have specimens. Here, we thought it would be a good idea to advertise in the local newspaper for specimens, if you had the time to arrange it.

On the way back to Oruro we stopped in Huanuni. We were told it was the only profitable mine run by COMIBOL. The pollution from the mill and raw sewage running into the little river that ran through the town was appalling. Many men and women were working in the sewage water in the river bottom, extracting cassiterite concentrates from the fines that the inefficient mill was dumping into the river. Many of the miners were reluctant to talk to us because the mine has strict regulations against collecting specimens. Huanuni has produced fine specimens of vivianite and other minerals, but to be successful in buying specimens here you would also have to spend considerable time cultivating the miners.

The following day we visited the mine of Morococala, which has produced so many fine vivianites. We were there the entire day and, little by little, were able to get the miners to start talking to us and selling us specimens. We were able to buy a good quantity of vivianite, most of which consisted of single or partial crystals which should be well-received by our customers. We were able to buy a handful of good matrix specimens, but nothing that would rate as spectacular. I had hoped to have these in time for the 1994 Tucson Gem and Mineral Show, but they did not make it in time.

Back in Cochabamba we did our laundry, sorted through our specimens and wondered if their sale would cover our expenses. We talked about various schemes to get the material out of the country and what to pack it in. One alternative that Alfredo suggested was baby coffins, which he said were not very expensive. He said that they were lined with Styrofoam and should make good packing boxes. Gary and I thought that once the minerals were unpacked on this end we could get some mileage out of them as ice chests or as boxes for Christmas presents for some of our sensitive liberal friends. We reckoned that you could be the baddest dude on any mountain with your very own Bolivian baby coffin ice chest. Gary departed for his home in San Francisco and I for Brazil and Peru.

Microminerals

by **Bill Henderson**

Inhibited Growth of Crystals

Crystals showing inhibited growth in particular directions are fascinating things. They are in some ways the opposite of crystals formed by dendritic growth, although the resultant crystal forms can be somewhat similar. One example is the "hourglass" form of gypsum, where the crystal is able to push away the sand or clay in which it is growing from certain crystal faces, but must encompass it in others. Finally, the opaque inclusions form an hourglass figure within the otherwise clear gypsum crystal, and trace the sizes and positions of the different types of faces as the crystal grew.

Much prettier (and formed by a different mechanism) are *trapiche* emeralds such as that shown in Figure 1. These crystals have a central core composed of an often tapered, columnar beryl crystal. Surrounding it like spokes of a wagon wheel are an additional six sectors of beryl, and between these sectors are areas of mixed composition; in the crystal shown, the mixture is mostly albite. The exact shape of the sectors, like those in the *chiastolite* variety of andalusite, varies from crystal to crystal, and along the length of a single crystal. The structure and mechanism of growth of these crystals, which have been found at the Peña Blanca mine near Muzo, Colombia, have been studied by Nassau and Jackson, who reported their results in a short paper in the *Lapidary Journal*, and in a more detailed report in the *American Mineralogist*. Briefly, their proposed mechanism for the formation of trapiche emeralds is as follows: First, the central, tapered core grows under hydrothermal conditions. Second, growth may slow or even stop for a while. Next, growth conditions change again, and both emerald and albite are formed. However, the hexagonal prism faces of the core crystal are able to maintain their uniform growth, producing pure emerald, while areas growing from the edges between prism faces are not, and are filled by albite. This results in six sectors of clear emerald, and six of predominantly albite and minor emerald. Thus, the central core and the six surrounding sectors of a trapiche emerald comprise a single, untwinned crystal.

There is a distinct difference between this type of growth and dendritic growth. The growth of these emerald crystals is from crystal *faces*. That of dendritic crystals is from crystal *edges and corners*.

The highly altered cordierite crystal from Kameoka, Kyoto Prefecture, Japan (shown in Figure 2) looks very similar to the trapiche emerald. Indeed, these crystals vary in pattern from crystal to crystal and along their length like the trapiche emeralds. It is tempting to conclude that they are formed by a similar mechanism. This example is a little more complicated, however. In the case of trapiche emerald, we are asked to accept that renewed growth occurs on the six faces of the hexagonal prism. Cordierite, however, is orthorhombic (although single crystals are often pseudohexagonal), and it can also twin to give pseudohexagonal forms. There are two possibilities, then. First, the six outer segments can be formed by renewed growth of a single, pseudohexagonal crystal by the trapiche mechanism on not one crystal form but two; the two faces of the pinacoid *b* and the four faces of the prism *m*. Second, the crystal shown could be the result of renewed growth of a complexly twinned core crystal.

Another example of crystals showing interrupted growth as above, but which results in a completely different crystal shape is the pyrite shown in Figures 3 and 4. This crystal and others like it came from the Westvaco mine in Wyoming, and were found imbedded in trona, from which they could be recovered by dissolving the matrix in water. They were described in 1971 by Pabst (1971), who showed by X-ray methods that the crystals are *not* twinned. Further, he showed that the striations on the projecting portions of the crystals do not meet at right angles at edges and do not have interfacial angles of the pyritohedron {210}, as do those of normal, striated pyrite. It is probable that these crystals too formed by the trapiche type of mechanism. That is, a normal cube formed; growth was interrupted; finally, further growth occurred, but only on the cube faces, and not the cube edges. The striations must project outward from places where complete coverage of the cube faces did not occur.

Thus far, we have dealt with three opaque minerals, the first two of which must be sectioned to show their internal structural variation. We will now examine two transparent ones, where the internal interruption of growth is visible.

The first is the corundum (var. *sapphire*) crystal from Badula, Sri Lanka, shown in Figure 5. Inside the crystal can be seen a series of voids or liquid-filled cavities forming a true, six-sided, three-dimensional hourglass figure, far better and more symmetrical than those seen in the two dimensional hourglass figures of gypsum. Each six sided step in the voids is bounded by six cavities, each of which appears to have four elongated sides joined at right angles; i.e., each is bounded by pinacoid and hexagonal prism faces. Again, it appears that, as the crystal grew, it was able to continue growth on its {$10\bar{1}0$} and {0001} *faces*, but repeatedly had trouble growing on the *edges* between the two forms. Why did it have no trouble growing on the edges between prism faces? The result, at any rate, is a truly beautiful thing. This, by the way, was the only one of two dozen spectacular Badula corundum crystals which showed the hourglass pattern distinctly. Another beautiful example with great crystal form and numerous inclusions is shown in Figure 6. These I obtained from Dick Gaines, a dealer who always has unique and interesting microcrystal material at reasonable prices.

The last example given is of colorless, transparent fluorite crystals from the Poudrette quarry, Mont Saint-Hilaire, Quebec. The interesting thing about these crystals (Fig. 7) is the opaque, off-white areas running from the centers of the crystals to the corners. There is an amusing little story in conjunction with these: Since the crystals have somewhat rough exteriors, I decided to apply a tiny amount of immersion oil with the same index of refraction as fluorite to the crystals to make the faces optically smoother, preparatory to photographing the inclusions. Behold, the "inclusions" disappeared! Rather than inclusions, the opaque areas were a series of hollows or voids which reach the surface of the crystals. On being filled with the oil, these were rendered optically homogeneous and, thus, invisible. It took a long time and repeated soakings in hexane to dissolve out the oil!

Here, then, we are looking at crystals which were able to grow very readily on their cube faces and edges, but were not able to grow on the cube corners, i.e. in the direction of the cube diagonals (see Figs. 8 and 9, which make clear the geometry of the voids within the crystals). However, the voids thus formed were not filled with some other mineral, but were left empty. It is interesting, too, that the voids are not parallel-sided, but appear as a series of cone-like hollows, each fitting into the large ends of the earlier ones.

Figure 1. **Trapiche emerald (beryl) from the Peña Blanca mine, near Muzo, Colombia. Diameter of crystal, 4 mm.**

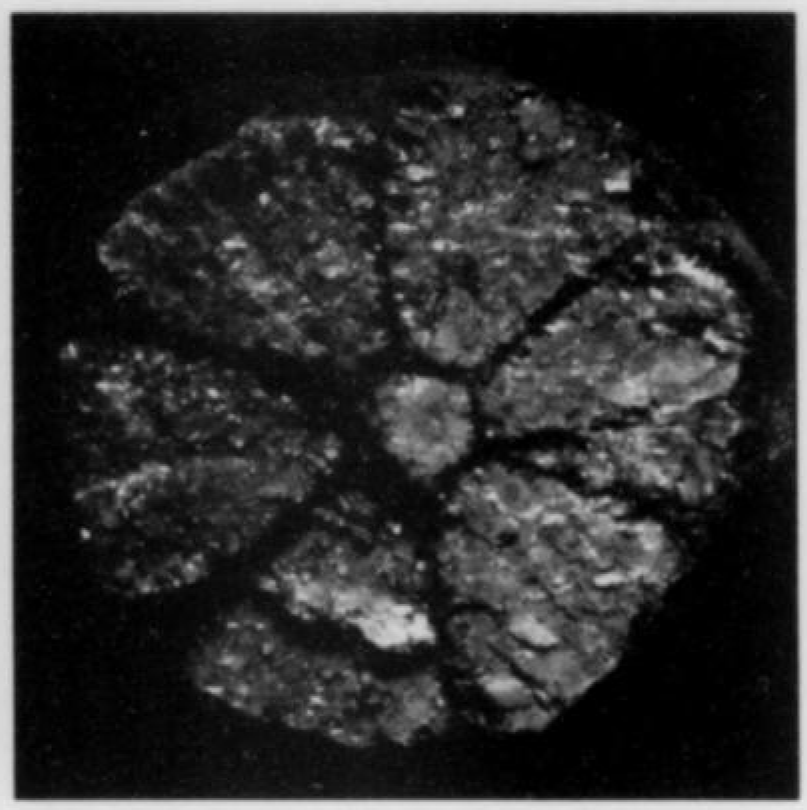

Figure 2. **Cordierite from Kameoka, Kyoto Prefecture, Japan. Diameter of crystal, 5 mm.**

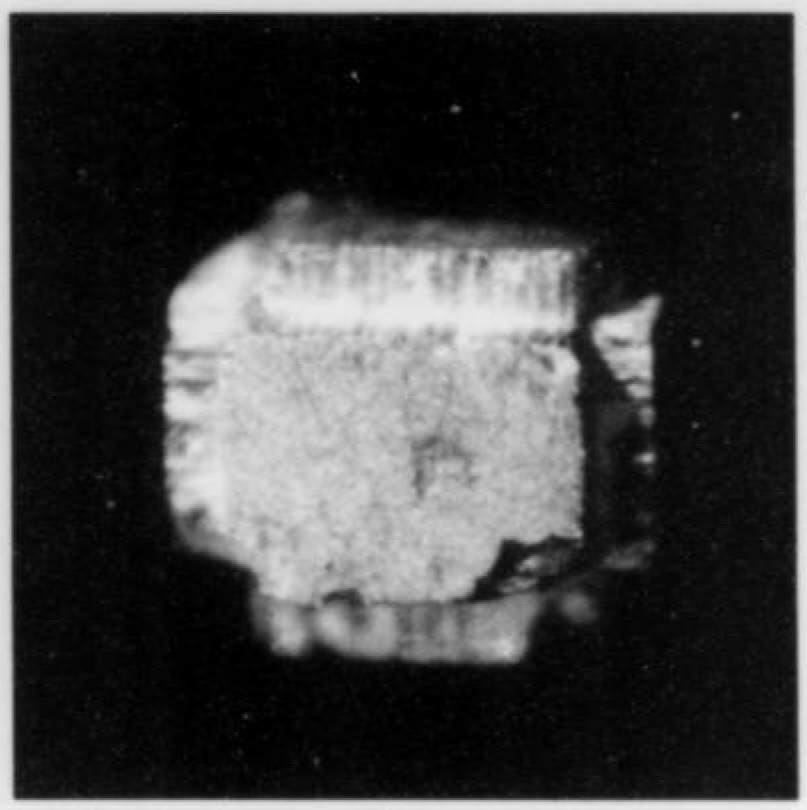

Figure 3. **"Triaxial" single crystal of pyrite, untwinned, ex-Neal Yedlin collection; 0.4 mm. From a drill core near the Westvaco mine, near Green River, Sweetwater County, Wyoming.**

Figure 5. **Sapphire crystal with hourglass phantoms, length 6 mm. From Badula, Sri Lanka.**

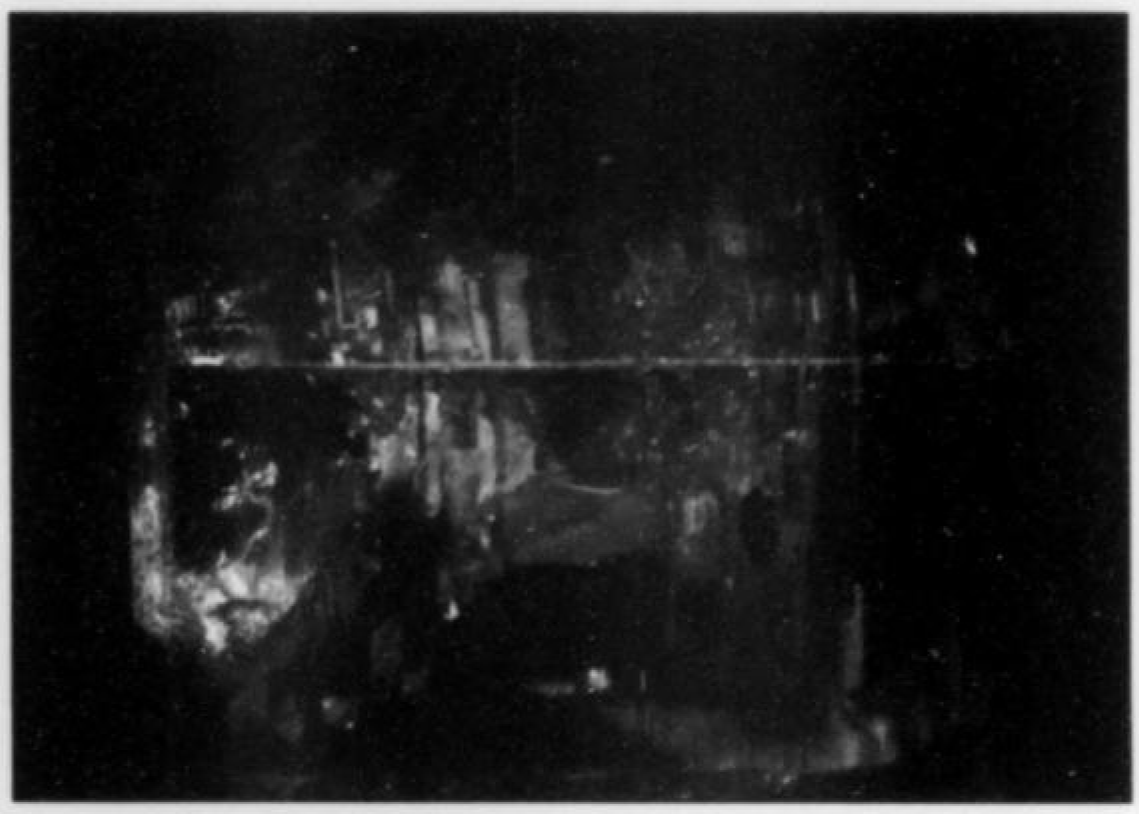

Figure 4. (below) **Sketch of typical "triaxial" pyrites as in Figure 3 *(above)*.**

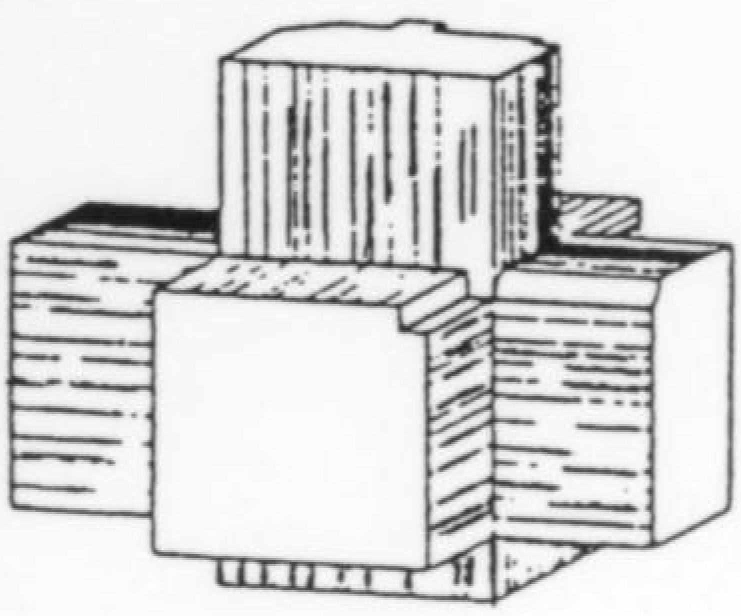

Figure 6. **Sapphire crystal with liquid and solid inclusions, from Badula, Sri Lanka. Size of crystal, 5 mm.**

Figure 8. **Typical fluorite crystal from Figure 7. Sketch by Garry Glenn.**

Figure 7. **Fluorite cubes with cone-shaped cavities running from the centers of the crystals to the corners. From the Poudrette quarry, Mont Saint-Hilaire, Quebec, Canada. Field of view, 1.3 mm. Collected by Charles and Marcelle Weber.**

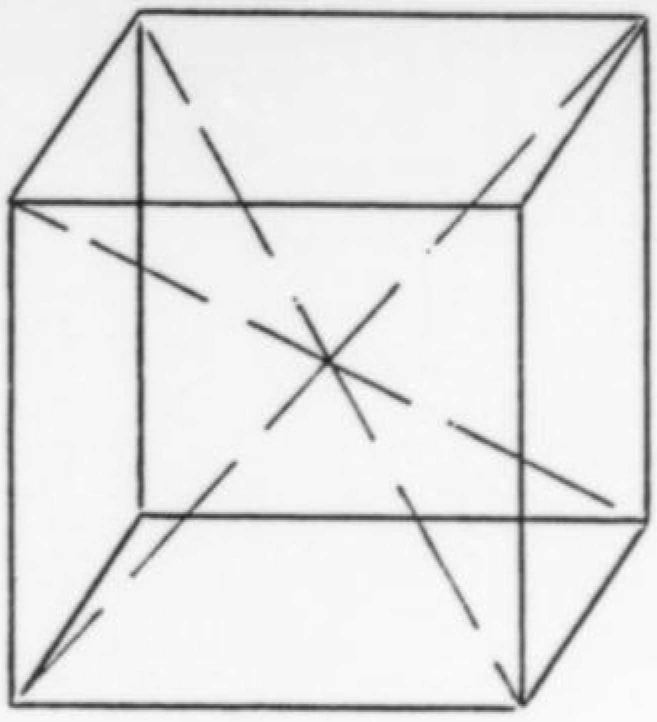

Figure 9. **Sketch showing cube diagonals along which hollow cavities of fluorite crystals in Figure 7 are aligned.**

A final question: Why is it that certain faces of some crystals such as these are unable to continue growing? It is well-known that trace impurities of many materials can drastically alter the shape of growing crystals. Addition of such materials can, on occasion, cause cubes to continue growth as octahedra, equant cubes to grow as whisker crystals, etc. They do so by forming thin, sometimes even undetectable, layers on growing faces, thus preventing or slowing further growth of all or selected faces. Adsorption of such impurities can occur at any time, but is more likely at a time when crystal growth has slowed or temporarily stopped. A good example of this phenomenon is the calcite formed epitaxially on the tips of the *c*-axes of earlier calcite crystals shown in Figure 10. When found, the large, earlier, rhombohedral crystals had a very thin coating of brown iron oxides on their surfaces. I removed the coating using sodium citrate/dithionite. However, the brown coating was retained between the earlier and subsequently formed calcite crystals. The following sequence is suggested: (1) the large, primary crystals grew; (2) growth stopped or slowed, and a thin coating of iron oxides formed on all the crystal faces; (3) formation of calcite began again, but the impurity coating allowed growth only at the extremities of the crystal *c*-axes (from the basal pinacoids), and not on other faces of the crystal. This phenomenon is frequently of critical importance in determining the forms and shape of growing crystals.

Figure 10. **Second-generation calcite epitaxial on first-generation calcite, and attached at terminations of *c*-axes. Field of view, 9 mm. From the Peske quarry, south of US Route 20, about 1 mile east of Raymond, Black Hawk County, Iowa. Collected by Ed Clopton.**

Crystals such as these are twice blessed; they are things of beauty, and they have an interesting story to tell. I hope readers will enjoy them as much as I have.

I thank Garry Glenn for his fine sketch of fluorite used in Figure 8.

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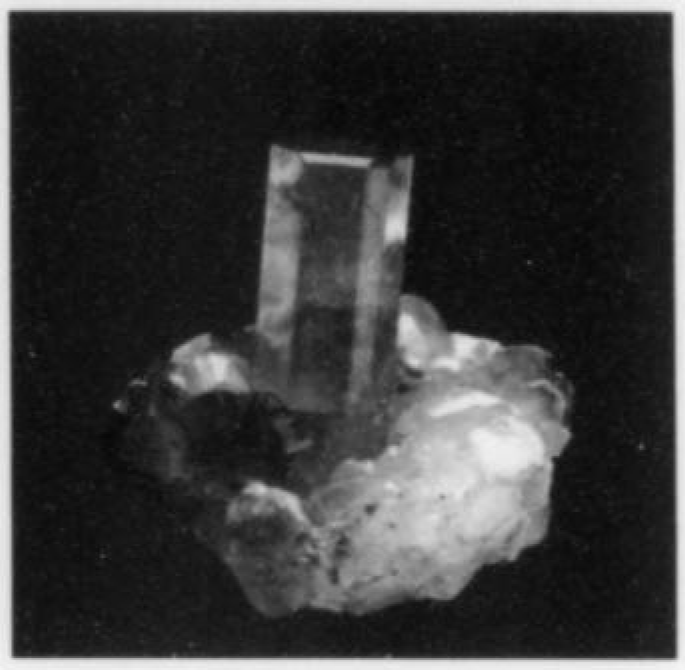

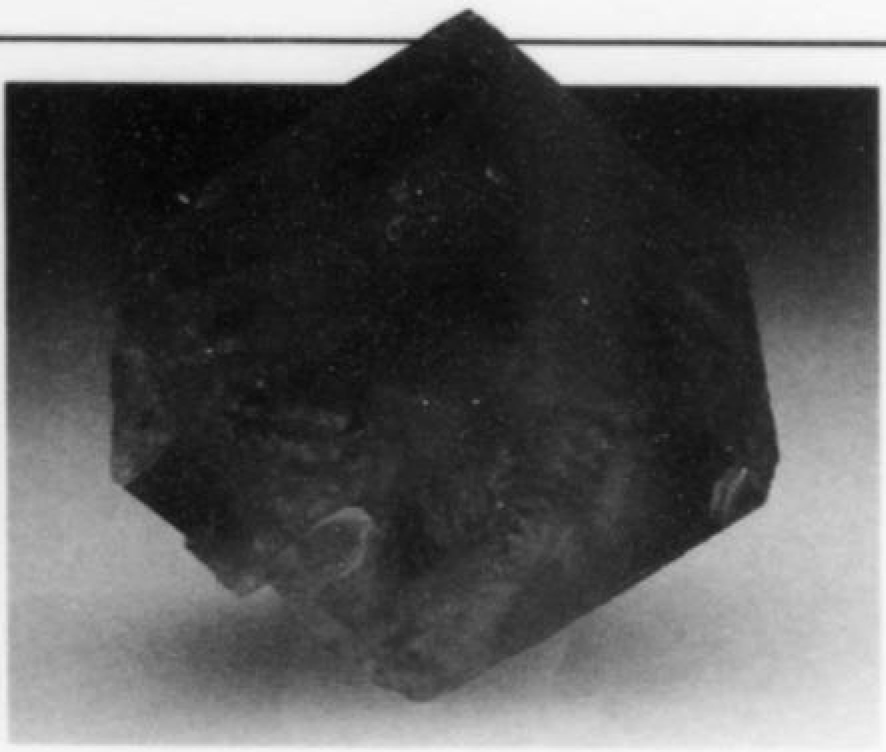


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Activities around the Country

"Publish or perish" applies not only to academia but to organizations. Newsletters are the life blood of groups with common interests. It might even be shown that membership fluctuates depending upon the effectiveness of such publications. Newsletters are also the glue which holds the FM membership together—the better the glue, the greater the togetherness. It is probable that members belonging to several FM chapters do so for the information in the respective bulletins.

The Indiana Chapter, its 59 members residing in six states, changed its name to the Midwest Chapter late in 1993. The chapter was well represented at the Pennsylvania Chapter's Symposium held in November 1993 at the Pennsylvania State University, under the leadership of Andrew Sicree, a newly elected FM Director. The Midwest Chapter places emphasis on field trips. In an effort to share the enjoyment of collecting mineral specimens with young people, the Executive Committee agreed to recommend that a local school teacher be invited to go along on a local field trip. Their meetings, held six times a year at the Indiana State Museum in Indianapolis or at various mineral shows, are open to the general public, but field trips to area mines and quarries are limited to FM members only or, on a one-time introductory basis, to prospective members. Dues are $15.00 for the first person in a family and $8.00 for additional family members, covering chapter and national dues and liability insurance. Applications may be obtained from Kim Greeman, 6447 Lafayette Road, Indianapolis, IN 46278. The Chapter President, Fred Lewis, has designed a new logo to reflect the new name.

The Colorado Chapter carries publishing to a level well beyond newsletters: they are discussing options for the printing of the new edition of *Minerals of Colorado*. Regina Modreski reports that "this awesome effort has been spearheaded by Gene Foord, and currently amounts to more than 1600 pages including a 201-page bibliography; it represents the work of many chapter members."

In July, members from the Pacific Northwest and the Colorado Chapters met in Butte, Montana, for the Butte Gem & Mineral Club's Annual Show, held on the Montana Tech College campus, home to the World Museum of Mining and the Montana Tech Mineral Museum. Over two dozen members and guests took part. John Cornish, Pac NW President, described events further: "The Butte Club for FM offered a mini-symposium in conjunction with the show for the first time this year. Three talks were: Pegmatites: New Finds in the Butte Area, PC Mine Japan-Law Twinned & Phantomed Quartz, and finally Butte Minerals."

The Pacific Northwest Chapter held its 5th Annual North Cascades (Washington Pass) Clean-up and Field Trip, Aug. 12–14. Although sixteen members and guests attended, Raymond Lasmanis wrote that the attendance was down; two of the FM officers could not attend because, as employees of the Dept. of Natural Resources, they were firefighting the record-setting forest fires—in fact there was a fire burning not far from the Klipchuck Campground, filling the valley with smoke.

Ray continues, "Saturday morning our clean-up plan fell apart as U.S. Forest Service staff were diverted to the fires. Eventually members headed out in the field to collect at the Silver Star pullout, Mile Post 164, and the base of Liberty Bell Mountain. The usual suite of minerals was found. The most significant discovery was made by Randy Becker with Lanny Ream: a fifth boulder was found to contain the very rare mineral calciohilairite. Chapter president John Cornish was also present and excavated smoky quartz crystals from the pocket. Everyone enjoyed comparing notes with Bob Boggs and Don Howard, two of the experts on the rare minerals of the Golden Horn Batholith.

"By Saturday afternoon we managed to contact the Forest Service and they supplied us with bags and gloves retrieved from fire camps. Instead of roadside garbage, they asked us to pick noxious weeds. Some took the opportunity to pick weeds during the cool evening while others spent Sunday morning pulling up tansy, knapweed and thistle. Some garbage was also collected including a mangled 30 MPH road sign." Their 6th Annual Clean-Up is scheduled for Aug. 11–13, 1995.

The Chapter's 20th annual Mineralogical Symposium, featuring calcite, was held September 23–25 at Tacoma, Washington. In addition to the talks, the symposium featured 18 display cases including a doubly-terminated, 175 pound calcite crystal from the Elmwood (Tenn.) mine. Symposium items including T-shirts and papers, may be ordered from Ray Lasmanis, 155-800 Sleater Kinney SE, Lacey, WA 98503.

Robert J. Smith of Seattle University was presented the group's Noble V. Witt Memorial Outstanding Service Award. He has served the chapter and the national FM for more than 20 years. The 21st Annual Mineral Symposium will be in Tacoma, Sept. 22–24, 1995.

The Southern California Chapter held a mineral symposium at the San Bernardino County Museum October 1 and 2. Their November meeting was held at the Pasadena Show and featured a symposium on gemstones of California. Robert Reynolds is the President.

The Great Basin Chapter held their Third Annual Symposium Oct. 15 and 16. An increase in attendance over the previous year and fund raising allowed a donation to the museum. They had a guided trip to Topaz Mountain in November. The group had initiated a project to describe the history and mineralogy of the Goodsprings District beginning with a trip to the Mount Potosi lead-zinc area. This project was prompted by the possibility that the area will soon be designated a Wilderness Area, closing it to public collecting. The area is thought to contain 200+ mines or prospects. Dues are $10; B. Hurley, 1917 Oakleaf Lane, Las Vegas, NV 89102, is President.

Jennifer Warnowsky, a graduate student at Temple University, received a 1994/1995 grant from the Memorial Fund of the Pennsylvania Chapter, to support her study of the mineralogy and petrology of the ultramafic body at Rt. 29 and Rt. 322, within the Pennsylvania piedmont, West Chester quadrangle. Her adviser is Dr. George H. Myer, Dept. of Geology. A paragraph from the abstract of her presentation in the chapter newsletter reads, "Oriented field samples were prepared for the microscope and X-ray diffraction analysis. Serial slices were cut for XRD purposes to study textural and possibly compositional influences on diffraction patterns. XRD preliminary data thus far indicates the presence of pecoraite, clinochrysotile, baumite and nepouite."

Roland Bounds was elected President of the Pennsylvania Chapter at a Board Meeting held January 15, 1995. The chapter's last symposium was held in October 1993 at Penn State. In the planning stages are a possible field trip in the spring, perhaps a swap in July, and a symposium on phosphates in West Chester in the fall. The chairman is George Rambo. Membership Chairman is Marge Matula, 1031 Honeysuckle Drive, Walnutport, PA 18088. Dues, which include national and chapter, are $10, or $18 for seniors over 62 and students.

The National Board Meeting was held at the Park Inn, Tucson, on Friday morning, February 10. The 1994 officers were re-elected: Karen J. Wenrich, *President*; Richard W. Thomssen, *Vice-President*; Nelson Shaffer, *Secretary*; and Michael Kokinos, *Treasurer.* Newly elected Directors were Joe Marty (Utah), Regina Aumente Modreski (Colorado), Robert Reynolds (California), Credo Schwab (Florida), Andrew A. Sicree (Pennsylvania) and re-elected, Peter J. Modreski. Directors until February 1996 are Arlene Handley, Michael Kokinos, Kay Robertson, Arthur Smith, Nelson Shaffer, Richard W. Thomssen, and until February 1997, Joel Bartsch, Beau Gordon, Mike Groben, Van King, Marcelle H. Weber and Karen J. Wenrich.

An FM Dealers Association was discussed at the 1994 Directors' Meeting, such dealers being willing to extend a discount to FM members. At least 15 dealers were listed in September, and the project, under Beau Gordon, was in effect at the Denver Show.

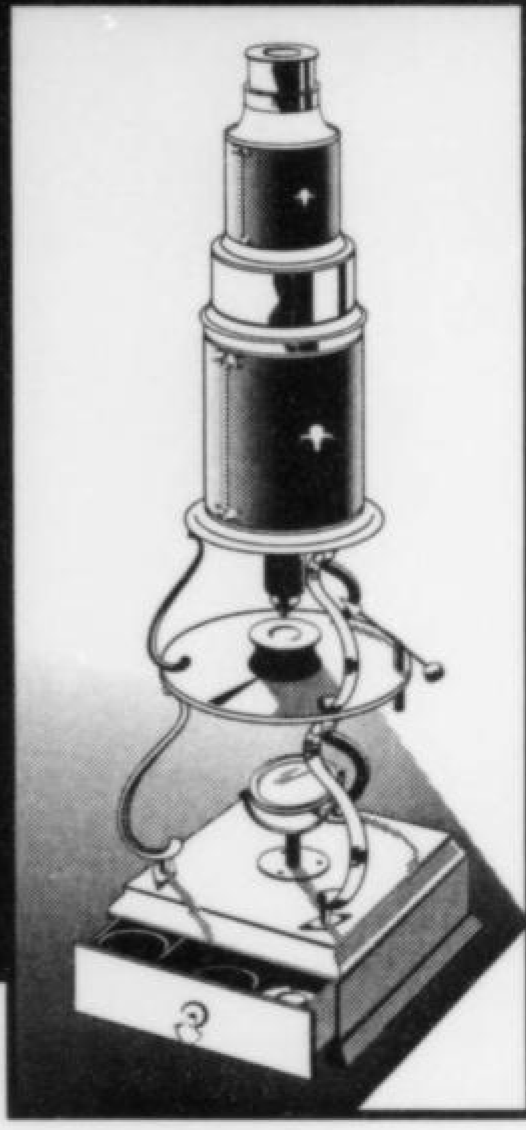
The FM social hour, inaugurated at the Denver Gem & Mineral Show in September, was repeated in Tucson. The affair was held 5:00–6:30 p.m., Wednesday, Feb. 8, at the Executive Inn, hosted by Martin Zinn and sponsored by the Arizona Mineral & Fossil Show and the FM Dealers Association. Mr. Zinn will also host an information reception for FM at the East Coast Gem & Mineral Show, August 12, 1995, in West Springfield, Massachusetts. The FM Annual Meeting was held February 11 at the Convention Center, Turquois Ballroom, 5–6:00 p.m.

Werner Lieber, FM member from Heidelberg, Germany, has honored Friends of Mineralogy with a donation of $1,000 which will be used for a special fund or project. Werner Lieber is one of the world's finest mineral photographers and is the author of numerous books and mineral calendars.

The 1994 Best Article Award for the *Mineralogical Record* was won by "The history and apparatus of blowpipe analysis" by Ulrich Burchard (vol. 23, July–August). Karen Wenrich presented the author with a "Certificate of Award," and contributed $200 to the Mineralogical Record in his honor.

Photo by Harold and Erica Van Pelt

The Gemmary



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What's New in Minerals?

Tucson Show 1995

by Thomas Moore

[February 1–12]

As "Tucson week" approached, I was plotted against perniciously by that Pacific Child, the weather-causing "El Niño" phenomenon, which by its devious methods sent a howling blizzard to hit the Providence, Rhode Island airport just at my scheduled takeoff time. But I dodged the storm by flying out twelve hours earlier from Bradley International in Hartford. Arriving in Tucson in the wee hours, I felt, in the silky balm of the air and the temperatures in the 70's, that I'd evaded the evil after all, to keep my date with good minerals and good mineral people. It was the mariachi band, free beer and snacks, and more weather-balm in the form of a soft starry sky over the Sunday night party at the Executive Inn which next made me think of the Ice Age still unfolding back home. So I dedicate this report, or at least this smirking first paragraph of it, to my hard-snow-shoveling wife and kids, who paid the price back in Connecticut for being non-mineralogical sorts (though otherwise fine human beings).

Once again I have to report a fairly modest profile for the show, as measured by the index of show-stopping new finds in large quantity. But it was good enough to inspire this, the longest and most heavily illustrated Tucson Show Report to date! Tucson is a phenomenon so huge, international and diverse that it's *always* engrossing for its many fine smaller discoveries, rare classics and one-of-a-kinders, and scattered debuts of books, periodicals, mining lamps, computer programs and carved lizards and things, and for good society, rumors, gossip and lore . . . and this isn't even counting the gem-business and fossil-trade colonizations of twenty or so hotels all over town, which presences manage somehow to contribute their own hums and buzzes to the scene's pleasantly manic ambiance. But readers of the *Mineralogical Record* don't need to hear still more hype for the Phenom; you'll want to start in on the mineral feast right away. As last time, I'll mix the courses, bringing out dishes seen at the Main Show and motel shows. Wendell Wilson and Jeff Scovil both also circulated about, taking pictures of specimens, including a few which never crossed my own path.

First onto the table, then, are some appetizers from Arizona. The new **vanadinite** locality on which I reported from Denver, the Pure Potential mine, Silver district, La Paz County, is already starting to justify its name by producing some fine hopper-growth vanadinite crystals in stacked groups of 2 or 3 cm and as loose singles to over 2 cm. *Arizona Minerals* (tel. 602-840-5552 or 602-831-9176), the source of these, also had some Pure Potential vanadinite specimens as described from Denver, with small, bright red hexagonal prisms blanketing variously sized matrixes. Although the newer, loose crystals haven't yet been taken alive on matrix, they make very impressive

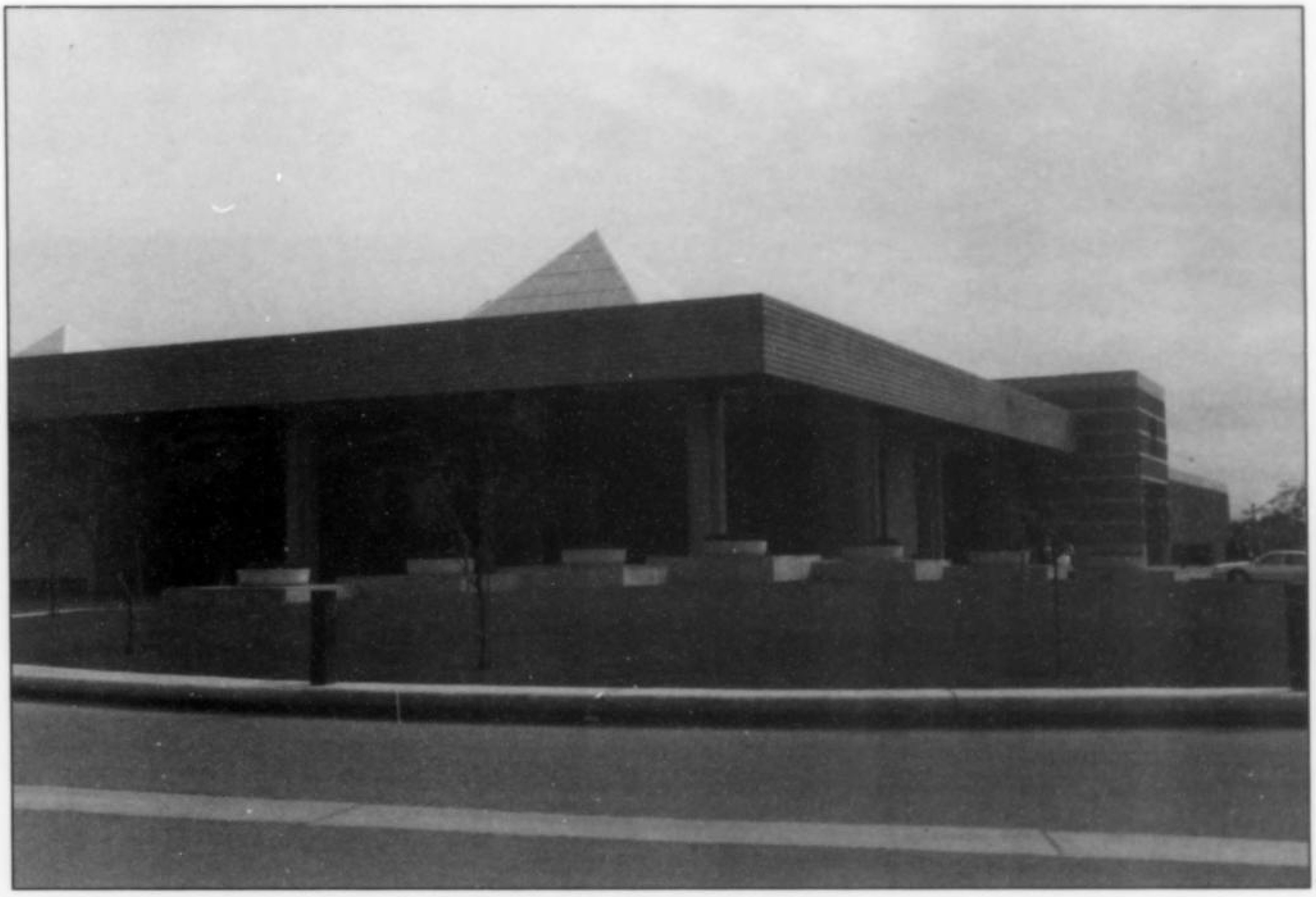

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Figure 1. **Tucson Convention Center.**

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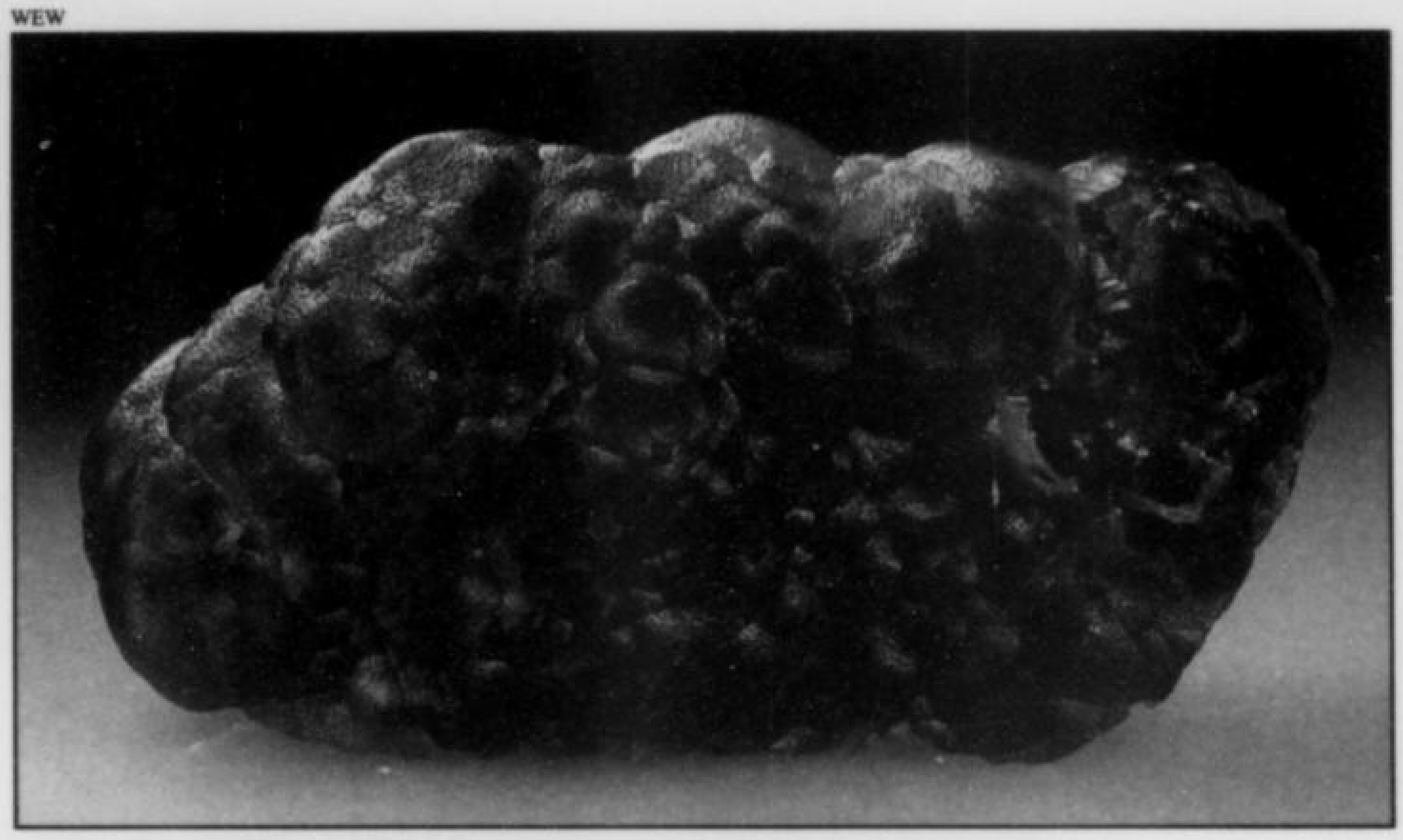

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Figure 2. (above) **Smithsonite, 7 cm, from the 79 mine. Dick Morris collection.**

Figure 3. **Chalcanthite, 2.3 cm, from the Planet mine, La Paz County, Arizona. Jeffrey Mining Company specimen.**

Figure 4. **Topaz crystal group, 4.3 cm, from the Thomas Range, Utah. Utah Mineral and Fossil Company specimen; Jeff Scovil photo.**

Figure 5. **Rhodochrosite crystals, 3.9 cm and 2.2 cm, from the Sweet Home mine near Alma, Colorado. Collector's Edge specimens.**

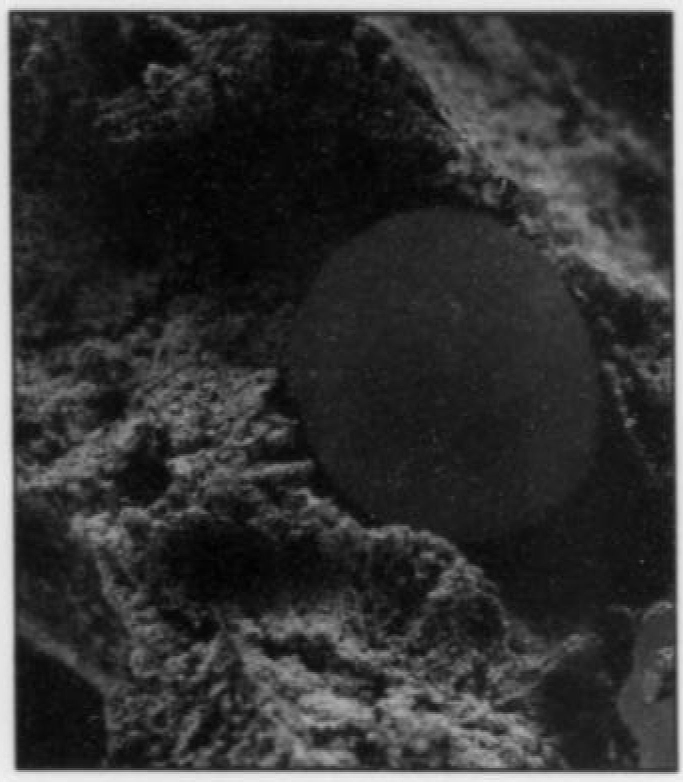

Figure 6. **Hemimorphite sphere, 1.4 cm, on matrix, from the 79 mine, Arizona. George Stevens specimen; Jeff Scovil photo.**

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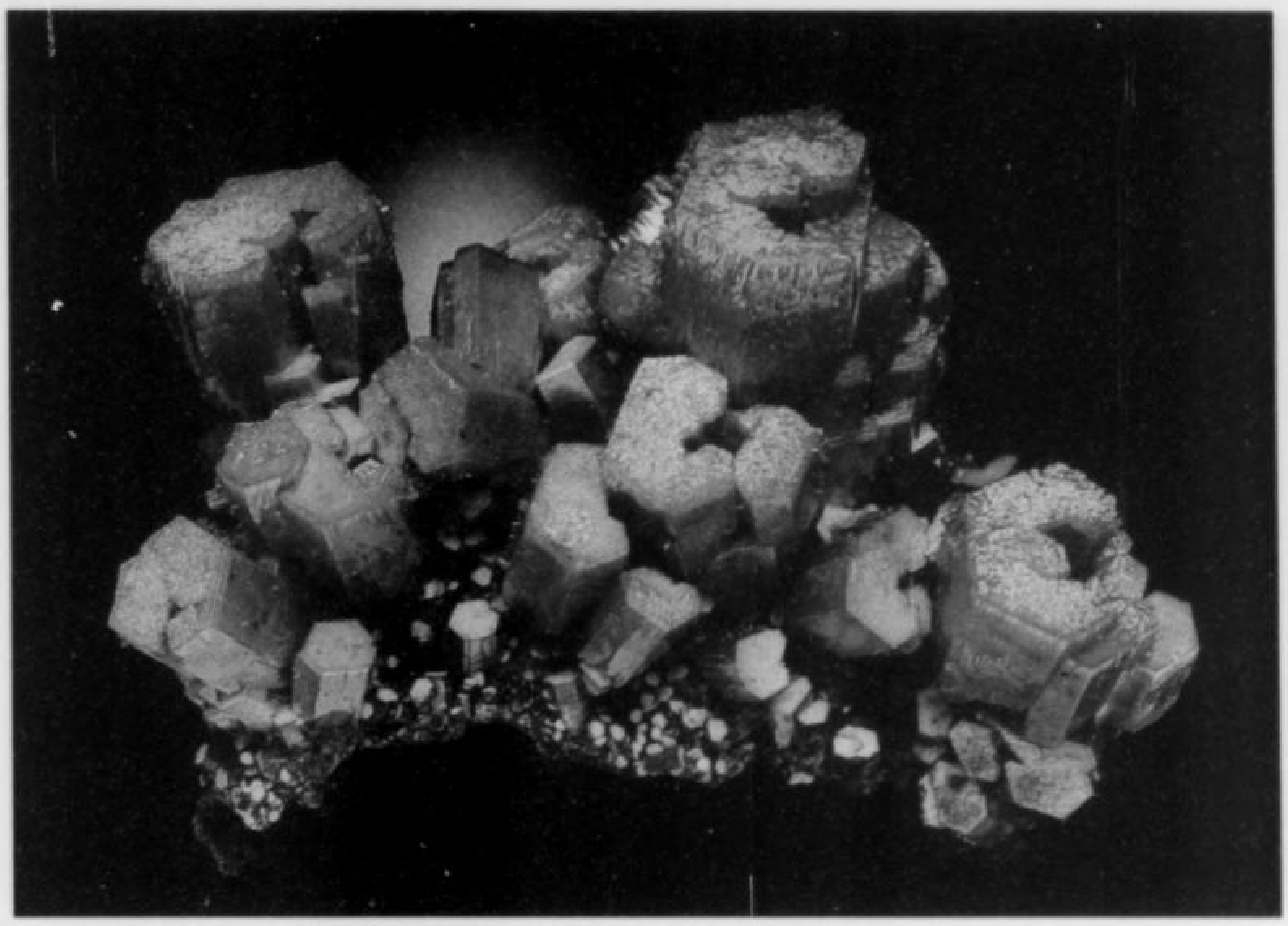

Figure 7. (above) Pyromorphite crystal group, 8.2 cm, from the Bunker Hill mine, Kellogg, Idaho. Wayne Thompson specimen; Jeff Scovil photo.

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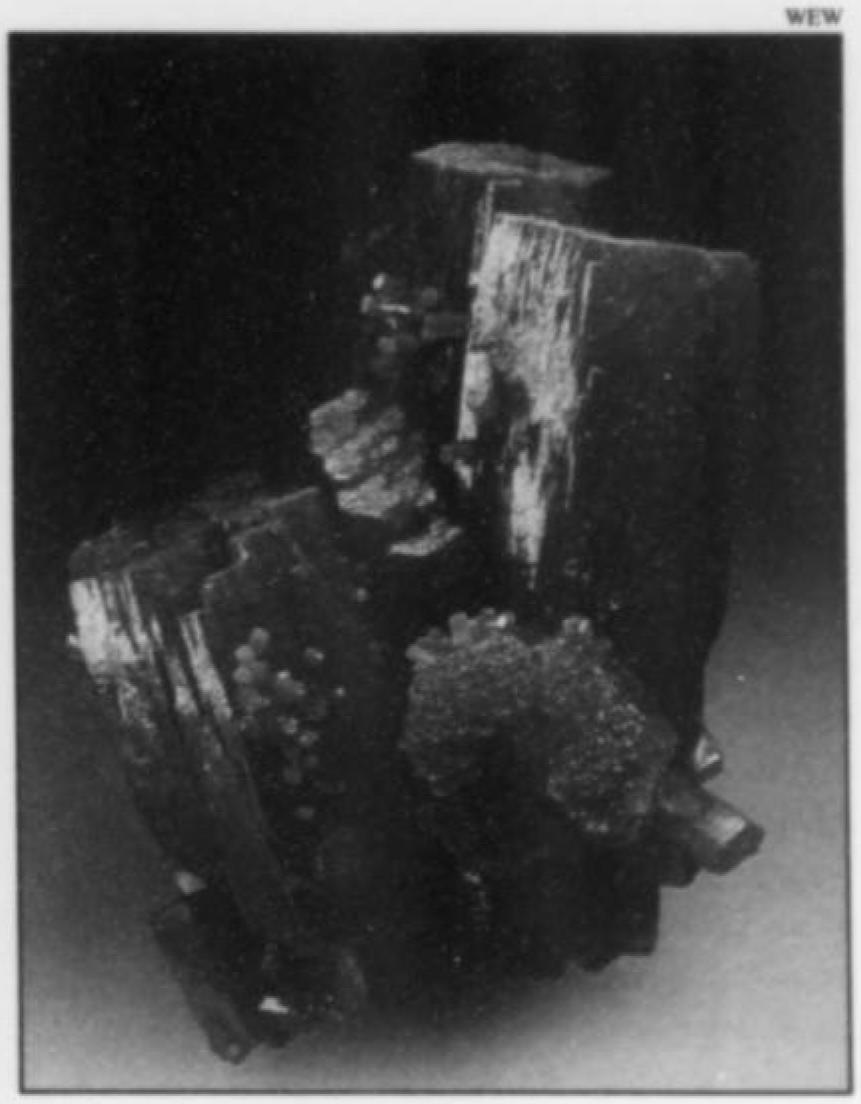

Figure 8. **Pyromorphite crystal group, 4.2 cm, from the Bunker Hill mine, Kellogg, Idaho. Dick Morris collection.**

Figure 9. **Pyromorphite crystal group, 10 cm, from the Bunker Hill mine, Kellogg, Idaho. Wayne Thompson specimen; Jeff Scovil photo.**

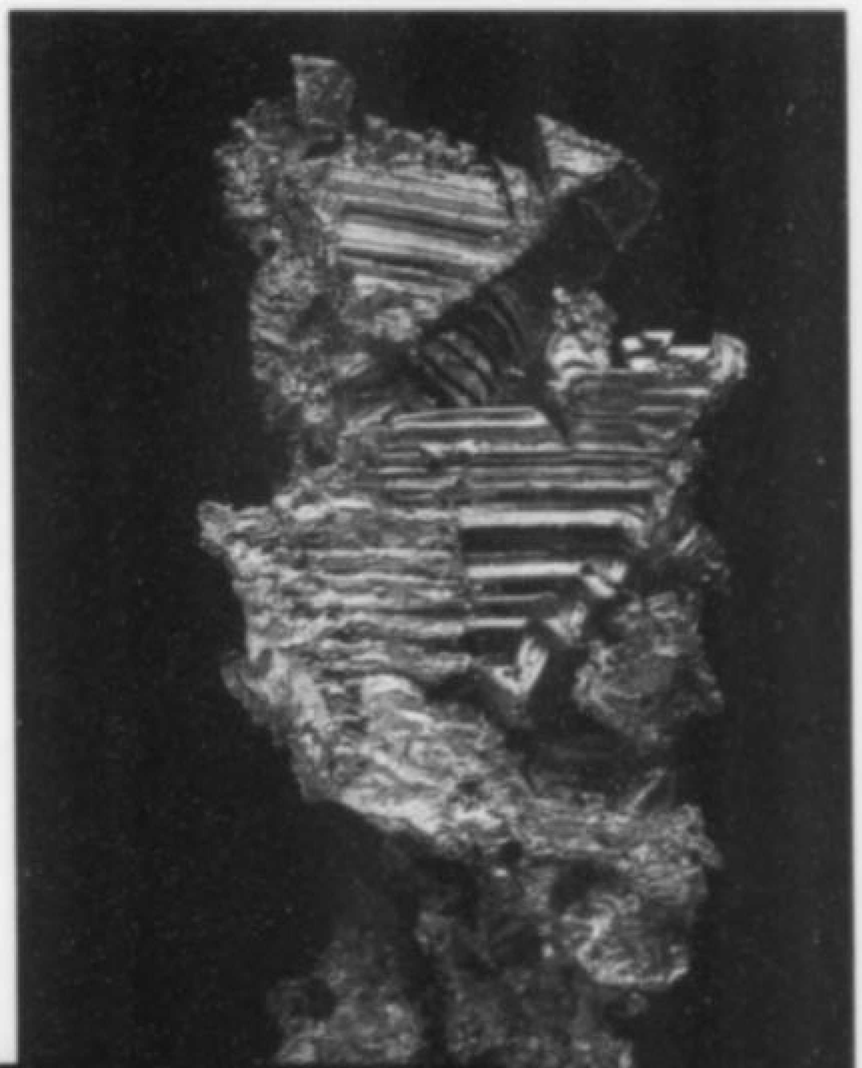

Figure 10. (above) **Gold crystal group, 6.9 cm, from the Colorado Quartz mine, Mariposa County, California. Collector's Edge specimen; Jeff Scovil photo.**

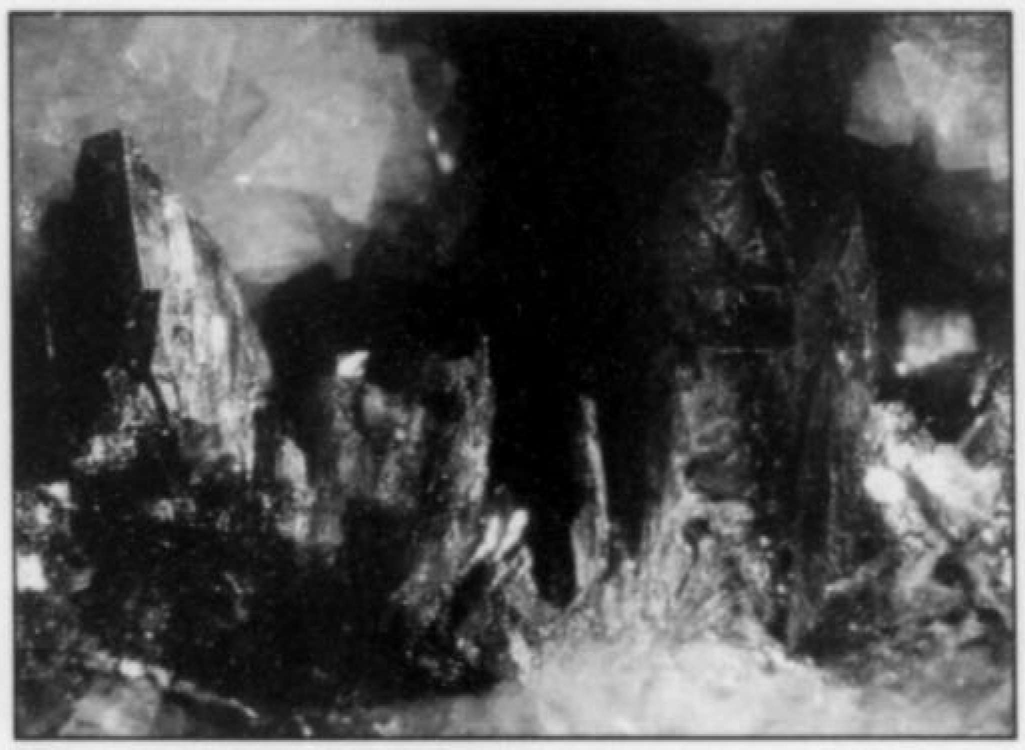

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Figure 11. **Rodalquilarite crystals to 4 mm from the Wendy pit, El Indio gold mine, Coquimbo department, Chile. William Pinch collection.**

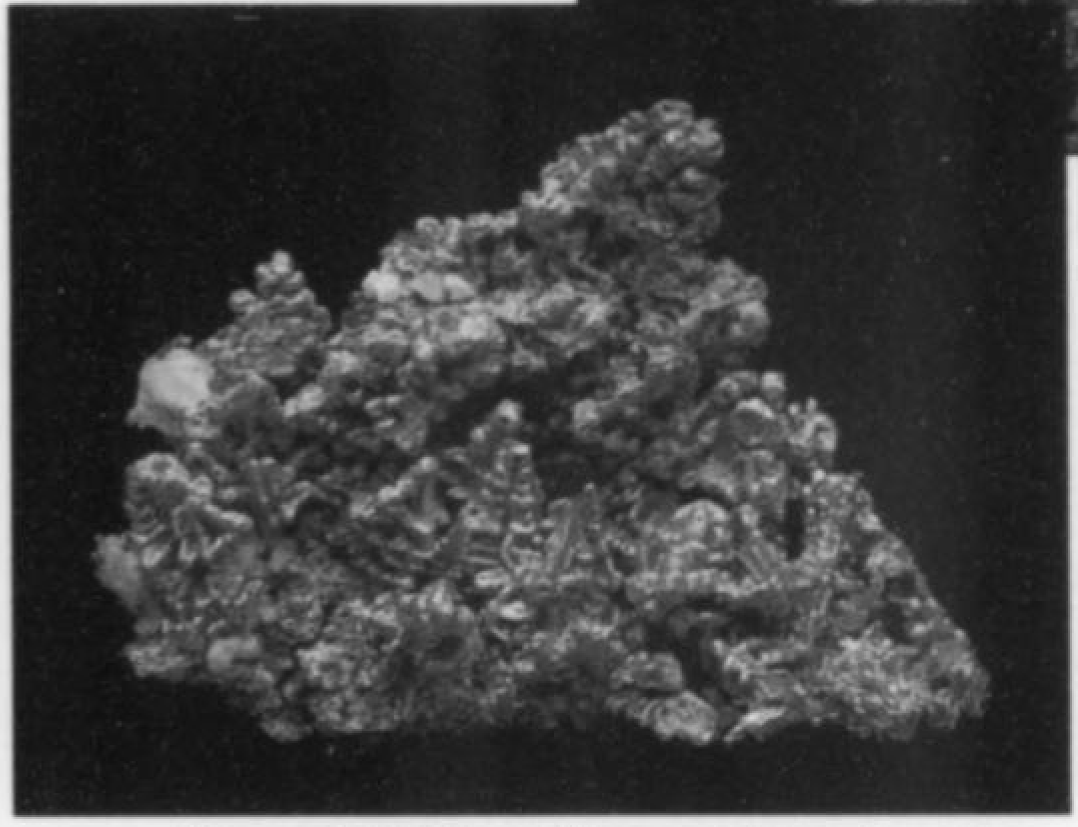

Figure 12. **Gold crystal group, 8.8 cm, from the Colorado Quartz mine, Mariposa County, California. Collector's Edge specimen; Jeff Scovil photo.**

thumbnails. "More work is proceeding . . . maybe next summer . . . ," says George Godas.

Jim Vacek of *49er Minerals* (1903 N. 74th St., Scottsdale, AZ 85257), in his room at the La Quinta Inn, had a couple of flats of nice thumbnails of **sphalerite**, **galena** and combinations thereof on **johannsenite** matrix, from the Iron Cap mine, Graham County, Arizona (see Wendell Wilson's article in vol. 19 no. 2). This was by far the greatest number of pieces from this locality I'd yet seen in one place. The sphalerite crystals are internally a lovely gemmy green, but resinous brown on surfaces; to get them to show off you have to coax them with fairly strong backlighting. But clean, sharp, twinned sphalerites can reach 2 cm. The slightly pitted, pale gray galena cubes that often share the matrix with them are interesting as well. A very nice thumbnail of this material could be had for around $30.

Bob and Maudine Sullivan (3202 Saguaro West Trail, Tucson, AZ 85745), ensconced in their usual room at the Desert Inn, had a nice surprise in the pseudomorph department. You've seen the humble, off-white, opaque, chisel-shaped pseudomorphs of **calcite after glauberite** from Camp Verde, Yavapai County, Arizona; well, the Sullivans had about 10 floater clusters of these averaging 6 or 7 cm across, and colored *sky-blue* by copper staining (one alone is medium green, presumably from malachite). These were found in the late 1950's, and reportedly are the only ones yet discovered.

And that was not all from Arizona, where collectors seem to have been particularly busy this past year. The famous 79 mine yielded the finest botryoidal apple-green **smithsonite** that it has ever produced. George Stevens (who had a room at the Executive Inn) and Malcolm Alder (who was set up outdoors at the Texaco Station near Congress Street) had many flats of specimens, the best of them looking virtually identical to good Kelly mine smithsonite except for the bright green color. George also had some fine, deep sky-blue hemimorphite from the same locality.

Jeffrey Mining Company had many flats of some of the most beautifully colorful minerals at the show: a strike of pure blue ramshorn **chalcanthite** from the Planet mine, La Paz County, Arizona. The thumbnails, miniatures and cabinet specimens, all with contrasting white matrix, were very reasonably priced and appear to be quite stable (unlike the post-mining crystals which tend to turn powdery and crumble).

One hesitates to say more than has already been said about the spectacular **topaz**, **red beryl** and **bixbyite** specimens from the Maynard claim in the Thomas Range, Utah. But John Holfert of *Utah Minerals & Fossils, Inc.* (P.O. Box 515583, Dallas, TX 75251-6583) had a roomful of wonderful pieces. Besides, he would like to pass on the likelihood that you'll hear sometime soon about *octahedral* garnets with epitaxial topaz from here, as well as about some rare phosphates and arsenates (besides durangite), including probably some new species. Meanwhile, his gemmy brown-orange topaz crystals in rhyolite vugs are quite as gorgeous as ever, and his bixbyite-cube-on-altered-garnet combos are as oddly appealing, and this time I saw the best miniatures I've yet seen of the large, gray, sandy topaz crystals rendered that way by blizzard-like inclusions of tiny bipyramidal quartz crystals. Some of these groups measure 5 x 5 cm, bristling with sharp, doubly terminated topaz prisms.

John Holfert has also been busy lately at the Calumet iron mine near Salida, Colorado, and was offering excellent, bright, loose striated blocky crystals of **epidote** from this place, as well as some large, handsome epidote groups to 12 cm across.

But say the word Colorado these days and folks at once crave their update on **rhodochrosite** production at the Sweet Home mine, Alma; as hardly needs saying by now, this specimen-mining project is being run by Bryan Lees of *Collector's Edge* (P.O. Box 1169, Golden, CO 80402). Recall that at the time of the last Denver Show a new pocket complex, the "Corner Pocket," was just beginning to show its stuff. Well, the stuff, debuting at the Main Show in Tucson this year, turns out to be very clean, razor-edged, gemmy rhodochrosite rhombohedrons of a bright red-pink color. Because the crystal size is most often around 1–2 cm, and they're so beautifully sharp and gemmy, lots of fine thumbnails have resulted from this strike—the first time in the project when this could be said of a single strike. On these thumbnails, the transparent pink rhombs, when not alone or in loose groups of two or three, sit lightly on needle quartz prisms, and often the matrix features also good sharp, brilliantly metallic black tetrahedrite crystals to 5 mm. Of course, some larger specimens of this type, with plentiful rhombs spread about the matrix, are also available. And showgoers seemed gratified especially to find that prices on these very vivid, bright specimens were lower than might have been expected: top-notch thumbnails ranged from $150 to $400. Nor is this paragraph even over. Beginning on the day after the Denver Show closed, a new pocket zone on the 2nd crosscut, about 30 feet in from where a big strike was made in 1926, turned out to be noble enough also to earn a name—the "Collector's Pocket." A vuggy zone with a total diameter of 8 feet produced clean, gemmy rhombs, not quite as lustrous as crystals from the Corner Pocket but more deeply rose-colored, reaching 4 cm on edge. Lightly sitting on quartz/tetrahedrite crystal matrixes, and quite often virtually damage-free, these crystals make superlative miniature and cabinet-sized specimens—and even *their* prices (though generally four-figured) seemed low, all things considered. The rosy epilog is that there will now surely be a 1995 collecting season at the Sweet Home, although plans extend no further than that.

It is a fact that compulsive flat-shuffling in the Executive Inn room of *Tom Wolfe Minerals* (P.O. Box 9791, Fountain Valley, CA 92728-9791) is always a pleasure, as Tom continues to have good supplies of (especially) western U.S. minerals. Highly noteworthy this time are about a dozen thumbnails of **grossular** garnet from the skarn deposit at Havila, Kern County, California: bright, lustrous, medium orange-brown dodecahedron/trapezohedrons to 2 cm, translucent to almost gemmy, either as loose clusters or on matrix, with an average price of $20.

From Oregon, something *really* new, as in "first mined late last week," showed up with *Dave Bunk Minerals* (9240 W. 49th Ave., #317, Wheat Ridge, CO 80033). It is pale brownish yellow, pearly-translucent **calcite** in very sharp, simple rhombs to 3 cm on edge, from near McMinnville, Yamhill County, Oregon—about 20 flats' worth. These pretty "butterscotch" rhombs cluster together, not too intimately, in a dark gray basalt scoria, and sometimes rest there on seam linings of white drusy analcime crystals. There are a couple of huge specimens about 30 cm across, but all sizes graced Dave's sunny terrace. A typically good, clean miniature with sharp, 2-cm rhombs might go for around $25.

It seems that the renowned Jersey vein of the Bunker Hill mine, Kellogg, Idaho, likes to yield up its very best **pyromorphite** pockets every 100 feet or so as work proceeds. That at any rate has been the pattern for about the last 15 years, despite rumors, now and again, of cessations of operations. Last October/November the blind pyromorphite date showed up on schedule, and turned out to be blindingly good: very large groups of cavernous crystals of typical form but of a color uncommon (for this mine for this crystal habit)—bright yellowish orange, and lustrous, and *big*, with individual barrels reaching 3 x 4 cm. Groups come in all sizes, and were to be found mostly with Wayne Thompson (1723 E. Winter Dr., Phoenix, AZ 85020), whose very best are a few majestic 25 x 25-cm pieces.

I learned still more about Dixie phosphates this year, when again I noticed some very attractive (*without* a microscope) seam-lining crystallizations from Alabama. Their handler, as before, is Beau Gordon of *Jendon Minerals* (P.O. Box 6214, Rome, GA 30162-6214). The Red Ball mine, Calhoun County, Alabama, was once a source of iron for Confederate cannon, and now is a source of colorful **strengite**, **cacoxenite**, **beraunite**, and **kidwellite** in earthy brown "bog iron" matrixes. Then, within the extensive Indian Mountain complex of

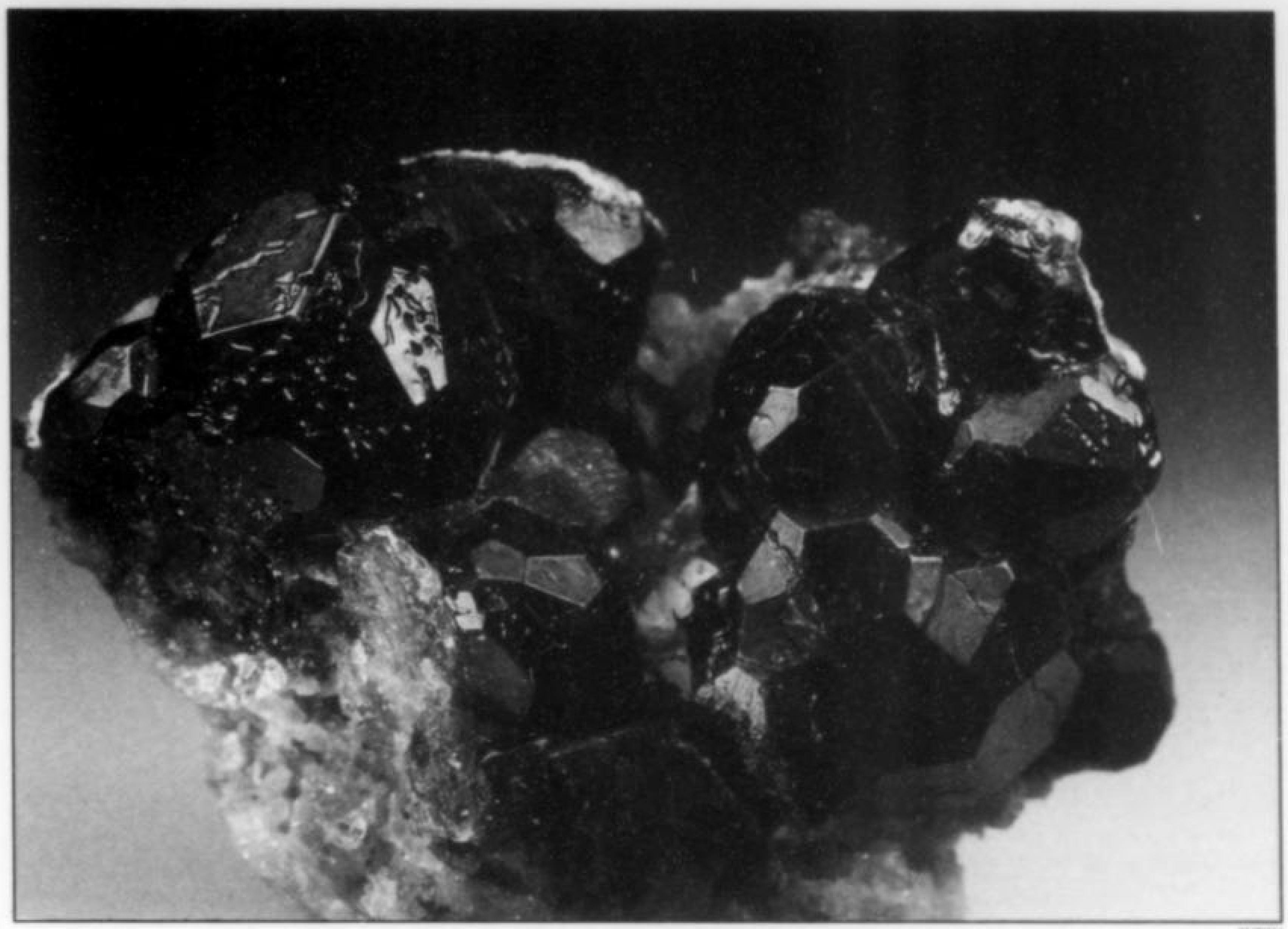

Figure 13. **Spinel crystal group, 4.7 cm across, from near MacDonald Island, Northwest Territory, Canada. Brad Wilson specimen.**

altered pegmatites in Cherokee County, a new dig called the Fault Line Prospect has yielded sparkly pale green seam linings of microcrystals of kidwellite, lavender strengite in radial balls to 4 mm, and some beautiful deep green sprays of acicular rockbridgeite to 6 mm. In various other Indian Mountain prospects there occur kidwellite pseudomorphs after small dufrenite crystals, and fine medium-purple strengite balls to 5 mm on dark matrix, resembling those from Svappavaara, Sweden. And at Augusta Ridge in Cherokee County (*not* part of Indian Mountain), a paler purple and duller-lustered but larger (to 8 mm) radial strengite occurs. In general these are nice-looking specimens even when the matrix is cabinet-sized and individual phosphate-species crystals remain microscopic: it's the sparkling busyness of pastels all over the blackish brown lumps of matrix that turns the aesthetic trick.

I come now to an important What's New, early whispers of which I'd heard at Denver but whose prolific reality filled three display cases and many flats in the La Quinta room of Casey Jones and Jane Koepp of *Burminco* (128 S. Encinitas Ave., Monrovia, CA 91016). It's a geochemically promiscuous suite of well-crystallized copper and copper-iron sulfide minerals, including the best **chalcocite** found anywhere in the U.S. for a very long time (since Bristol, Connecticut's heyday perhaps); the locality is the Flambeau mine near Ladysmith, Rusk County, Wisconsin. [Ed. note: an article is in preparation on this occurrence.] This is a high-grade copper deposit, confirmed by core drilling in 1968 and now being actively mined. Last year, at a depth of about 80 feet on the western half of the 2,600 x 550-foot open pit, mining breached a rich supergene enrichment zone with many pockets containing the crystallized sulfides, as well as malachite/azurite, arsenopyrite, and minor native copper, gold and pyrite. "Ore extraction will be completed in approximately four years, at which time the site will be returned to pre-mining natural conditions," affirms the flyer. Meantime, Casey and Jane collected chalcocite specimens in the summer of 1994 (hence the whispers at Denver), and more and better ones from another pocket zone in late December. There is a diversity of colors and habits of the chalcocite. Rarely, pseudohexagonal, slightly rounded discoid tabs reminiscent of old Cornwall specimens occur in stacks to 3 cm high; iridescent black crystals of this type may also be sprinkled singly over iridescent microcrystallized bornite. Usually, though, the chalcocite comes as fatter, more equant crystals to 1 cm, and these are not black but a brassy dark yellow from thin, somewhat rough coatings of chalcopyrite. Then there are chalcocite crystal groups coated with midnight-blue iridescent bornite, and occasional complete pseudomorphs of bornite after chalcocite. Finally, chalcopyrite occurs in mammillary, dark bronze-brown "blister" specimens, which may be pseudomorphed to bornite, which in turn may show later sprinklings of brilliant black pseudohexagonal chalcocite crystals. The best single specimen I saw (though reportedly John Barlow had already made off with a still better one) is a sharp prismatic cruciform-twinned 2.5-cm chalcocite crystal standing straight up, with smaller ones at the base, the whole thing bright bronze with the chalcopyrite coating. The price on this last-named piece, it must be said, was in the low four figures, but prices do drop off exponentially, with relieved sighs from all and sundry. The hundreds of thumbnails, in whatever style, are choice acquisitions for around $20 to $30. Casey and Jane intend to return to the supergene zone "very soon," before bench blasting proceeds beyond it, and they aspire particularly to get some good malachite this time, but more fine sulfides would also suffice, and certainly are not unreasonable to hope for.

California **gold** was once again available in superb specimens, mostly from the Eagle's Nest mine, from Wayne and Dona Leicht (*Kristalle*). However, rumors had been circulating before the show that the old Colorado Quartz mine was once again yielding specimens as good or better than any in its history. Jeff Scovil tracked a couple of these beauties down (measuring 6.9 cm and 8.8 cm of solid, crystalline gold in the rounded octahedral habit characteristic of the locality) at *Collector's Edge* and photographed them to show here.

Might as well step a bit further north, now, for the usual quick look at matters Canadian. There is a new black **spinel** (thin backlit shards are a very deep blue) from "near Macdonald Island," Northwest Territories, in the far Arctic North, a thousand miles from the nearest road. Collected last summer by Brad Wilson, the specimens are groups of blocky-elongate, dull greenish gray diopside crystals to 4 cm studded with spinel in complex, rounded isometric form-combinations to 7 cm. All sizes of these dignified-looking things were being sold by

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Figure 14. **Boracite crystal, 4 mm, in matrix, from the Bamberg saline deposit, Germany. Michel Jouty specimen.**

Figure 15. **Anorthoclase crystals to 3.1 cm showing a pronounced "schiller" or "moonstone" effect, from the La Pili mine, near Camargo, Chihuahua, Mexico. Miguel Romero collection.**

Figure 16. **Albite-encrusted sodalite crystals, 4.2 cm and 3.9 cm, with yellow calcite, from Mont Saint-Hilaire, Quebec. Gilles Haineault specimens.**

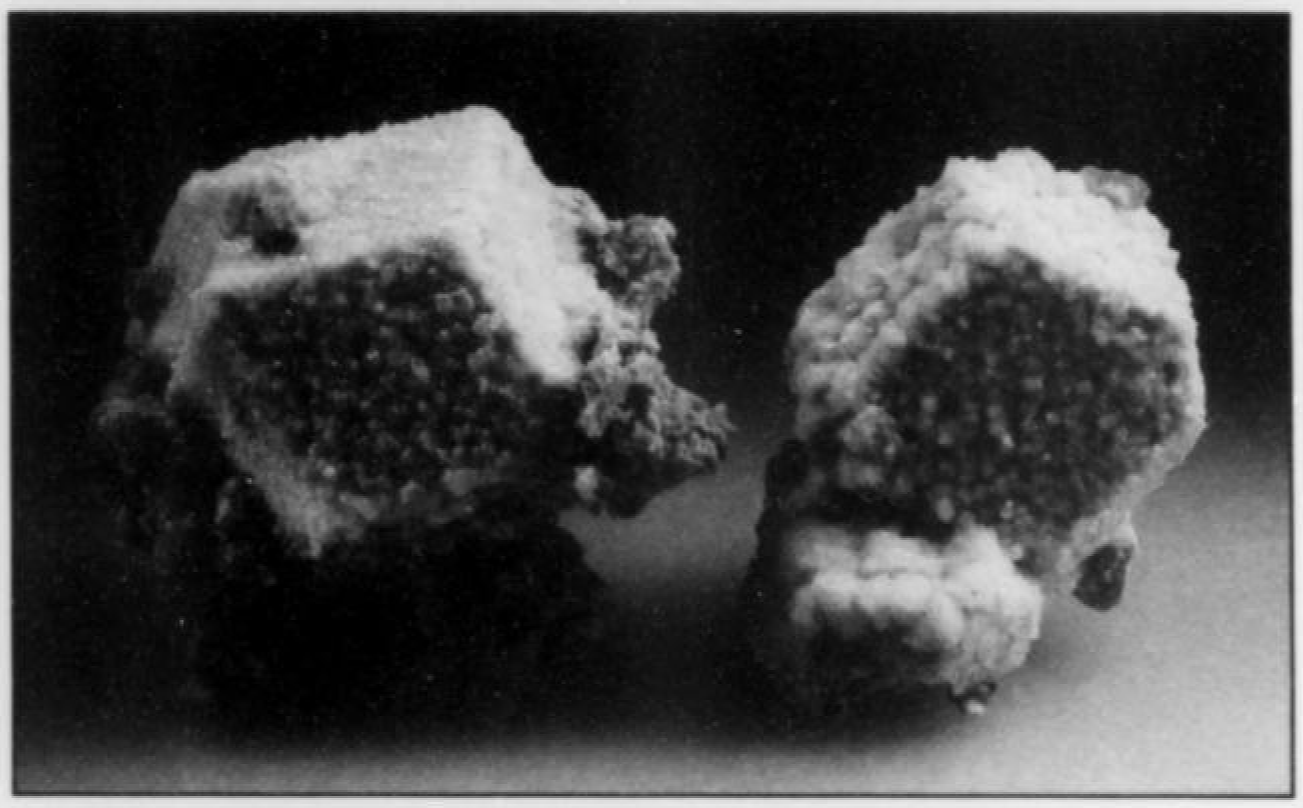

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Figure 17. **Grossular crystals to 1.2 cm from Sierra de las Cruces, Coahuilla, Mexico. Mike Bergman specimen; Jeff Scovil photo.**

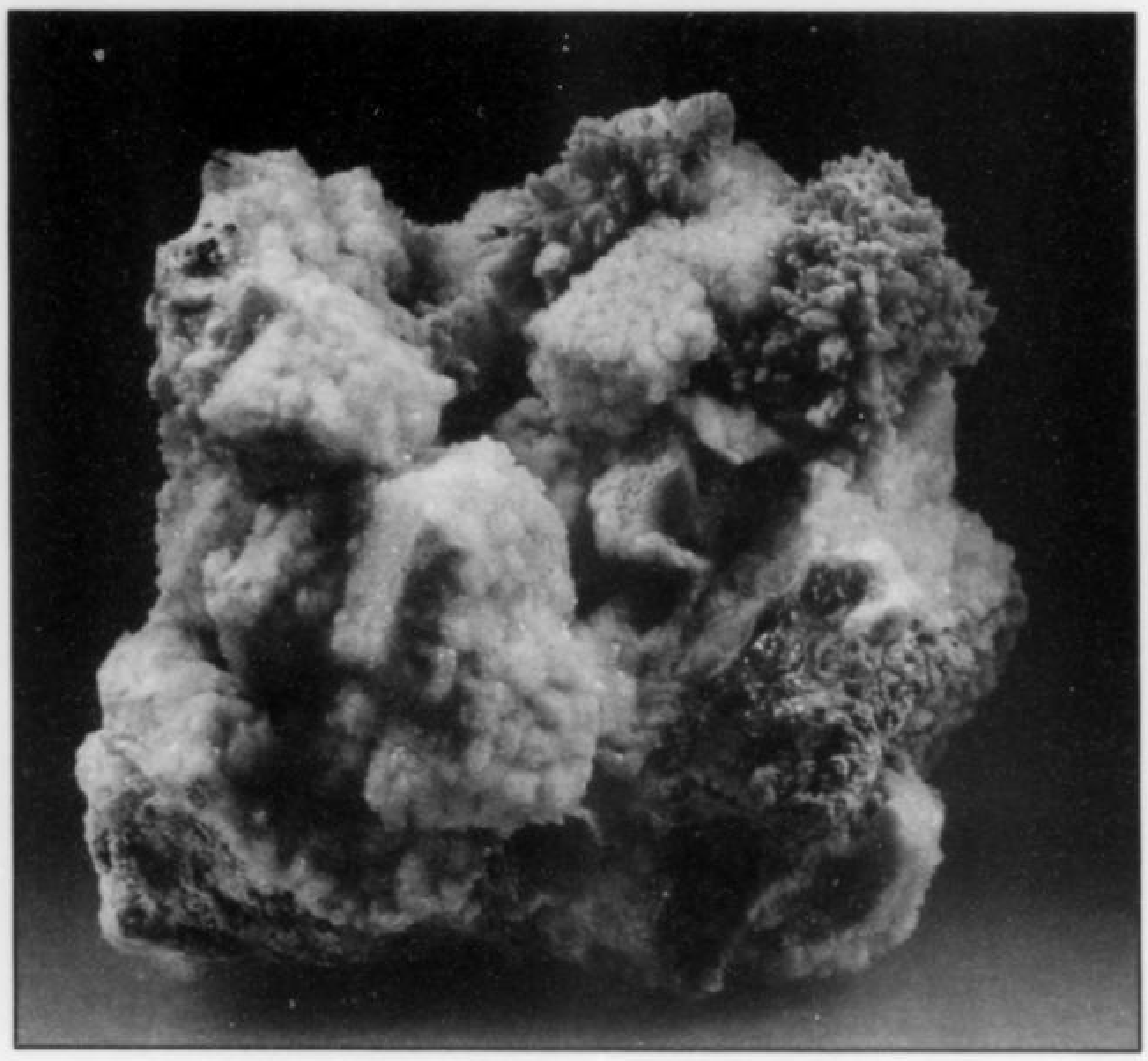

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Figure 18. **Albite-encrusted sodalite crystal group, 6 cm, with yellow calcite, from Mont Saint-Hilaire, Quebec. Gilles Haineault specimen.**

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Figure 19. **Fluorapatite crystal, 2.3 cm, from the Sceptre claims, Emeral Lake, Yukon, Canada. Tyson's Minerals specimen.**

Figure 20. Quartz crystal, 1.5 cm, showing numerous liquid inclusions, from Orpierre/Ribiero, Hautes Alpes, France. Michel Jouty specimen.

Figure 21. Hureaulite crystal, 8 mm, from the Joca mine, Galileia, Minas Gerais, Brazil. Carlos Barbosa specimen.

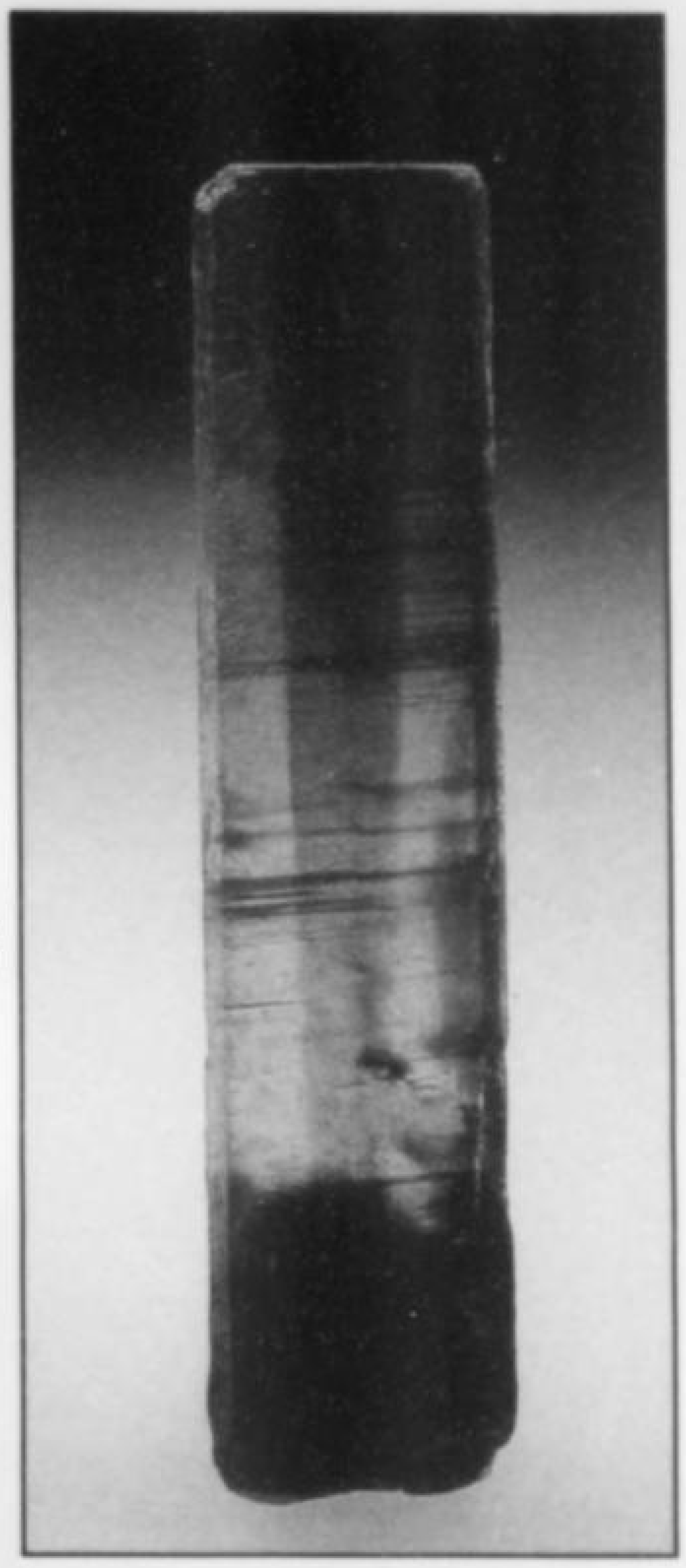

Figure 22. Kyanite crystal, 5.9 cm, from Goias, Brazil. Valadares Minerals specimen; Jeff Scovil collection and photo.

Figure 24. Heulandite crystal group, 3.5 cm, from Pato Branco, Paraña, Brazil. Valadares Minerals specimen; Jeff Scovil photo.

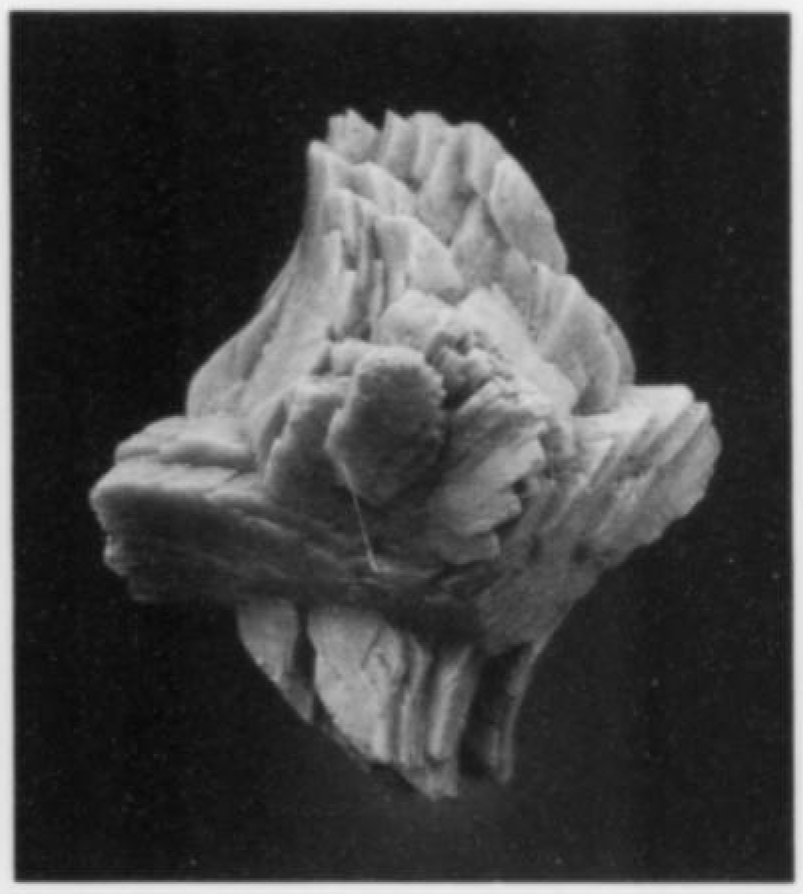

Figure 23. Heulandite crystal group, 2.9 cm, colored pale green by inclusions, from Aurangabad, India. Oceanic Linkways specimen; Tom Moore collection.

Figure 25. Florencite-(Ce) crystal, 1.9 cm, from the Brumado mine, Bahia, Brazil. Alvaro Lucio specimen.

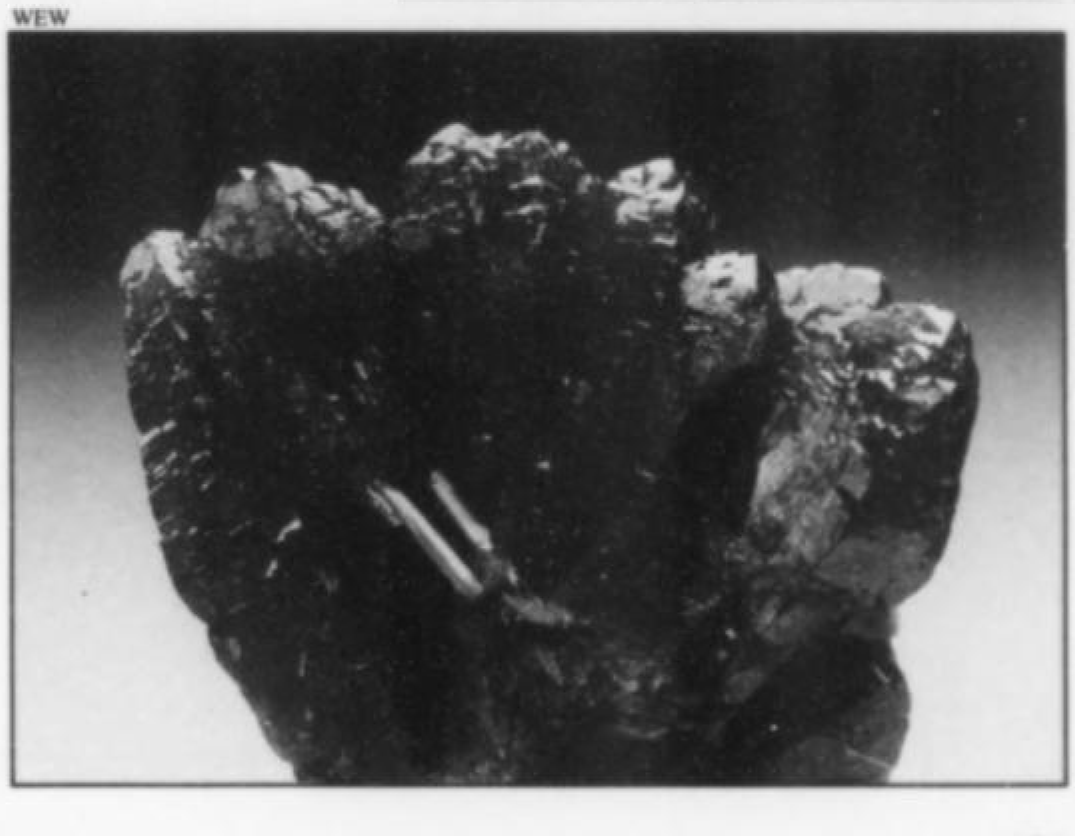

Figure 26. Xenotime crystal group, 1.6 cm, with rutile, from Novo Horizonte, Bahia, Brazil. Luis Menezes specimen.

Brad in the Executive Inn room of Gilles Haineault.

And surely you've heard that name before, for Gilles Haineault of *Collection Haineault* (2266 Rue Ste.-Alexandre, Longueuil, Quebec, J4J 3T9 Canada) is perhaps the greatest of all the Masters of Mont Saint-Hilaire, and he usually has fascinating arrays of old and new Saint-Hilaire materials—as he did this year. In July 1994, Gilles hit a pocket containing some of the best formed, biggest, and prettiest **sodalite** crystals yet found: good, sharp, loose yellow dodecahedrons averaging 2 cm, enlivened, though also roughened and camouflaged, by solid sparkly crusts of white to pale pink albite microcrystals. Fine thumbnails for $150 to $200, as well as a few miniature-sized matrix pieces, were available. Saint-Hilaire sodalite, by the way, when not blanketed by the albite, fluoresces bright orange.

Gilles also collected, late last May, some top-grade **catapleiite** in pale brown rosettes to 6 cm across, and some unusually pretty **polylithionite** in loose flared "books" of thumbnail size, some of these adorned with bright black **aegirine** needles around their rims. Stout, thick prisms of **pectolite** have been found before at Saint-Hilaire (see the special issue which was vol. 21 no. 4), but the new ones here are very fine: transparent and colorless 1 x 1 x 2-cm crystals with fine triclinic terminations, most having cloudy gray inclusions which do not at all mar the bright glassiness of the surfaces. Finally, superlative thumbnails of deep orange-pink **serandite** in complete blocky floater crystals graced these shelves; one of these classic older-timers could be had for around $150.

Rod Tyson of *Tyson's Minerals* had his usual fine array of Canadian minerals, including many superb Mont Saint-Hilaire and Rapid Creek specimens. New this year were some lovely green, water-clear **fluorapatite** crystals from the Sceptre claims at Emerald Lake, Yukon Territory. Thumbnail-size crystals 2 to 3 cm long and perhaps 4 mm to 2 cm in diameter were quickly snapped up by the earliest visitors to his room in the Executive Inn. The crystals generally seem to lack matrix, but make up for it in the glassy luster, high transparency and pleasant color.

Now, forgetting about those peso problems, come along to Mexico, and simultaneously back again to Jim Vacek's *49er Minerals* room at La Quinta. Just inside the door was a case with a sign, claiming "Azurite roses are forever," over a couple of glass shelves bearing, sure enough, about 30 beautiful **azurite** roses. Ranging from small-miniature size to 7 cm across, they are quite fine, remarkably damage-free, deep blue, and sharp-edged; the locality is the Santa Rosa mine, Conception del Oro, Zacatecas, Mexico. In all essentials, I'd say, they equal the best from Chessy and China, and fall short of the best from Bisbee only by being a bit duller-lustered. There is scant malachite and just as scant "matrix"—actually the roses are found encased in a sort of funky fraipontite/montmorillonite white clay, which is duly removed, except for leaving a few white spots here and there.

Another Mexican standout is the bright grapefruit-pink **grossular** that's been dug during the last few months, apparently by a local rancher, at Sierra de las Cruces, Coahuila. Crystals are dodecahedrons to 3 cm, the prettiest ones around 1.5 cm, intergrown as seam linings or nicely individualized, i.e. sitting up smartly, in cavities in a blotchy acid-cleaned gray-white matrix. Some crystals achieve gemminess; but, thanks to their color, even the cloudier ones make winning specimens when well composed on the matrix. On a few there are well-formed tan-colored **vesuvianite** crystals too. These grossulars were fairly widespread around the show, but the best belonged to Mike Bergmann of *Galena Rock Shop* (713 S. Bench St., Galena, IL 61036). As a further note on Mexican minerals it might be mentioned that Wayne Thompson is still merchandizing giant and wonderful wulfenite groups from the San Francisco mine, Sonora.

Benny Fenn (who had a room at the Executive Inn) had a large lot of some very interesting feldspar crystals from the La Pili mine, between Camargo and Naica, Chihuahua, Mexico. Originally labeled as "sanidine," a chemical analysis conducted recently indicates a composition of $Ab_{58}Or_{42}$, which I guess makes them **anorthoclase**. Anyway, the crystals are blocky and rectangular to rather platy, with good luster and a rather plain gray color. What gives them class is a very pronounced "schiller" or bluish "moonstone" effect, making them probably the finest known crystal specimens to exhibit this phenomenon. Benny's been mining them for about a year, and has hundreds of reasonably priced specimens available, with crystals up to 8 or 10 cm in size.

Jack Lowell (*Colorado Gem and Mineral Company*, P.O. Box 424, Tempe, AZ 85281) in the Desert Inn had some nice specimens of smoky quartz with good albite and microcline crystals from a new (on the market, at least) locality, Chilpancingo, Guerrero. The quartz and feldspar crystals are of reasonable size (4 to 6 cm typically), and some are accompanied by attractive red garnet crystals to 6 mm on the feldspar and floating *in* the quartz, and also sprays and bundles of epidote crystals to more than 1 cm. A baveno twin on matrix was also recovered. This locality may well be producing more in the future.

Michel Jouty (231 Route des Nants, 7400 Chamonix, France) had as usual a flat glass case devoted to placer-mined **gold** and **platinum**, and this time his wire gold from the vast jungly goldfield of the state of Choco, southern Colombia, begged notice. There were about 30 loose, 1-cm to 3-cm wires of buttery yellow color, many coyly curved over near one end to make "ram's horn" shapes. A remarkable 3.5-cm piece consisted of three thick wires lying parallel against each other, the whole then curved in a U. Gold production from this remote area (not contiguous with the one in southern Venezuela) has been sporadically ongoing for about the past 15 years.

Chile has also not been unproductive of late. Niel Prenn of Sparks, Nevada, brought up some specimens of the rare mineral **rodalquilarite** which are surely the finest known for the species. The bladed and spear-shaped crystals reach 4 mm in size, and occur as attractive clusters on what looks like tan-colored dolomite or alunite crystal-lined vugs and seams. **Emmonsite** is also associated. The locality is the Wendy pit, El Indio gold mine, in Coquimbo department. These hit the market right at the end of the Denver Show in September, and Bill Pinch had the best example (a fine cabinet piece) on exhibit at the Tucson Show.

What's new from Brazil? Well, you might ask Edson and Laercio Endrigo of *Valadares Minerals* (Rua Capote Valente 513, Apt. 133, São Paulo, Brazil), who had fine specimens of a new **heulandite** from basalt-flow cavities near Pato Branco in the state of Paraña. Found in November of last year, the heulandite comes in jumbled groups, rosettes and parallel bundles of bladed crystals, with individuals to about 2 cm, and is of an unusual, lively orange-brown color. The most attractive specimens are ones in which the heulandite rests against traces of the earthy green glauconite layer that lined the cavities. About a hundred thumbnail, miniature, and small cabinet pieces made it to Tucson with the Endrigos.

Scattered much more widely about the show were the translucent violet-pink **hureaulite** crystals (with **reddingite** and other phosphates) in glistening pegmatite-cavity fillings, some with well-defined hureaulite individuals to 5 mm: at least a dozen dealers, including of course most of the Brazilians, had these. The locality given is the Joca mine, Galileia, Minas Gerais—apparently *not* the same place as the hureaulite locality written up long ago in the *Record*, namely the Criminosa mine, Minas Gerais, where very large hureaulite crystals occurred in loose groups with barbosalite.

Then too from Brazil were the loose prisms of wonderfully gemmy and colorful **elbaite** in the flat glass case in the room of Steven Smale (69 Highgate Rd., Kensington, CA 94707). Usually I avoid ogling (and writing about) Brazilian elbaite, as the arcane multiplicity of its moods and of its localities seems too much for my non-gemstone-oriented consciousness to want to cope with. But even I recognized the names of the Cruzeiro and Santa Rosa mines, and seeing their elbaites here juxtaposed—so differently styled, both so beautiful—was inter-

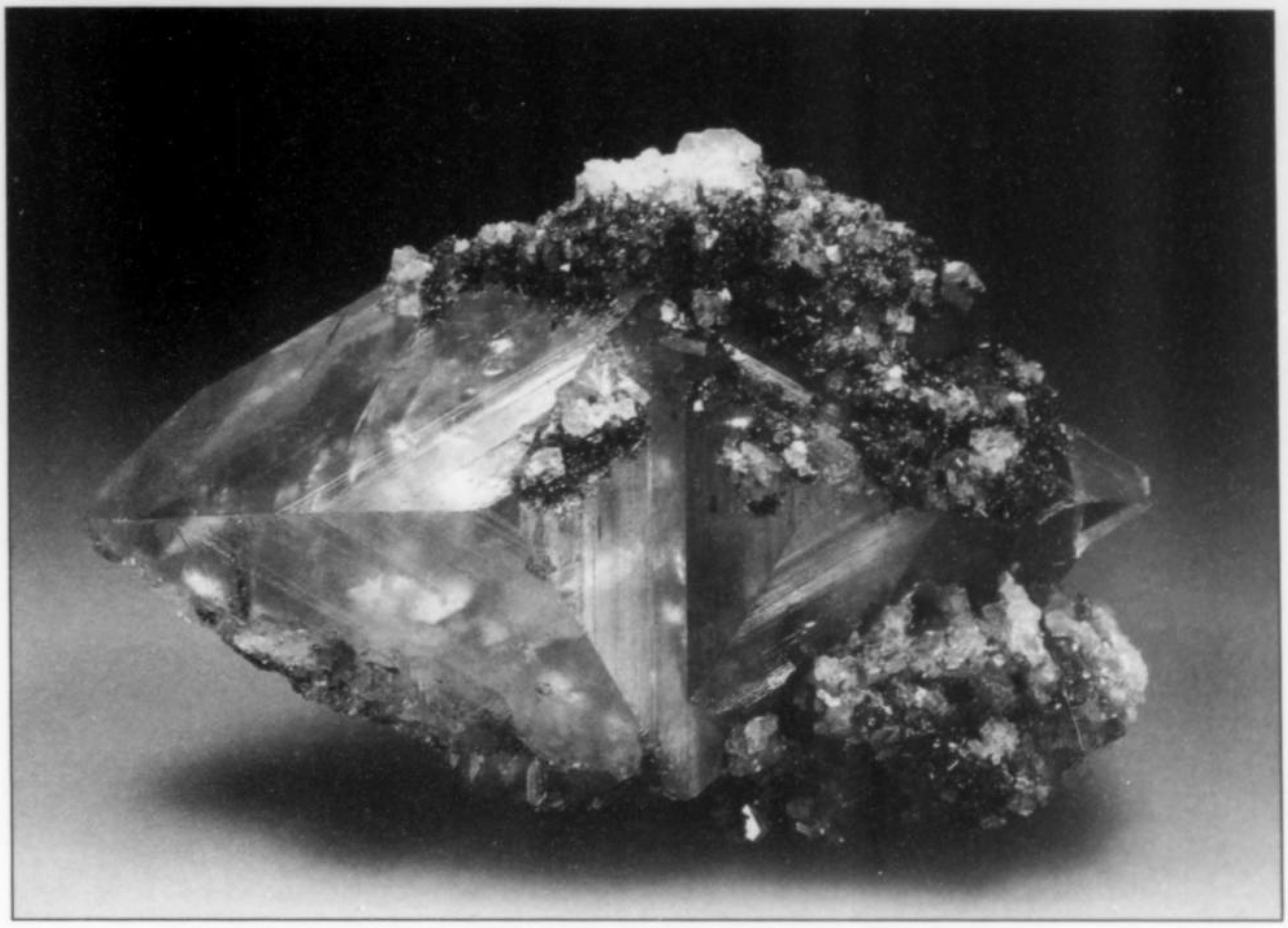

Figure 27. **Dolomite crystal twin, 18.6 cm, with magnesite and uvite from the Brumado mine, Bahia, Brazil. Julio Landmann collection; Jeff Scovil photo.**

estingly educational, as was also the Smales' conversation on this and other topics. The Cruzeiro prisms are new (mined last April), with sharply defined horizontal zones going from deep green to colorless to vivid pink at the pyramidal terminations, the crystals from 3 to 7 cm long, and all largely gemmy. The Santa Rosas are older, and zoned in the classic "watermelon" way, i.e. with pink cores and blue-green (flat basal) terminations, the blue-greenness wrapping down the sides in "ghost" zones through which one can see inner pink; look down *c* from the broken end to get the watermelon-rind effect. Which reminds me, the lovely, blocky, colorless **euclase** gem crystals with that blue stripe down the middle, from Equador, Rio Grande do Norte, have been getting much more plentiful, and prices are distinctly lower, just since I noted these from Denver.

Luis Menezes still had a few of the excellent **xenotime** crystal clusters (reported earlier) from Novo Horizonte, Bahia, Brazil. The little fans of prismatic brown crystals to a centimeter or more sometimes also have rutile needles associated.

The famous Brumado mine in Bahia continues to be one of Brazil's most fascinating and productive localities. Like Mont Saint-Hilaire in Quebec, it seems to turn out something really new every year, while continuing to yield its regular array of well-known beauties. In the case of Brumado, the well-known beauties are the superb red and green **uvite** crystals and clusters associated with blocky magnesite. Carlos Barbosa and Ken Roberts had excellent examples, and collectors would be wise to select a few of these while still available (complacency can be fatal if output should suddenly cease).

The "something new" from Brumado this year was a real surprise: the world's finest crystals of the rare-earth mineral **florencite-(Ce)**, containing 14.7% Ce_2O_3. And these are not micromount-size either, but in well-formed crystals up to nearly 2 cm, perched on the smooth faces of magnesite crystals (from which they easily detach). These crystals were originally thought to be the related species goyazite, but chemical analysis has refined the identification to florencite-(Ce). The crystals are a pleasant butterscotch-yellow, rather opaque, medium-dull to fairly bright in luster, and show an interesting combination of trigonal prism and rhomb or steep scalenohedron faces. Carlos Barbosa and Alvaro Lucio each had a few specimens, mostly with crystals around 5 mm.

One "something new" was not sufficient this year for Brumado; the locality also yielded some incredible twinned **dolomite** crystals up to nearly 19 cm (over 7 inches!). The best of these, lustrous and well-formed with small magnesite and uvite crystals in association, went to the Julio Landmann collection.

Finally, among the many products of Brazil this year we might single out the interesting **kyanite** crystals available from *Valadares Minerals*. These (mostly single) crystals from a locality in Goias reach 8 or 9 cm in length and are characterized by a bright blue zone running longitudinally down the center, flanked by very pale blue zones, the whole having good glassy luster and fair transparency. Their habit is flat and ruler-like, perhaps 1 or 2 cm wide and a few millimeters thick; terminated crystals are hard to find since these must be broken from enclosing rock, but a few do exist for the careful searcher.

There is very little to say this time about old Europe. Michel Jouty (see under Colombian gold) had about eight small miniatures of a lushly dark green, sparkling, chlorite-infused **quartz** from Passo del Forno, Alpe Devero, Italy—very nice "jack-straw" floater groups collected last summer. He also had a few dainty thumbnails of a Herkimer-like French **quartz**, with 1-cm transparent colorless "diamonds" perched on tan, cherty matrix, from Ribiero or Orpierre (two nearby localities) in the Departement of Hautes Alpes, France. And finally, it was nice to see among Jouty's things some small but classic, blue **boracite** crystals to 3 or 4 mm, in matrix, from the Bamberg

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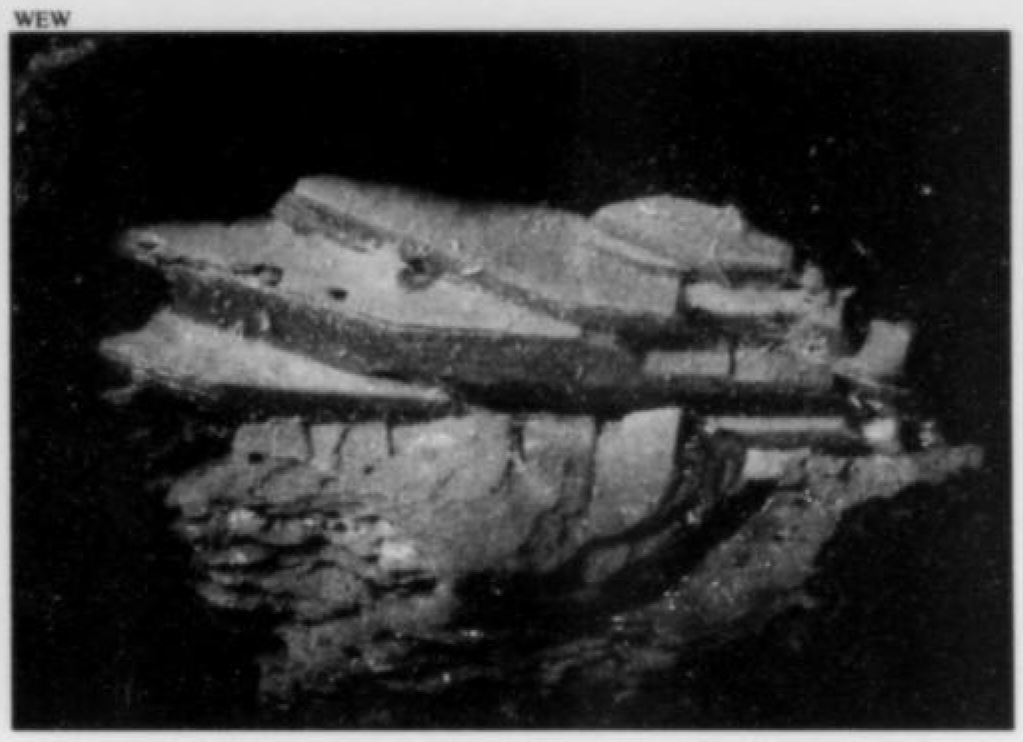

Figure 28. **Marthozite crystal group, 1 cm across, in selenian digenite from the Musonoi Extension mine, Katanga, Zaire. Mineralogical Research Company specimen.**

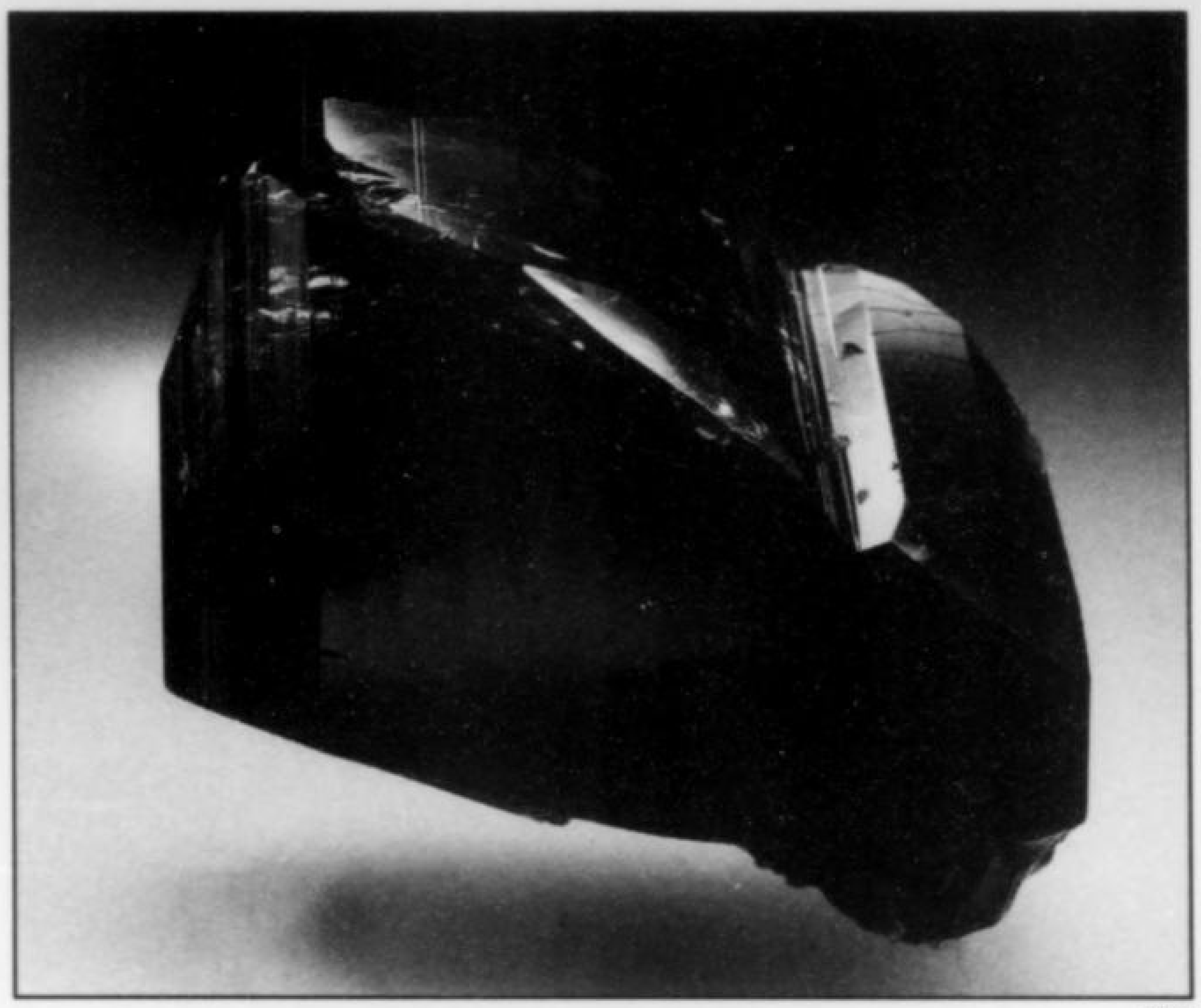

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Figure 30. **Zoisite ("tanzanite") crystal, 5 cm, from the Umba Valley, Tanzania. Wayne Thompson specimen.**

Figure 29. (below) **Forsterite crystals by the flat (offered by Herb Obodda), labeled "Naran, Kagan Valley, Mansehra district, Pakistan."**

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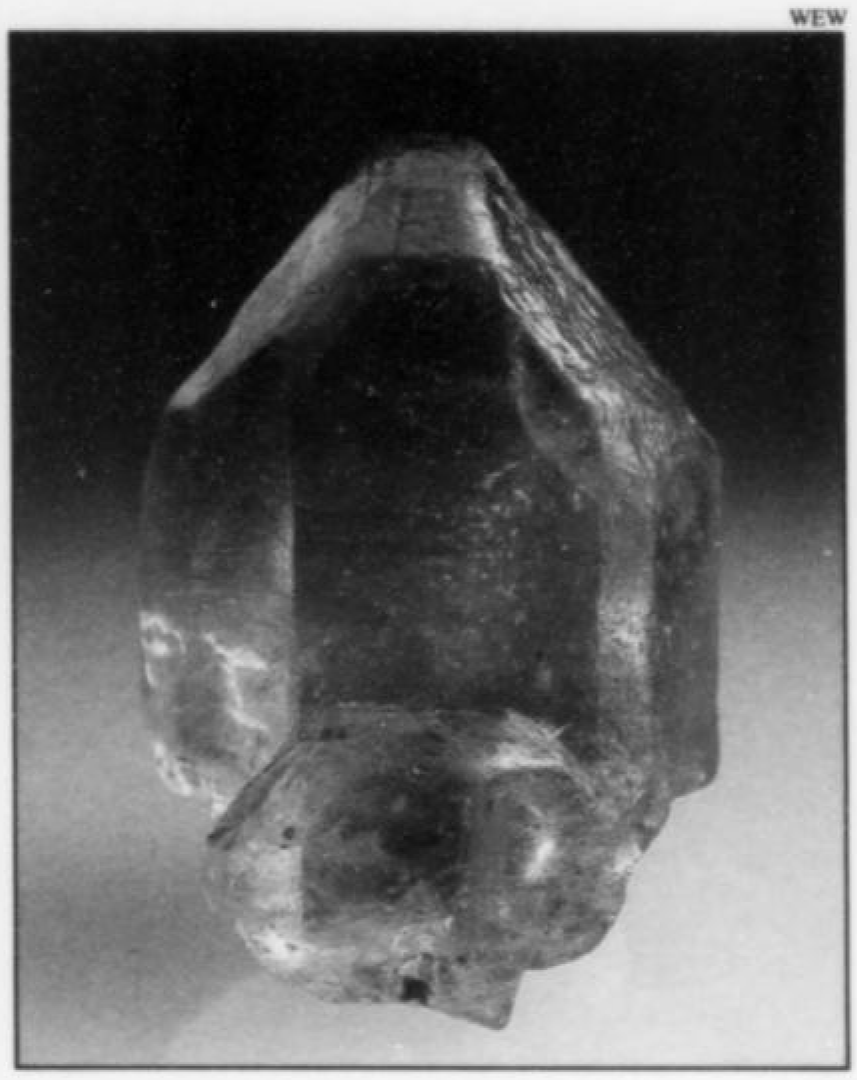

Figure 31. **Forsterite crystal, 1.9 cm, northern Pakistan. François Lietard specimen.**

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Figure 32. (right) **Sklodowskite crystal group, about 8 mm across, from the Musonoi Extension mine, Katanga, Zaire. Mineralogical Research Company specimen.**

saline deposit in Germany. The fine, recently mined English specimens, much larger in crystal size, have taken all the boracite headlines lately (some good ones were available elsewhere in the Executive Inn), but one should never completely forget the old classics.

The important (if peculiar) **gold** locality of Hope's Nose, Torquay, Devon, England, generally held to be pretty much cleaned out, did manage last year to yield a few terrific dendritic gold specimens, with delicate, brilliant fronds to 2.5 cm precariously embedded by a few leaftips in remnants of acid-etched calcite on brown matrix. There was a 4 x 6-cm show-stopper for $4,200, three other miniatures, four thumbnails, and a small swarm of tiny loose dendrites. Most of this gold is conventionally yellow, but parts of ferns on a couple of specimens are almost silvery-white because of the high palladium content that is the chemical trademark of this occurrence. Peter Lyckberg (Box 25147, S-40031 Göteborg, Sweden) is the man who brought these fine golds to Tucson.

Dave Bunk (see under Oregon calcite) had a considerable stash of the new **garnets** from Sandaré, Diakon Arrondisement, Nioro du Sahel District, Republic of Mali. The species has been found to be grossular, except for a single black thumbnail crystal of Dave's with an andradite outer shell. Indeed these crystals are concentrically zoned, with black-brown to medium-brown to blotchy brown/green outer layers, progressing to much lighter green centers: these centers have yielded a few peridot-like faceted gems. The matrixless crystals are dodecahedrons, trapezohedrons, and all combinations of these; good sharp ones occur in sizes from thumbnails up to five hulkers near 20 cm in diameter. The same deposit (a calc-silicate skarn?) also produces fair, dull to medium-lustered crystals of **epidote** and **vesuvianite**, and mammillary **prehnite**.

Always good for a treasure or two from central Africa is Belgian dealer Gilbert Gautier (7, avenue Alexandre III, 78600 Maisons-Laffitte, Belgium), who sells minerals only at major shows. But he must enjoy it, as he always presides with high jollity at his popular stand, as he did this year at the Main Show. He had about 50 miniatures of some new, very colorful **malachite/azurite** found as rounded clusters enclosed in clay near Mulungwishi (a Protestant mission), Katanga, Zaire. There are small, ferny "primary" malachite sprays on the very bright blue aggregates of azurite blades to 1 cm. Even more pretty are some hematite-phantom quartz crystal groups, also brand new, from Katongo, Katanga: the transparent quartz prisms, to 4 cm, are colored a limpid rose-peach inside, and the phantoms typically come to within 5 mm of the tips, where they sharply end parallel to terminal rhombohedral faces. A nice thumbnail went for $25 to $30. Finally, from Katonto (with a T), Katanga, Gilbert had a handful of specimens of a dense violet-gray quartzite with open seams showing thin coatings of microcrystals of **turquoise** in radial tufts, impressive under the loupe, resembling and equalling those from Lynch Station, Virginia.

Sharon Cisneros (*Mineralogical Research Company*) had her share of rare African minerals as well, including a suite of uranium minerals from Zaire. I especially liked a miniature she had of yellow **sklodowskite** with needles to 1 cm pointing inward from all sides of a vug, just like the better-known specimens of its green cousin, cuprosklodowskite. In addition, she had a miniature-size digenite matrix containing a small vug with a 1-cm parallel-growth crystal of **marthozite**. Both of these came from the Muzonoi Extension mine, Katanga province, Zaire.

The Umba Valley gem deposits in Tanzania continue to produce fine blue/purple **zoisite** ("tanzanite"), although their distribution and marketing infrastructure is so finely honed that almost all specimens end up getting cut (hence the rarity of specimen crystals for us collectors). Nevertheless, the occasional fine crystal does get through, like the gorgeous 5-cm specimen in Wayne Thompson's room at the Executive Inn. Like all of the best crystals, this one shows its remarkable trichroic nature to anyone willing to hold it up before a strong light: brilliant, transparent purple when viewed through the large *a* face, deep cobalt-blue when viewed through the *b* face (at 90° to the *a* face), and an incredible, deep scarlet-red when viewed down the *c* axis, from the top of the crystal. In this particular crystal some brown is also visible near the termination. Exquisite crystals like this are beyond the means of all but the best-funded collectors, but what a thrill it is for us lowly "average" collectors to see one in person from time to time, even if we can never own it!

A nice Tsumeb collection, assembled in Namibia from the 1950's through the 1980's, was being sold in the Executive Inn by Christian Gornick (Am Seelberg 40, D-30629 Hannover, Germany). There were perhaps a couple of hundred fair-to-fine, all-sized specimens of the major Tsumeb species. Outshining most of these, though, were Christian's **azurite** specimens from Tsumeb's upper levels, mined from pillars in the 1970's—about 50 miniatures and cabinet pieces. The best azurite crystals are thick, well-terminated, and blocky, sometimes looking like modified rhombohedrons; they are a satisfying deep blue, although only medium-lustered, and in excellent condition. One great, proud malachite pseudomorph piece, 6 x 7 x 8 cm, has earthy green crystals of extremely sharp azurite habit to 3 cm long, in a very aesthetic, spiky group ($5,000).

Predictably, Indian zeolites around the show filled a total table space fairly large enough to apply for statehood. Our jadedness with these very beautiful and often explosively dramatic things is of course a shame, but probably can't be helped, given such massive output. Yet one new Deccan-trap oddity should certainly be of interest. I refer to **heulandite** that is colored uniformly a pleasantly milky, medium gray-green by (presumably) fine-grained included chlorite, much reminiscent in color of some Alpine chlorite-infused adularia crystals. But the form here is typically that of heulandite, in tightly intergrown single crystals and parallel, curved bundles. These were reportedly found in November 1994, in a single roadcut near Poona. *Oceanic Linkways Inc.* (303 5th Ave., Suite 904-906, New York, NY 10016) had a half-flat of miniature matrix specimens, but my favorites (naturally) were a few very sharp floater thumbnails.

Great abundances of average-quality **cavansite** on white stilbite from the Wagholi quarry, Poona, India, around the hotel rooms bespoke a new strike of this beautiful but well-known stuff, and the familiarity plus mediocrity had decided me not to mention it—ah, but then at the Main Show I saw the Good Ones, holding court at the stand of *Wilke Mineralien* (44 Odenwald Ring, D-64859 Eppertshausen, Germany). Dr. Wilke has all along been the person mainly responsible for bringing out these almost unbelievably, insanely bright blue radial cavansite balls so strikingly set against white stilbite crystals, and he supervised the careful exploratory work which resulted, in December 1994, in these record-setting specimens coming from about 50 meters away from the first, 1988, find. The best of the new ones are matrix pieces, ranging from 12 to 17 cm, whereon very pale brown stilbite crystals to 5 mm line cavities and are studded, in turn, with generous numbers of 2-cm to 3-cm cavansite detonations. There are also a very few small miniatures showing the standard radial balls attaching to edge-on bundles of the rare parallel-bladed cavansite, these blade-streaks reaching 3 cm long. And the large specimens in Dr. Wilke's exhibition case were even *better.* Don't give up on getting some of this gorgeous material, if you are still seeking it . . . though of course you might have to content yourself with one of the myriad thumbnail specimens of loose radial balls, which are now quite easy to find as well as to pay for.

From Pakistan, reliable mountaineer Dudley Blauwet of *Mountain Minerals International* (P.O. Box 302, Louisville, CO 80027-0302) had one of his exotica again: thin, colorless to milky, and quite transparent when colorless, striated prisms (with terminations) of **hambergite** from Drot, Gilgit-Skardu Road, Northern Areas, Pakistan. One of these splintery loose crystals measures 7 cm, while another is 5 cm long and doubly terminated.

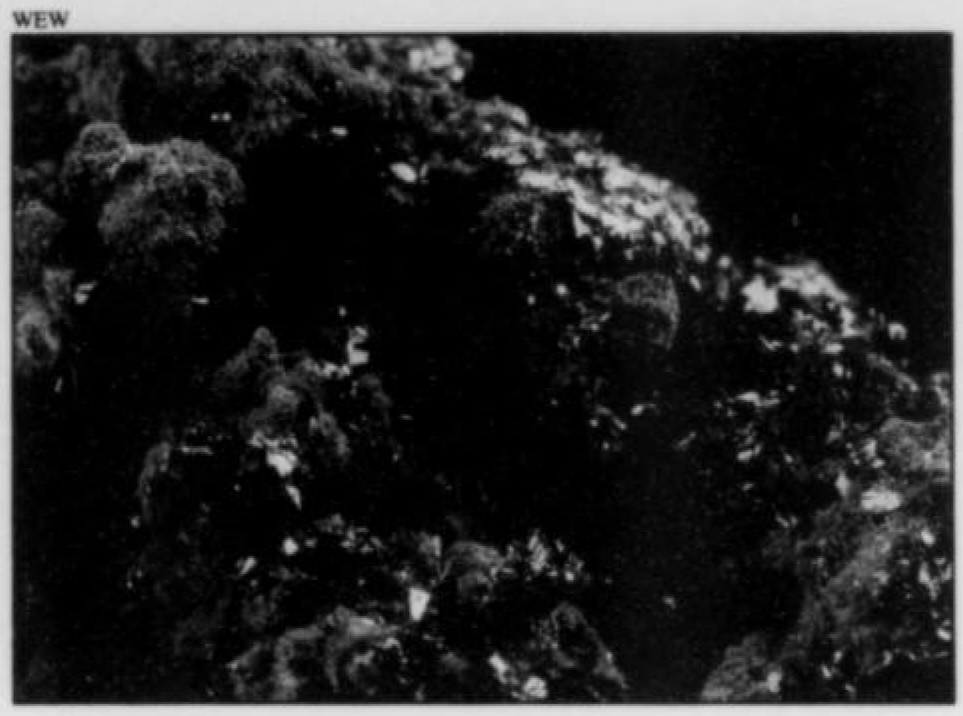

Figure 33. **Unnamed rhenium sulfide mineral, in small (<1 mm) flexible flakes on andesitic basalt from a fumarole associated with the Kudriavy volcano, Iturup Island, Kurily, Russia. Fersman Mineralogical Museum specimen; William Pinch collection.**

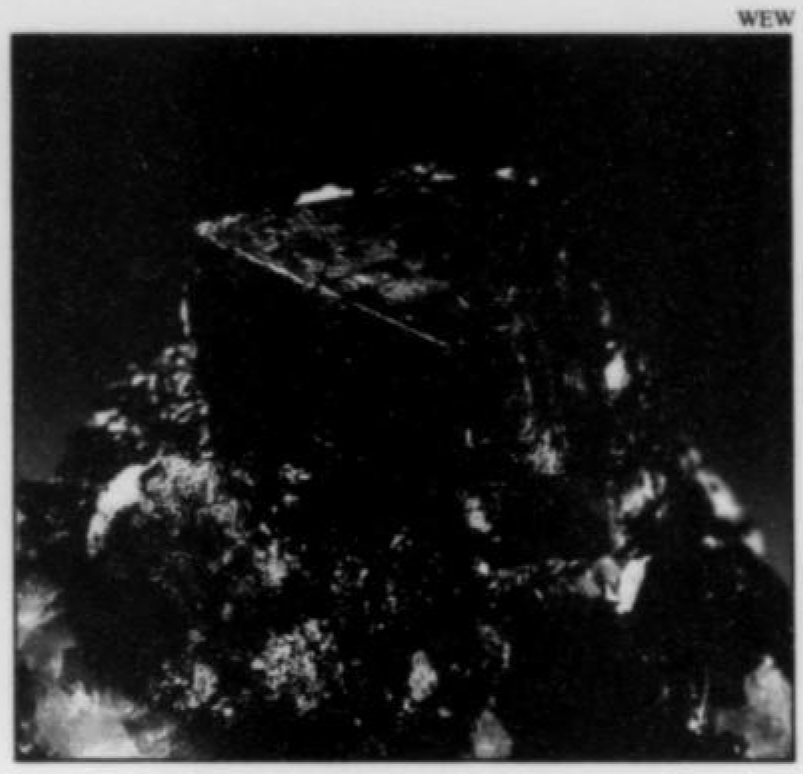

Figure 34. **Pyrochlore crystal, 1.6 cm, on granite from Vein #140, Vishnovogorsk, central Urals, Chelyabinsk Oblast, Russia. Pljaskov-Van Scriver specimen.**

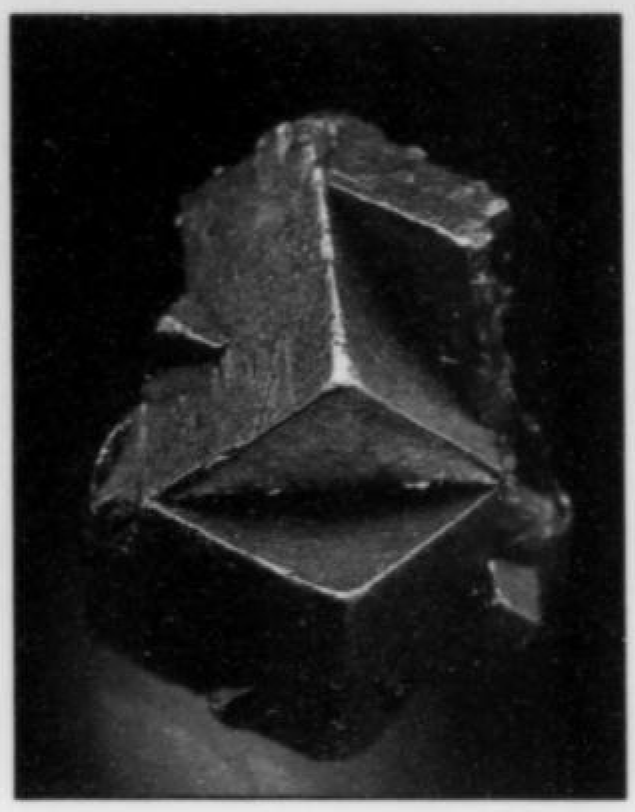

Figure 35. **Platinum crystal twin, 7 mm, from Konder near Nelkan, Anjano-Maiskiv region, Khabarovsk Oblast, Russia. Collector's Edge specimen; Jeff Scovil photo.**

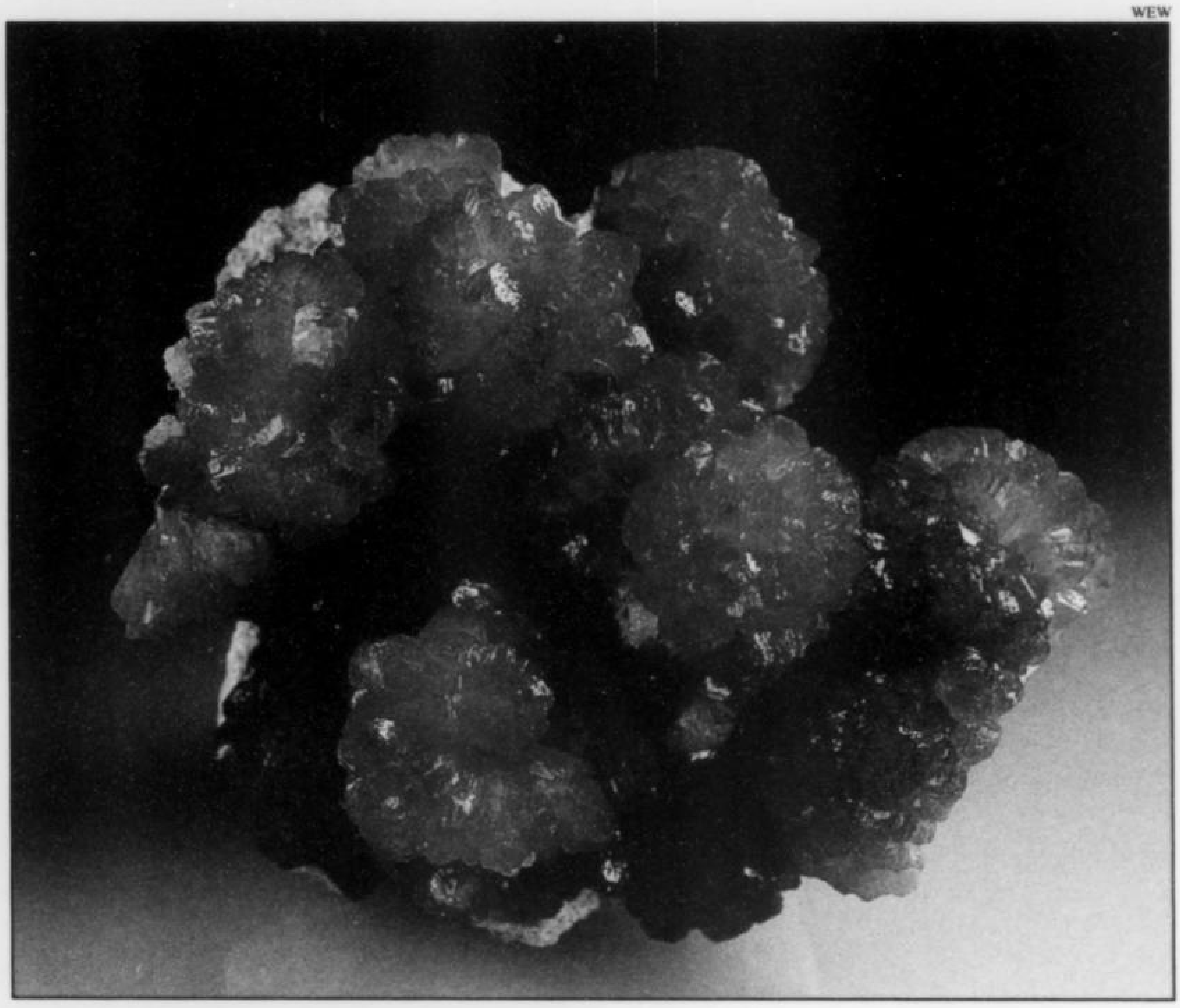

Figure 37. **Stellerite crystal group, 5.5 cm across, from the Sarbayskaya quarry, near Rudniy, Kusteni Oblast, Russia. Pljaskov-Van Scriver specimen.**

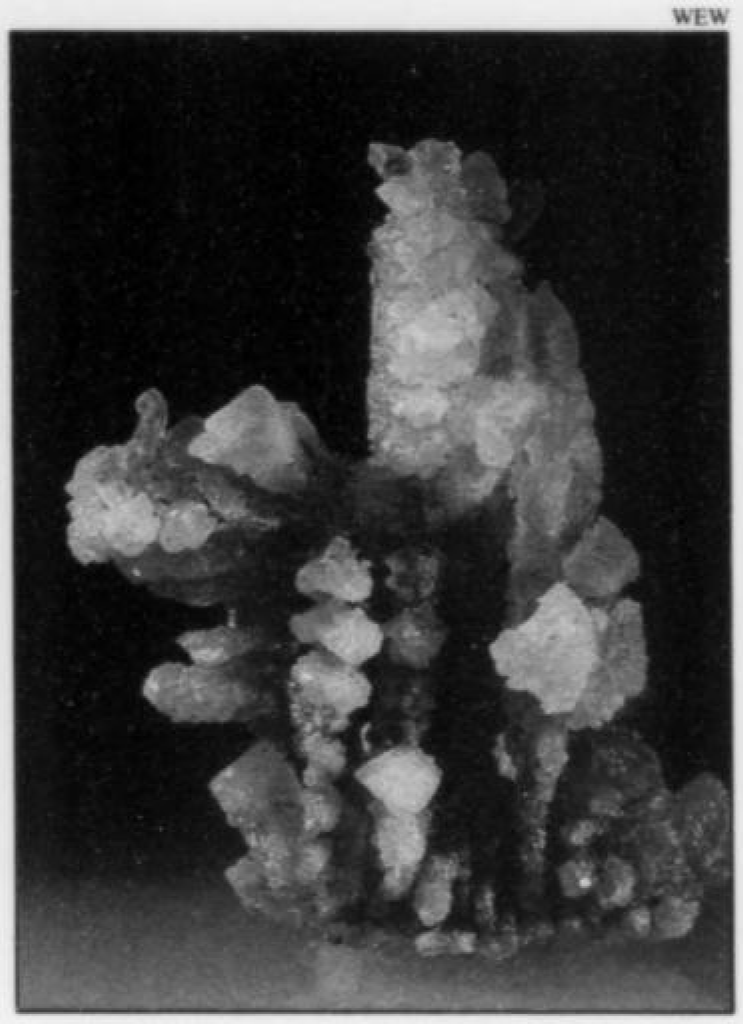

Figure 36. **Sal ammoniac crystal group with sulfur, 3 cm, from near Ravat Village, Tadjikistan. Pljaskov-Van Scriver specimen.**

Figure 39. **Eudialyte crystal, 1.4 cm, from Mt. Eveslogchorr, central Khibiny Massif, 50 km east-northeast of Apatity, Murmansk oblast, Kola Peninsula, Russia. Pljaskov-Van Scriver specimen.**

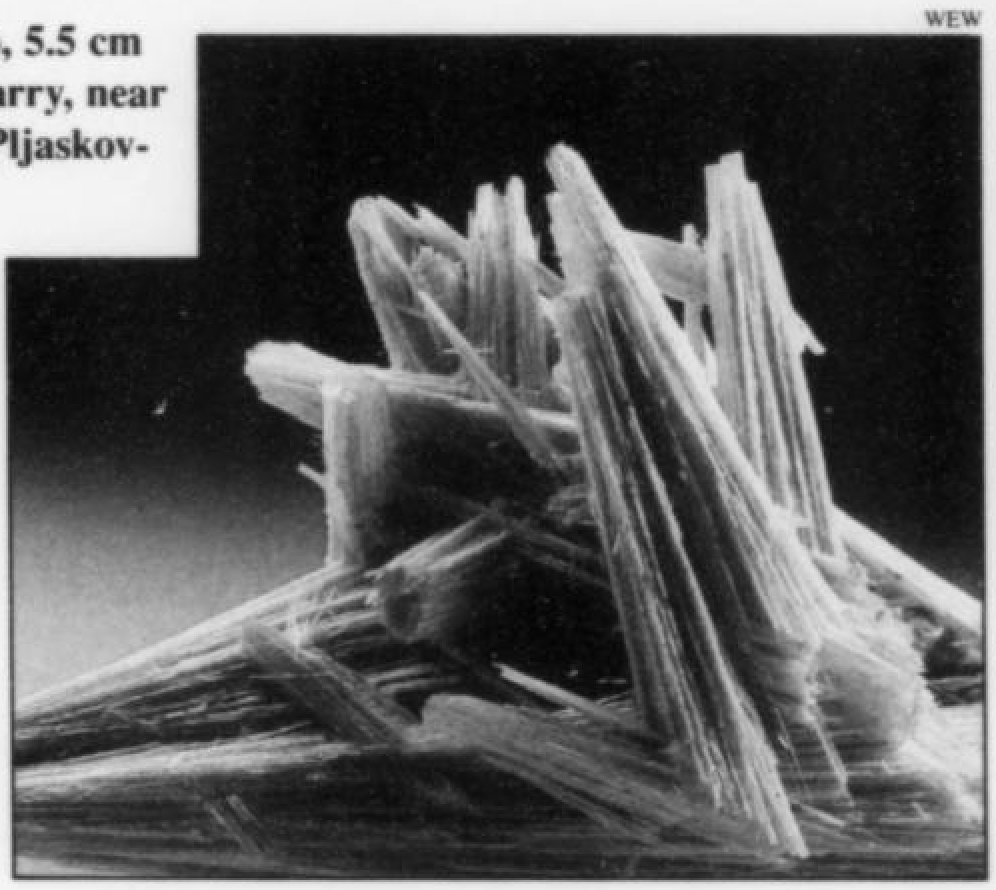

Figure 38. **Elpidite crystals to 2 cm, from Mt. Alluayo, Lovozero massif, Murmansk oblast, Kola Peninsula, Russia. Pljaskov-Van Scriver specimen.**

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Figure 40. **Beryl crystal, 5.5 cm, from mine no. 2, Volodarsk-Volynsk, Zhitomir region, Ukraine. Pljaskov-Van Scriver specimen.**

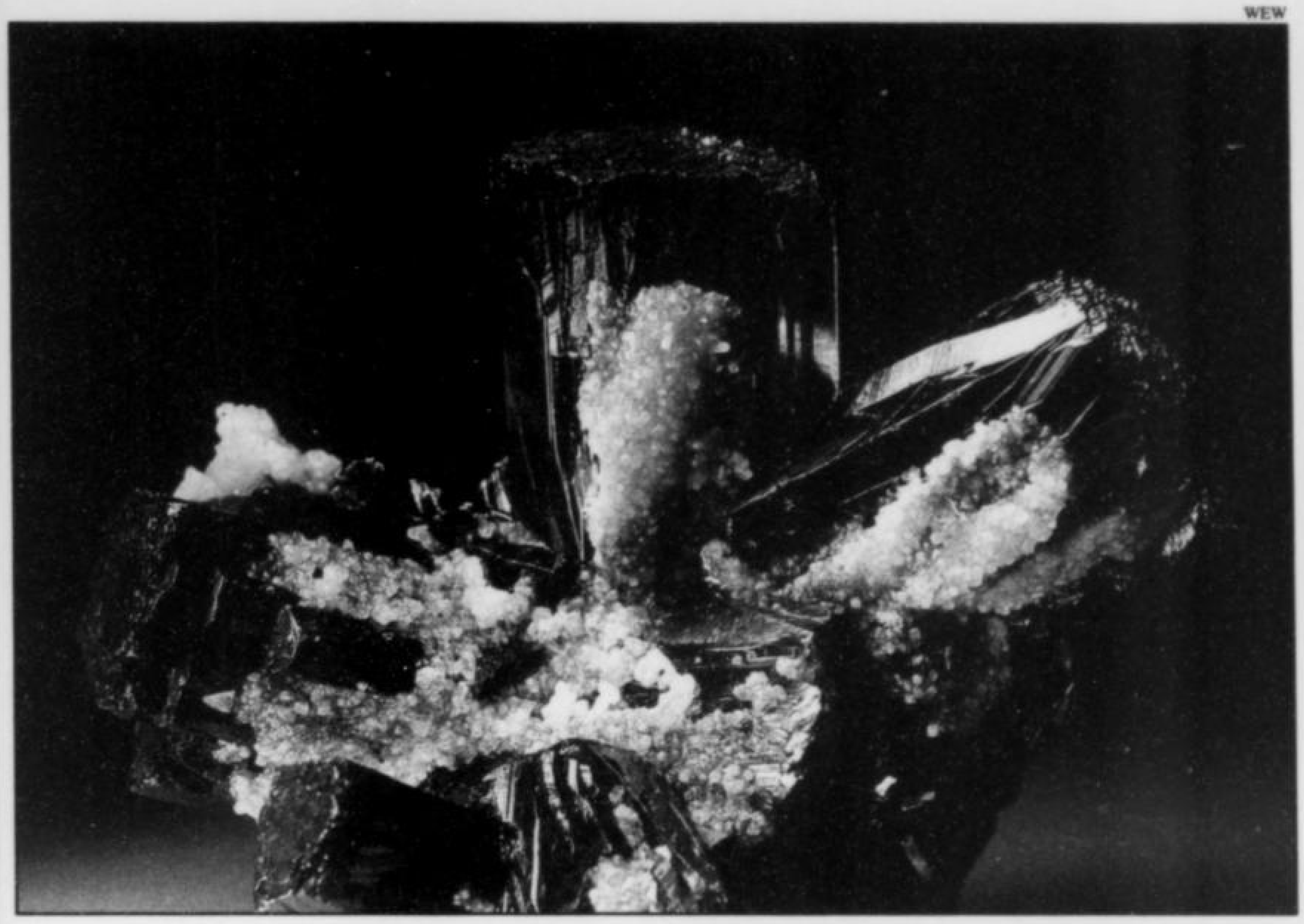

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Figure 41. **Pyrargyrite crystal group, 7.5 across, from the Santo Niño vein, Fresnillo, Zacatecas, Mexico. All of the crystals are a deep transparent red, and shown by the central crystal which has been backlit. This specimen, from the Miguel Romero collection, was exhibited at the Tucson Gem and Mineral Show.**

Figure 42. **Green beryl crystal, 22.5 cm, on quartz from Mursinka, Ural Mountains, Russia (an old specimen). Pljaskov-Van Scriver specimen; Jeff Scovil photo.**

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Figure 43. **Titanite crystal cluster, 2.5 cm across, from the Dodo mine, 75 km northeast of Saranpaul, Polar Urals, Tyumen Oblast, Russia. Pljaskov-Van Scriver specimen.**

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Figure 44. **Diamond crystals, 8 mm, from the Argyle mine, Kimberley, Western Australia. Cal Graeber Minerals specimen.**

And Pakistan seems now to be the final, authoritative home country of those peripatetic **peridots** which were first advertised as coming from Afghanistan, then China. Dealers' labels still differ on particulars, though, about *where* in Pakistan these fine crystals of forsterite (var. peridot) occur; Dudley says that it is Sumput Nala (*Nala* = "River" or "Creek"), near Dasu (*one* S), Kohistan, Northwest Frontier Provinces.* The crystals are euhedral, usually slightly rounded and surficially frosted, and wedge-terminated to somewhat tabular, occasionally in an altered serpentine-like matrix but usually loose. According to Wayne Thompson, the occurrence actually consists of several pits along a single trend, each one yielding a somewhat different habit. They can get up to 8 cm long, and are generally thick, and reliably gemmy inside. Dudley himself had some, as did Wayne Thompson, Ken and Rosemary Roberts, François Lietard, and many berobed and beturbaned Pakistanis around the hotel rooms; and Herb Obodda had three whole flats of small ones!

Doing just their second Tucson Show this year were some politely eager Chinese folks (with indispensable translator) from a dealership named after its owner: *Zheng Jian-Rong* (75 Renmin Rd., Changsha, People's Republic of China). In this Executive Inn room were diverse supplies of recent Chinese minerals of now familiar kinds (**cinnabar**, blue **fluorite**, **stibnite**), including a few noteworthy flats of very good scarlet **realgar** in loose crystals to 7 cm, and a few mammoth calcite/realgar pieces, from the Shimen mine, Hunan Province. Most interesting to me, though, was their tableful of tabular **beryl** (var. aquamarine), orange **scheelite**, and **cassiterite** specimens from Xue Bao Diang Mountain, Sichuan Province—and the source-information that came with these (once that translator got back into the room). According to Mr. Zheng, this locality is nothing more than a mountain with some near-surficial tin veins near the top of it: there is no "mine" and no ore production; there are only local farmers and villagers who climb the mountain with basic explosives and tools, blast their way to the specimen pockets, and haul the rocks down again to sell or trade with whomever. As we know by now, some of these specimens can be very fine, with near-gemmy orange scheelite pseudo-octahedrons to several centimeters, gemmy flat beryls, and brilliant cassiterite clusters, all resting (though never all three on the same matrix) on flat plates of densely packed gray-white mica (zinnwaldite?) books lying edge-on. At the Main Show, Ken and Rosemary Roberts of *Roberts Minerals* (P.O. Box 1267, Twain Harte, CA 95383) had a few magnificent specimens of the cassiterite, and an undamaged gemmy aquamarine tab 6 cm across on matrix—but the locality name from their sources is the "Ping Wu mine."

Also, Chinese **diamonds** in kimberlite matrix, Siberia-style, made their debut with Zheng Jian-Rong: eight miniatures with 2–3 mm diamonds, colorless/gemmy but of subhedral form, fairly deeply embedded, from Mengyin, Shandong Province.

Matrix **diamonds**, matter of fact, hereby get to be my segue to the usual lengthy Russian tour. In the Smales' room, Warren Boyd of *R. T. Boyd Limited* (Box 69546, 109 Thomas St., Oakville, Ontario, L6J 7R4 Canada) was proudly showing about 25 diamond-in-kimberlite specimens from the Udachny mine, Northern Siberia, and, it must be said, they outdistanced the Chinese ones by several *versts*. The embedded, clear octahedrons ranged from 0.5 to 2 carats by weight, with the champion being a flattened octahedron 1 cm across, only about half embedded in a 4 x 5-cm kimberlite lump.

The last couple of years have seen much justified excitement about the giant **sperrylite** crystals and crystal clusters found (and still being found) enclosed in a dense mixture of massive sulfides, some of the sulfides rare and/or new species, at Talnach, Norilsk, Siberia. Now it seems that late hydrothermal activity added some silicates also to this complex deposit, and Dr. Jaroslav Hyršl of the Czech dealership of *KARP* (P.O. Box 54, 272 80 Kladno, Czech Republic) showed me evidence: delicate wafery groups of very thin tabular, transparent, colorless to pale pink **apophyllite**, with individuals to 5 cm, subparallel clusters reaching 15 cm across, on matrix. That locality again is Talnach [platinum deposit], Norilsk [town], Siberia, Russia. Also from here come good specimens of **prehnite** with sharp, blocky, white crystals to 5 mm, as well as **thaumasite**, **calcite**, and black subhedral **wurtzite** crystals in massive **anhydrite**.

An even odder geochemical happening was unearthed by some Russian scientists last year as they were investigating fumarole vents at the Kudriavy volcano, on the northern tip of Iturup Island in the Kuril Island Arc, which divides the Sea of Okhotsk from the Pacific Ocean. Highly lustrous metallic microcrystals as small druses on fragments of pyroclastic debris at one particular vent have been determined to be **rhenium sulfide**, either ReS_2 or Re_2S_3 or both—the first clearly identified mineral(s) ever found in which the extremely rare element rhenium is an essential constituent. Such concentrations out of the volcanic gases require an enrichment by eight orders of magnitude, the Russians say, over the already high measured concentration of 2–10 parts per billion of mobilized rhenium in the vapor. At Tucson, believe it or not, specimens were available, (unofficially) named after the rare metal. Three miniatures offered by a dealership named *Syntaxis*, and ten more by the Fersman Museum, Moscow, are dark lumps of volcanic cinder with fairly generous coverages of brilliant metallic gray-white microcrystal coatings. (For the initial published note on this unique occurrence see *Nature*, vol. 369, 5 May 1994, p. 51–52.)

Hungarian geologist András Lelkes (H-1051 Budapest, Hercegprímás u. 11, Hungary) had an Executive Inn room full of quite inexpensive specimens of the major, familiar species from Dalnegorsk, Primorskiy Kraj, Russia, and some Dalnegorsk oddities, e.g. **galena** on hedenbergite and greenish **beta-quartz** crystals. These were nice enough, but András also had the best of the show's sparse sampling of specimens of Russian **pyrochlore**. Opaque, vitreous brown, simple floater octahedrons can, while remaining quite sharp-edged, get up to 4 cm on edge. Somewhere along the Tatarka River, Krasnojarski Kraj, near Novosibirsk, Siberia, is an alluvial deposit where these giant crystals apparently float loose and may be picked out by hand (hence the absence of matrix pieces). The story runs that some mineral-smart people from the Urals have already come by and picked the "easy" ones out from the alluvium, so that getting more fine crystals out may necessitate finding the host rock and working it. Pyrochlore of this aspect is not to be confused with the adamantine brown-red crystals found lining calcite-filled seams at the niobium mine at Veshnovogorsk, Middle Urals—a good couple of thousand miles away to the west.

The Executive Inn room occupied by *Heliodor* (Pljaskov-Van Scriver Minerals, P.O. Box 10, 19900 Prague 9, Czech Republic) is always a mecca for those who want/need to keep up with what's new from Russia and Kazakhstan. The debut of Russian **platinum** crystals in this room during the 1993 Tucson Show made a big splash, of course, and now, eureka, there are more: perhaps half a dozen loose, almost razor-edged gray-white cube-penetration or spinel twins all around 5 mm, i.e. somewhat smaller but sharper than the earlier ones. The locality is Konder (village), near Nelkan, Ajano-Maiskiv Region, Khabarovsky Kraj, Russia. More mundanely but also more aesthetically, the bright yellow-orange radial balls of **stellerite** from the

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*Ed note: There is much confusion over the specific locality name because of the remoteness of the area, but all names do refer to what is essentially one locality, a string of six or eight prospect pits extending over a distance of 2 or 3 km. Nearby towns are Dasu (the largest), Kamila, Patan, Besham Village, Kagan and Naran. The locality is a two-day hike from Kamila, but can also be approached from Naran on the other side of the mountain. The most precise name for the site (not found on maps but used by all the local people) is *"Suppatt"* (or "S'pat" or "Sumput"), which refers to a small camp or cluster of seasonally-occupied huts in a summer grazing area at an altitude of about 14,000 feet. Probably the best way to state the locality is "Suppatt, between Kamila and Naran." (Information courtesy of Tahir Iqbal, who has visited the site.)

Sarbayskaya quarry, near Rudniy, Kusteni Oblast, N. Kazakhstan, were abundant, not only at *Heliodor* but generally at the show, and they're getting better and better. Occurring on a granular quartz matrix, the balls can reach 4 cm across.

From the great copper mine at Dzhezkazgan, Kazakhstan, some miniature specimens of splintery metallic gray **betekhtinite** in acicular flat-lying groups on matrix were being offered at the Main Show by *Wilke Mineralien*, and Dr. Wilke had chemical readouts (a customized one for each specimen) to prove that this betekhtinite, unlike some earlier material, is for real, i.e. not pseudomorphous after an earlier sulfosalt species.

Next, *Heliodor* had a flat full of excellent loose thumbnail prisms of deep red, part-gemmy **elbaite** from the Mikhaylovskoye mine, Malkane Pegmatite Field, near Krasniy Chikoy, Chita Oblast, South Siberia, good ones going for around $75. From the Eveslohor mine near Hibini, Kola Peninsula, there are further tricklings of the blocky, squat, dully raspberry-red single crystals, to 3 cm, of **eudialyte**, typically lying flat on a nepheline/aegirine/astrophyllite matrix. And, found just last fall, hence a true What's New for this show, there is **elpidite**, glassy to frosty off-white acicular crystals to 6 cm long, lightly pressed together in splintery groups somewhat resembling Flux mine, Arizona, cerussite and radically prettier than elpidite from Saint-Hilaire; these are from a pocket at Mt. Allnayo, Lovozero Massif, Kola Peninsula.

Heliodor also had a fine selection of—what else?—heliodor (yellow-green **beryl**) from the now-famous pegmatites at Volodarsk Volynsk in the Ukraine. Other dealers in the motels and the main show also had good selections, totalling such a large number of crystals that surely most collectors who really want one can now find a nice example in their price range. It is wonderful to see such abundance on something so beautiful, which in earlier years only the best-connected collectors could acquire.

Other goodies from *Heliodor* included a few more of the exquisite little **sal ammoniac** specimens in right-angle dendritic growths to 3 or 4 cm (some with native sulfur); brown **lorenzenite** crystals to 2 cm or more from near Hibini on the Kola Peninsula, Russia; superb, brown **titanite** crystal clusters to 2.5 cm across from the Dodo mine, 75 km northeast of Saranpaul in the Polar Urals, Russia; and a gorgeous old classic, a 22.5-cm aquamarine beryl crystal on quartz from the Ural Mountains, Russia.

Had enough of Russia? Well, there is just one more country left on the Grand tour.

A new Australian find was being shown at La Quinta by Dehne McLaughlin (22 Lanyon Tce. Moil, N.T. 0810 Australia): arborescent branchings of subhedral medium-bright native **copper** crystals shot all through masses of a glistening bright black stuff that at first glance made me think of iron-rich sphalerite but that actually is "*coal*" ("**pyrobitumen**" as the labels were calling it). The blebs and globules of "coal" threaded through and around by the copper are theorized by Dehne to have resulted from inorganic reduction of CO_2 in the supergene zone of this copper orebody that fills a volcanic breccia pipe, the Sandy Flat pipe, Redbank, N.T., Australia. And the copper/coal specimens even are strangely attractive: miniatures at their best are busy and twinkly, and cost around $100. From an overlying gossan zone of the same orebody, acicular cuprite makes thin seam linings of fine, brilliant red webbing in earthy "limonite." Finally, Cal and Kerith Graeber had four beautiful 8-mm diamond octahedrons of a rich brown color from the Argyle mine, Kimberley, Western Australia. These are the first Argyle crystals I've seen on the market, the 1990 *Mineralogical Record* article notwithstanding (vol. 21, p. 559–564).

Want something really surprising as a P.S.? How about terminated, fist-size green **tourmaline** crystals from a locality in *North Vietnam*!? The site, at Phac Ba Lake in Yen Bai province, has yielded a number of large crystals showing great promise (Jim and Mary Fong-Walker of *Ikon Minerals* had them).

I have no direct information on how dealers generally fared at this show, but my general sense, and the gist of overheard conversations all week, is that traffic was off somewhat from last year. At the Main Show, though, and despite the sparser crowds than last year, I certainly noticed no diminution in per-head energy levels; and gawkers gawked appreciatively at the many fine displays, especially the ones devoted to topaz, this year's theme species.

However, fatigue—mine, by now, after writing all this; yours, no doubt, after reading it—suggests that I'd best just give a quick list of the exhibits that most impressed me. To give also some sense of their number, variety and creativity, and of the effect of walking down that long middle row of cases enjoying one thing after another in no particular order, I'll list them as they appear in my notes:

Minerals of the Alps (Kay Robertson); "Black is Beautiful" (Beckie Bird); Morphology of Galena from East Rodopa Mountain, Bulgaria (Alexander Dikov); European classics from the Narodny Museum, Prague; Topaz [thumbnails] from Around the World (Sharon Cisneros); The Alabachka/Mursinka Gem Field (Peter Lyckberg); the 111-pound gemmy pale yellow topaz crystal from Teofilo Otoni, Brazil, acquired by the Smithsonian in 1981 and displayed all alone in a side case; Classic Russian Topaz (St. Petersburg Mining Institute); wonderful worldwide specimens from the Steve Smale collection; topaz from Schneckenstein (Bergakademie Frieberg); The Little Three mine, Ramona, California (Los Angeles County Natural History Museum); two cases of pseudomorph specimens, one by the Cincinnati Museum of Natural History, the other by the Royal Ontario Museum, Toronto; an incredible case of "imperial" Brazilian topaz crystals to 10 cm or more and cut gems of same, by an anonymous exhibitor; and many more than only a full listing could do justice to.

Awards

This year the coveted Desautels Award (successor to the earlier McDole trophy which was retired when McDole buddy Al McGuinness died), signifying still the "best rocks in the show," went to Paula Presmyk for her exquisite thumbnail collection. As it turns out, Paula also won the Lidstrom Award for best single specimen of any species, in this case a polybasite from Fresnillo, Mexico, in the same case. This is not the first time but actually the seventh or eighth that the same person has won the awards for best case and best individual specimen in the same year.

The Friends of Mineralogy presented their Best Article of the Year Award to Ulrich Burchard for his detailed review of the history of blowpipe analysis and portable blowpipe kits. This is the first time that a purely historical article has been recognized as Best Article of the Year. (For those of you wondering whether *The History of Mineral Collecting* special issue from November-December was in the running for this award, it was not; the editor's own works are considered exempt from consideration by the selection committee.)

Finally, there came the moment during the Saturday night program when the now-famous Carnegie Mineralogical Award is bestowed on an individual, group, organization or institution in "recognition of outstanding contributions which promote mineralogical preservation, conservation and education." The recipient this year was none other than *The Mineralogical Record* itself! Quoting from the press release provided by the Carnegie Museum of Natural History:

> The *Mineralogical Record*, considered one of the finest mineral-related periodicals in the world, is the recipient of The Carnegie Mineralogical Award for 1994. The magazine was formally recognized when Dr. Wendell E. Wilson, its editor and publisher, accepted the award from Dr. James E. King, director of The Carnegie Museum of Natural History, at a ceremony held the evening of Saturday, February 11 during the Tucson Gem and Mineral Show in Arizona.
>
> Now in its 26th year, the *Mineralogical Record* contributes to the science and hobby of mineralogy by presenting scientific, technical and aesthetic information of interest to both professional and amateur mineral collectors. Articles cover a broad

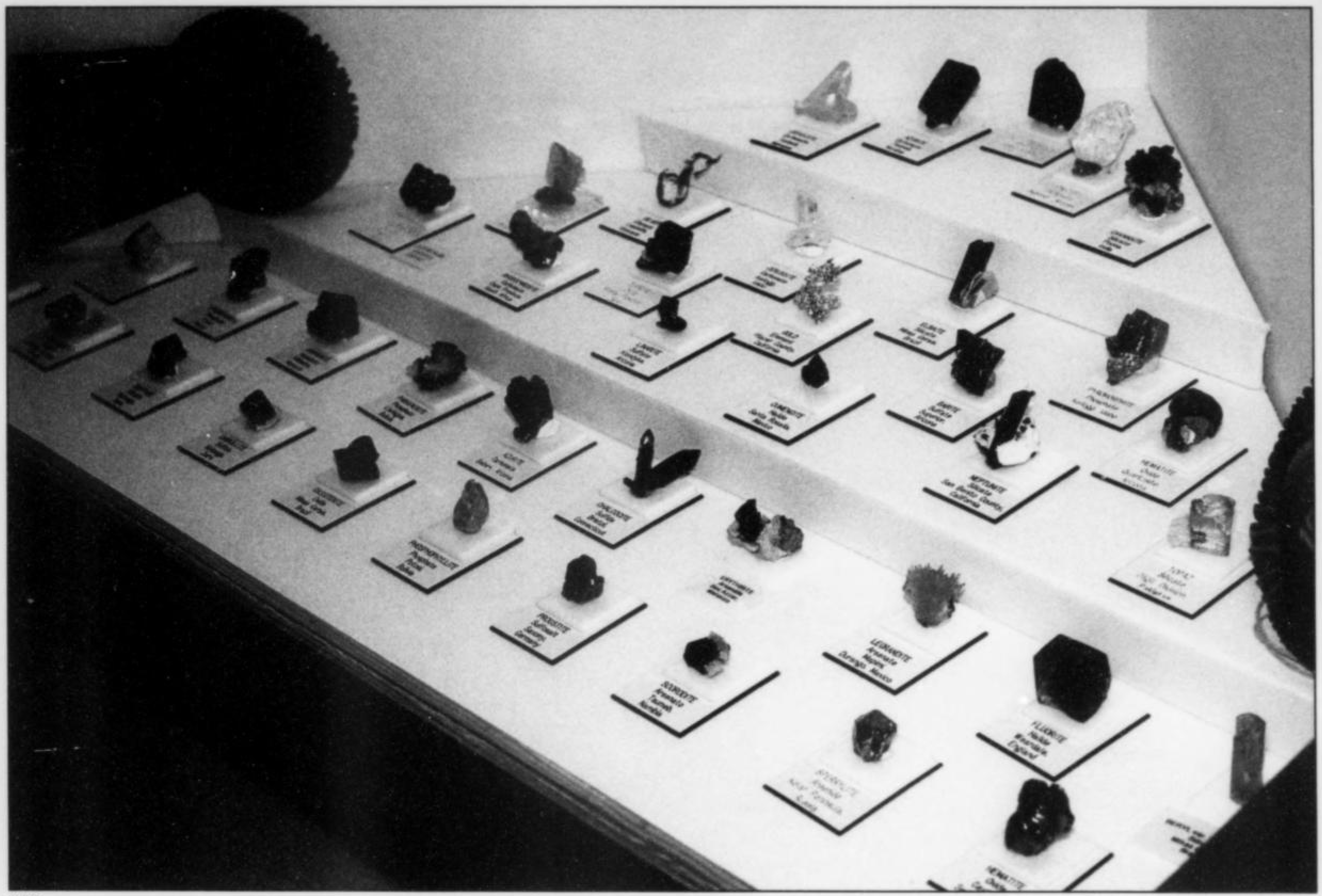

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Figure 45. **Paula Presmyk's case of thumbnail specimens, which was the winner of the Desautels Award; her polybasite (far left, middle tier) also won the Lidstrom Award for best individual specimen.**

range of subjects and levels of technicality, and have included pieces on mineral localities and regions; historical studies; profiles of museums, scientists, mineral dealers and private collectors; book reviews; and collecting anecdotes. Original research, particularly the description of new species, is a regular feature, and the magazine's quality photographic printing have set the standard for current mineral photography. In 1982, with the discovery of minrecordite, the *Mineralogical Record* became the only journal to have a new mineral species named in its honor.

Special-topic issues of the *Mineralogical Record* have focused on pegmatites, gold, tourmaline, silver, Arizona, Colorado, New Mexico, Nevada, Michigan's "Copper Country," Katanga, Greenland, Australia, mineral museums of Eastern Europe and, most recently, the history of mineral collecting from 1530 to 1799. Many of these issues stand alone as reference books and some have been published in hardcover editions.

In addition, the magazine has spawned a variety of subsidiary publications, including seven successive editions of the *Glossary of Mineral Species*, the definitive book on *Micromounting*, the International Mineralogical Association's *World Directory of Mineral Collections*, a cross-index to the localities represented in Goldschmidts' *Atlas der Krystallformen*, a superb work on *The Minerals of Cornwall and Devon* and the *Collector's Guide to Antique Miners' Candlesticks* (a book a mining history). Facsimile reproduction of a number of very old illustrated mineralogical works, that most collectors would otherwise never have the opportunity to see or own, have also been published.

In accepting the award on behalf of the magazine, Dr. Wilson made special note of the large number of people who have had a part in making the *Mineralogical Record* possible: John S. White, the founding editor; Dr. Arthur Montgomery, whose financial assistance got the *Record* going in the beginning; the Friends of Mineralogy; Mary Lynn Michela, the magazine's circulation manager since the very beginning; over 700 authors and photographers whose published work over 25 years represents countless thousands of hours of skilled research and labor; the hundreds of specimen owners who have allowed their minerals to be photographed and illustrated; the associate editors and directors; the many financial donors and sponsors; the thousands of donors and buyers who became involved in the fund-raising auctions; the many volunteers who assisted with those auctions; the hundreds of advertisers and especially the thousands of readers who have supported the magazine with their subscriptions and with their feedback. All of these people, he said, can claim a share in this award . . .

> All in all, a significant portion of the entire mineral community has collaborated in making the magazine possible . . . It's been a real community effort, and the *Record* stands, I hope, as a reflection of that enthusiastic community.

Nominations for next year's Carnegie Mineralogical Award should be sent to Marc L. Wilson, Section of Minerals, The Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, PA 15213.

Adios until next year, when the featured topic of the Tucson Show will be ***fluorescent minerals!***

Thomas Moore
15 Lakeview Drive
Niantic, CT 06357

Book Reviews

Meisterwerke Sächsischer Minerale ["Masterpieces of Saxon Minerals"]

by Eberhard Equit. Published (1994) by Eberhard Equit & Co. Verlagsgesellschaft, Fehrbelliner Strasse 49, D-10119 Berlin, Germany; tel./Fax: 011-49-030-448-3737. Hardcover, 24 x 31 cm, bound together as one: price $120; Hardcover folder edition containing bound text and loose plates: price $140. Add $15 for airmail postage to the U.S.

This review will be difficult to write without overusing my list of superlatives. Eberhard Equit, a professional artist and enthusiastic mineral collector, has borrowed nearly 100 of the finest Saxon mineral specimens now in German museums and private collections, and has spent three years rendering them in actual-size paintings of exquisite photographic detail. These are among the finest examples of mineral art produced in the last several centuries, and it would

No. 1

No. 2

Nr. 1: Apatite from Greifensteine
Nr. 2: Apatite from Ehrenfriedersdorf
(Specimen paintings by Eberhard Equit)

be a shame for any serious mineral collector to miss the opportunity of owning a copy of this book (only 1,500 have been printed).

Following a foreword and a brief introduction to Saxon minerals (13 pages, in German), there are first 11 plates depicting historic Saxon mining landscapes, mine buildings, headframes, an open pit, and the famous Schneckenstein topaz locality. These I did not find especially inspiring. But then comes the real treat: 49 full-color plates (about $9^{1}/_{2}$ x 12 inches) depicting 98 individual specimens, including many of such high quality that most collectors will be surprised to learn that such things exist: cabinet-size groups of large and well-formed native bismuth crystals, big crystal groups of nickel-skutterudite, octahedral blue fluorite crystals to 4 cm on an edge, big black whewellite crystals on matrix, superb scheelite crystals to an inch across, in groups on a fluorite crystal matrix, an incredible azurite group, and of course the expected plethora of proustites, the wonderful wire silvers, and the many other minerals that only the real students of German mineralogy will have known from Saxony: lustrous black cassiterite, green and purple apatite, golden barite, gemmy red roselite, beryl crystals (yellow and aqua), big mimetite crystals, blocky torbernites, and a really fine crocoite cabinet specimen to rival anything from the Urals, among others. Finally, at the end, is a list of collections that were drawn upon for specimens.

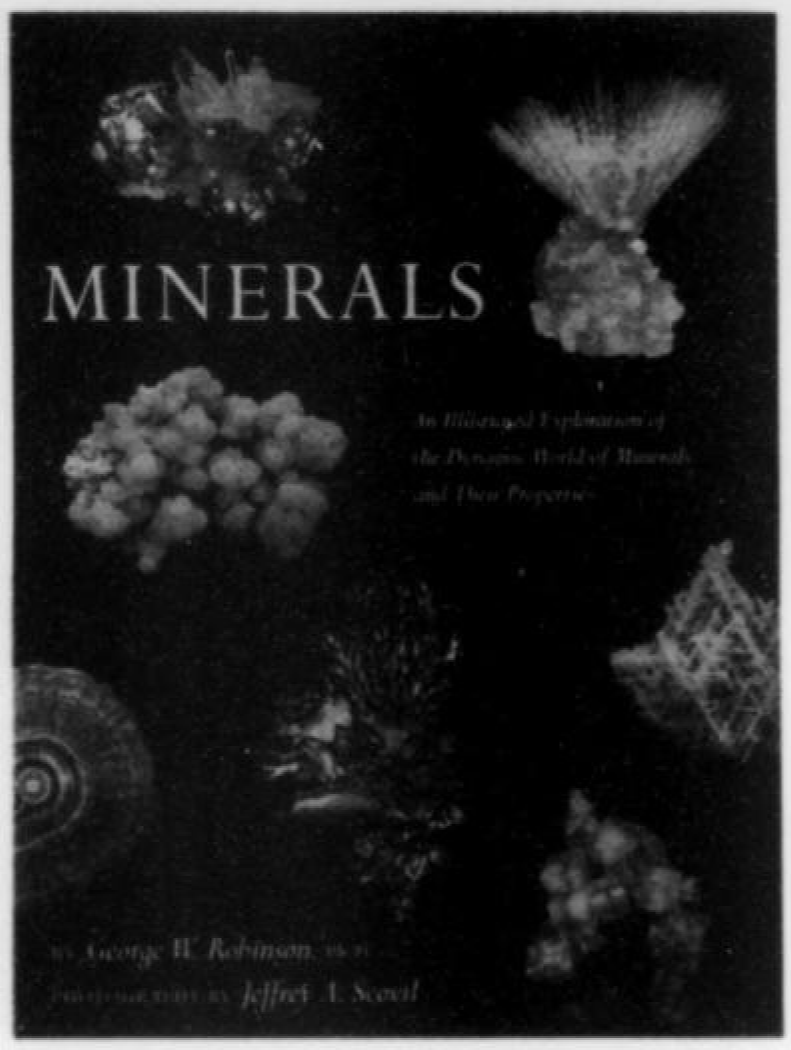
The only other comparable work in modern times was the fine portfolio of mineral paintings published by Claus Caspari back in the 1960's. Equit's work, like Caspari's, is clearly a labor of love, and we can be grateful that he was able to publish it at such a high level of quality. The printing was done using an extremely fine screen for maximum detail, and many of the metallic minerals are heighted by metallic inks, a feature not employed by Caspari, but traditional in early works of the 1700's and 1800's. The paper is very smooth but not glossy, and has a substantial thickness. In short, they did it right, and merit the highest recommendation.

This is a magnificent mineral book, truly in the old style, which can claim a place on even the antiquary's bookshelf, right alongside the famous illustrated works of Sowerby and Rashleigh.

W.E.W.

Minerals; An Illustrated Exploration of the Dynamic World of Minerals and Their Properties

by George W. Robinson, photography by Jeffrey A. Scovil. Published (1994) by Simon and Schuster, Rockefeller Center, 1230 Avenue of the Americas, New York, NY 10020. Hardcover with color dust jacket, 208 pages, 23 x 31 cm; price: US $40.00 ($52.00 Canadian).



This book, with text by George Robinson and photographs by Jeffrey Scovil, is the latest entry in the elegant "coffee-table book" category, and is a fine, fresh effort all around. Ever since Desautels' *The Mineral Kingdom* and Hurlbut's *Minerals and Man* came out in 1968, almost everyone with even a minor interest in minerals has enjoyed having such books around, sometimes to read and sometimes just to browse through the beautiful specimen photos.

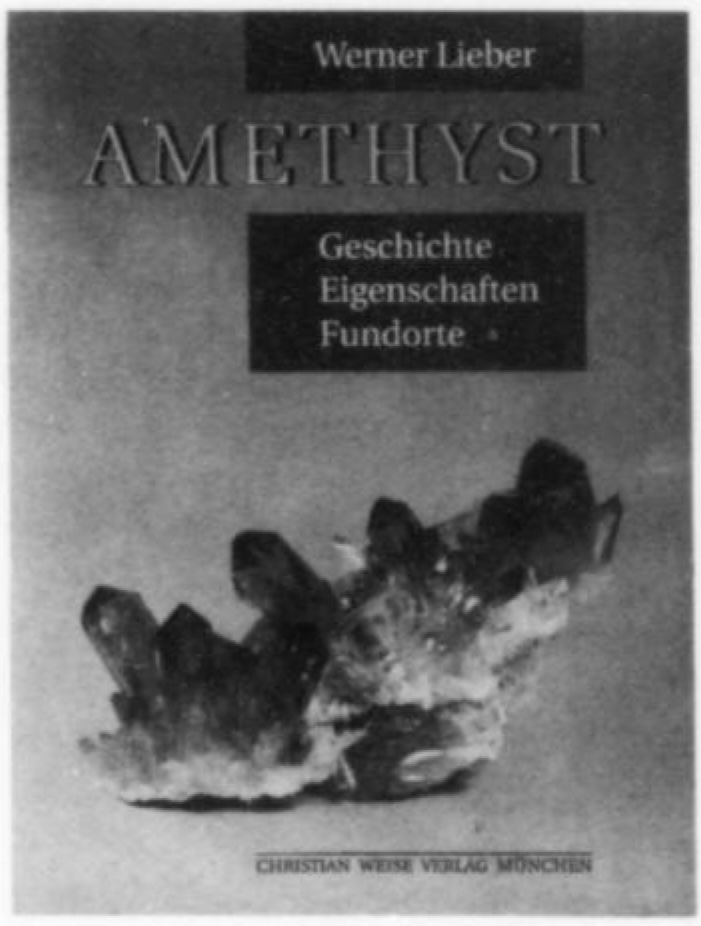
In the current case, Robinson's text and Scovil's photos each stand well alone and, when merged, present a comfortable balance between science and beauty . . . the best of both worlds.

The text, written in language which non-professionals can understand, describes systematically the ways and environments in which minerals are formed. Beginning on a large scale with plate tectonics, the author then describes mineral formation by four major processes: crystallization from magma, precipitation from water, chemical alteration, and recrystallization. In 28 chapters the book describes the various types of rocks and minerals formed by these four processes. In so doing, it makes understandable the formation of such interesting or little-known rocks and their associated minerals as carbonatites, evaporites, skarns and rodingites. Furthermore, the book emphasizes the impermanence of minerals on a geological time scale, and the critical importance of a changing chemical and physical environment on the stability of minerals. It makes clear which minerals can be expected in each type of occurrence. Appendices include a recommended reading list, and a table of over 120 common mineral species and the types of localities in which they occur. Excellent diagrams accompanying the text make clear the principles being presented.

The photography depicts nearly 150 excellent crystal specimens and a few cut stones selected from the extensive, world-class collection of the Canadian Museum of Nature in Ottawa. This is the first assemblage of high-quality specimen photography to showcase the general CMN collection, and as such the photos alone justify the price of the book. There are many treasures shown here which even the advanced collector familiar with the Museum's holdings will enjoy seeing. A fine Russian pyrochlore (found only recently) demonstrates that the collection is right up to date. And museum-quality classics such as the Brazilian euclase and rose quartz specimens, the Cavradi hematite, the Hotazel rhodochrosite, the Lengenbach jordanite, the Ojuela legrandite, the Kongsberg silver, and a fascinating two-generation Musonoi torbernite/metatorbernite, among many others, help to convey the depth of this great collection. In addition, the technical and aesthetic quality of the photography (specimen quality aside) serves to firmly establish Jeffrey Scovil among the ranks of the world's top mineral photographers.

The only minor shortcoming, if it can be called that, is a tendency to resort to unsophisticated analogies (e.g. "somewhat like a tossed salad as compared to vegetable juice," and "after all, we can't make a ham sandwich from leftover turkey") which may put off the advanced reader. However, I highly recommend this text for beginning and middle-rank students of mineralogy who wish to learn more about the why's and how's of mineral formation; this is far more than simple descriptive mineralogy. And, of course, the illustrations, as museum documentation and as objects of aesthetic enjoyment, can be heartily recommended to all.

William A. Henderson, Jr.



Amethyst

by Werner Lieber, published (1994) by Christian Weise, Munich; hardcover, 21.5 x 28.5 cm, 188 pages, ISBN #3-921656-33-8; price DM 98 (about $65) plus postage. In German only, but worth the price for the photographs alone.

Dr. Werner Lieber, for many years Chief Chemist with Heidelberger Zement AG in Germany, and a driving force among mineral collectors in that country, is also well known to North American mineral collectors as an Associate Photographer for the *Mineralogical Record,* and as a collector of fine thumbnail specimens. His previous books, such as *Kristalle unter der Lupe* (1972), *Canyons, Kupfer und Kakteen* (1987), and *Calcit, Baustein des Lebens* (1990), have been illustrated lavishly with his exquisite photographs, scenic and scientific. The current volume, *Amethyst,* is no exception.

It is clear that much thought and preparation has been put into this book, not only by Dr. Lieber but by his publishers. The dust jacket is a finely composed, graded layout in shades of amethyst, and the cloth cover itself is a rich purple. Inside, the text is organized neatly into three parts: an historical introduction, a section on the mineralogy of amethyst, and a description of amethyst occurrences worldwide.

In the historical section we find reference to the human use of amethyst in one way or another over the past 5,000 years. Maps of Egyptian mines, photographs of an amethyst-beaded girdle from the grave of Princess Mereret (daughter of Sesostris II), and of an amethyst ring from Jericho, and outlines of hieroglyphic descriptions of the search for amethyst testify to the strength of its appeal from earliest times. Illustrations of sophisticated work by Roman and Greek artisans lead on into the use of amethyst in reliquaries and religious ornamentation in the Middle Ages, and, finally, to the modern carvings of Idar-Oberstein and China.

Scientific descriptions of amethyst occupy some 30 pages. While there is little here that cannot be found in other publications, Lieber has tied it neatly together, beginning with quartz and its polymorphs, and carrying forward into the development of typical amethystine quartz crystals, particularly in geodes. Chemical and physical properties are dealt with in straightforward fashion, with good, plain drawings illustrating twinning and the orientation of SiO_4 tetrahedra. As might be expected, there is a great deal of emphasis on optical properties, particularly as they lead into the development of color. Splendid color photographs of polished crystal slices between crossed polars add to the explanations. Photomicrographs of goethite, lepidocrocite and other inclusions enhance the descriptions. Most importantly, a section on the various oxidation states of iron and aluminum in relation to the colors developed in quartz under both radiation and heating adds a critical explanation of the phenomenon. A final two pages on the methods of synthesis give the information needed to distinguish between natural and synthetic amethyst.

The last section of the book, by far the biggest at 118 pages, is a description of worldwide occurrences of amethyst. Here, beginning with a plate of amethyst-bearing postage stamps to illustrate the importance of the mineral to many countries, Lieber launches into a sort of fantasy flight of photography. Each location, starting with Europe, then proceeding through Asia, Australia, Africa and the Americas, is meticulously documented, and illustrated where possible with photographs of the location, of the amethyst produced, and of local amethyst postage stamps. This is where the "fantasy flight" comes in, since the description of the localities acts really as a sort of a framework on which to hang a whole series of stunning photographs of amethyst of every shape and kind. These are photographs of natural crystals: there are no cut stones shown in this section (beyond slabbed and polished geodes and stalactites). Those photographs are the meat of the section, but be that as it may, the accompanying historical black and white photographs of localities are just as valuable in their own right.

The book closes with a reasonably complete literature list, a short index, and a list of localities.

As with almost any publication, there are minor typographical errors throughout, particularly in place names. Those are of little consequence. A more telling omission for some readers might be the rather shallow treatment of the gemological aspects of amethyst. There are no illustrations of cut stones after the historical section, except on some stamps. Information of interest to the gemologist is given as a series of references to other works, rather than in detail in the book. The references are, however, very thorough.

Although the book is published in German, the splendor of the photographs more than makes up for any language inability the reader might have. This one is a must for the mineral collector's library.

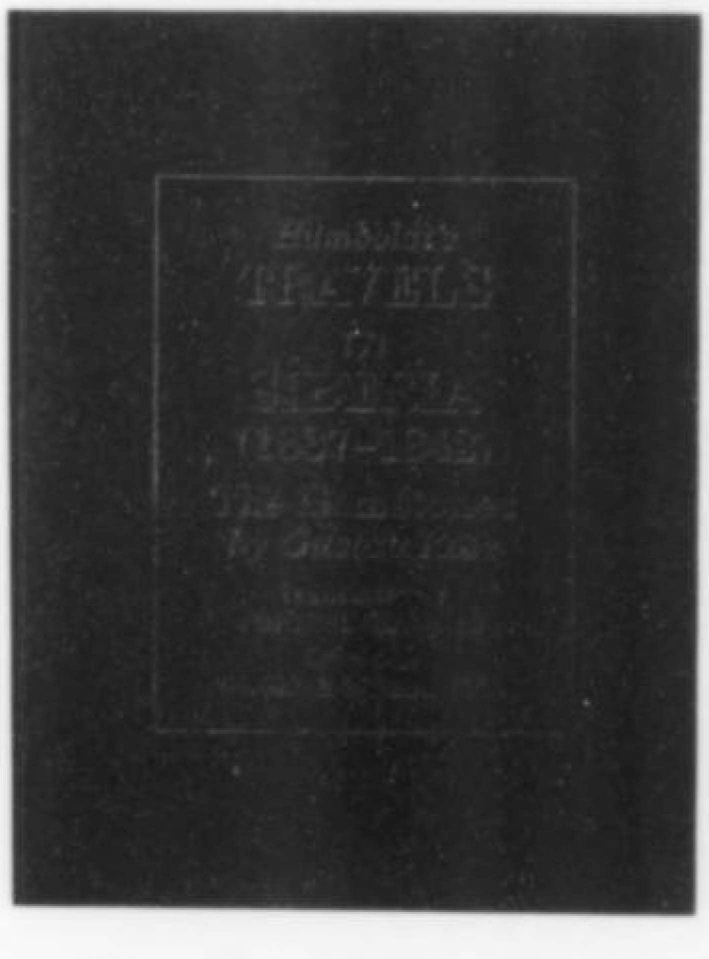
Quintin Wight

Mineralien und Fundstellen Deutschland ["Minerals and Localities of Germany"]

by Reiner Haake, Siegfried Flach and Rainer Bode. Published (1994) by Bode Verlag GmbH, Postfach 405, D-45716 Haltern, Germany. Hardcover, 21 x 28 cm, 244 pages, ISBN 3-925094-49-0, price DM 78 excluding postage. This is part 2, part 1 having been published in 1989. The two volumes are available as a set for DM 150.00. [in German]

This, the second volume of the mineralogy of Germany, covers the eastern part of the country. One thousand localities are identified in the regions of Mecklenburg, Brandenburg, Sachsen-Anhalt, Ostharz, Thüringen, Thuringer Wald. Ostthüringer Schiefergebirge, Vogtland, West-Erzgebirge, Schwarzenberger Kuppel, central Erzgebirge, ore deposits in Freiberg, Osterzgebirge, Granulitgebirge, Lausitz and Übriges Sachsen. Roughly 700 mineral species are discussed, illustrated by 350 photos, 220 in color. The excellent specimen photos are primarily the work of Rainer Bode, one of Europe's leading mineral photographers. As in part 1 (reviewed here in vol. 21, no. 5, p. 496), the text covers the mineralized areas first, then gives the descriptive mineralogy arranged in chemical order. There are locality and species indexes; for species first described from Germany, the original reference is cited. The two volumes comprise a major work, and a valuable reference on the topological mineralogy of Germany.

Michael O'Donoghue



Humboldt's Travels in Siberia (1837–1842); The Gemstones by Gustav Rose

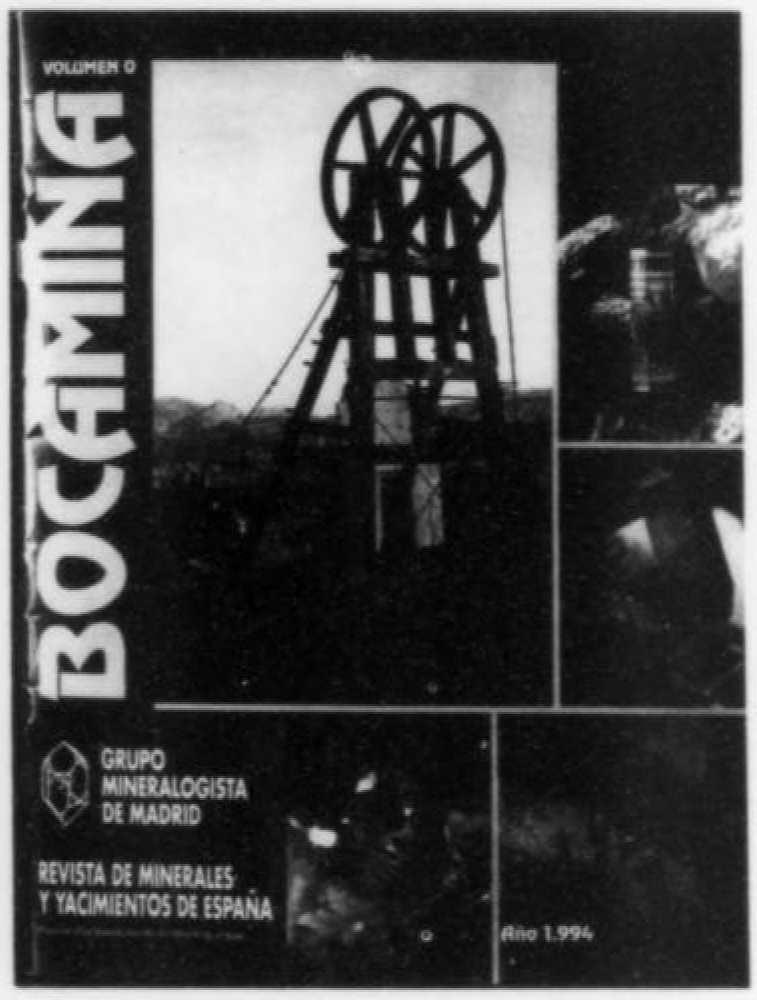
translated by John Sinkankas. Published (1994) by Geoscience Press, Inc., 12629 N. Tatum Blvd., Suite 201, Phoenix, AZ 85032. Hardcover, 22 x 28 cm, 80 pages, price: $25 plus postage. ISBN 0-945005-17-2.

At the invitation of the Russian Czar, Nicholas I (1796–1855), three German scientists undertook a scientific expedition into the remote Siberian reaches of the Russian Empire in 1837. Alexander von Humboldt, accompanied by Gustav Rose and Christian Ehrenberg, covered nearly 16,000 kilometers in their travels, reaching as far east as the Altai Mountains, just north of the Mongolian border. Rose, the mineralogical expert of the group, recorded the account of their investigations, published in 1837 as *Reise nach dem Ural, dem Altai und dem Kaspischen Meere.*

John Sinkankas has made this enjoyable work accessible now to the English-speaking community by providing a translation of the good parts, i.e. those dealing with the gem deposits (omitting, unfortunately, some of the non-gem mineral species covered, but that's quibbling). Occurrences dealt with include the Mursinka pegmatites, the Gumeschevsk copper mine, the Nizhne-Tagilsk district, the Schaitansk tourmaline deposit, the Takovaja emerald deposit (including discussion of the famous chrysoberyls) and the Miask deposits, among others. In addition, Sinkankas has provided the reader with ample footnotes, helpful definitions, conversion factors for Rose's weights and measures, corrections and criticisms which allow a full comprehension of the extracts. At the end we find also a short biography of Rose himself.

This is a fine, scholarly contribution which happens also to make very interesting reading. I recommend it to anyone with an interest in the history of mineralogy or gemology.

W.E.W.



Bocamina, Magazine of the Mineral Deposits and Mineralogy of Spain

by the Grupo Mineralogista de Madrid (1994), Publisher Gonzalo Garcia Garcia, Editor in Chief Jose Manuel Gordillo Piñan, E.T.S. de Ingenieros de Minas de Madrid, Departamento de Ingeniería Geológica, C/Ríos Rosas, 21, 28003 Madrid, Spain. Saddle-stitched magazine format, 23 x 30 cm, 66 pages with color photography throughout. (In Spanish)

This is the first trial issue of a magazine devoted specifically to mineral collecting in Spain. The editors and authors have done an excellent job of packing as much pure collector interest into the issue as possible. Taking some of Spain's most famous specimen localities one at a time and reviewing the species of principal interest, they have saved space by eliminating historical and geological descriptions and going straight for the minerals.

The 28 localities covered are lavishly illustrated with 108 superb color specimen photos and 58 (mostly black and white) locality photos taken at the surface workings and underground. Localities covered include such famous names as Almadén, Linares, El Horcajo, Eugui, Rio Tinto, Hiendelaencina, the fluorite occurrences at La Collada and Berbes, and the Picos de Europa sphalerite deposit, among others.

This issue is a delight for the mineral lover, though advanced collectors will lament the omission of at least some bibliographies which might have put them in touch with more detailed discussions of these localities. Will there be a second issue of *Bocamina* in the future? That has yet to be decided, but even if not, "volumen O" will be good to have at hand as a refresher course on some of the more important and aesthetic collectible minerals of Spain.

W.E.W.

MINLOG

mineral collection cataloging software. Published (1993) by Beaver Software Development, P.O. Box 1608, Marietta, GA 30061; tel: 1-800-785-7358. Price: $85 to $230, depending on version; demo disk available for $5, refundable with order.

Probably the most important thing anyone can do with a mineral collection [or a mineral *photo* collection. Ed.], besides housing it in a clean, dry place, is number and catalog it. Don't hope that labels will stay with specimens; any collector who has bought or been given an old collection has encountered the problem of unlabeled specimens.

Old catalogs are paper-based, in notebooks, ledgers, card files; but today nothing can match the value and flexibility of a computerized catalog organized on a database program. Information can be entered in a computer database in any order and edited readily; the catalog, even a large one, can be kept on a floppy disk that fits in a pocket and can be duplicated quickly and easily. Best of all, computer catalogs can be searched and arranged in many ways, depending on how the original format of the catalog is set up. What a database won't do is write the information down for you. Any catalog involves a time commitment, and an elaborate catalog for a large collection can take a great deal of time. For some, organizing a catalog and entering the information is one of the joys of having a collection; for others it is drudgery. But if you want a catalog, you have to spend the time making it, whether it is computer-based or not.

A few years ago, would-be computer catalogers had to know how to use a database program, and develop a catalog format themselves. Now there are two mineralogical database cataloging programs available—the *Museum Database System* developed by Joe Nagle of *Kustos* (2961 Semiahmoo Trail, Surrey, BC), and *MINLOG*, by Jim Beaver of *Beaver Software Development* (P.O. Box 1608, Marietta, GA 30061). The *Museum Database System* is custom designed to fit the needs of any collection, and it can accommodate long passages of text. The catalog can be organized and searched in almost any way you can think of, to retrieve any information you want. Powerful and flexible, it is also designed to not become obsolete but to adapt to new database programs that will come along. However, it is really intended for large collections, and it is expensive—several thousand dollars for a typical installation plus training. If you want the best, a system that can do anything, contact Joe. However, if you want something good, serviceable, and inexpensive ($85 to $225, depending on the version) *MINLOG* is a good choice. There is also a *MINLOG* gem database, which can be included in the mineral program or bought separately; it is not reviewed here.

MINLOG requires an IBM-compatible computer running Windows 3.1 or higher. If you don't have a computer yet, *MINLOG* is a good reason to get one. If you are a novice, some of the jargon about fields and clicking in this article may be unfamiliar; sorry. (It took me about a year to become comfortable using a computer; my daughter started at eight and thinks it's instinctive.) If you have a computer and want to try *MINLOG,* Jim sends out a demo disk for $5, with a fee applicable towards purchase of the program. The disk contains a limited version of *MINLOG* and a walk-through tutorial. The underlying database program for *MINLOG* is Borland International's *ObjectVision*. You do not get full access to *ObjectVision* by buying *MINLOG,* but you do get to use some of *ObjectVision*'s functions.

I have spent some time playing with *MINLOG.* It is a straightforward program that is easy to use. The manual is clearly written, but would benefit from editing to emphasize the basic points. However, it is not unfriendly, as the average program manual is, and an hour spent fooling around with the program and getting to know its parts is enough to get you going with it. Once you are into the data entry form, the procedure is simple, and the time and thought that has been spent on this program become evident.

The data entry form is where you do the work of entering information. It looks like a catalog card, with sections for number and name, locality information, acquisition information, and "other," including associations, occurrence, dimensions, comments, key words, and storage location. You can enter as little as the specimen number, or you can fill in every detail. The key to the catalog is that each specimen must have a unique number that ties it to a specific entry. A group of specimens can be given the same number if they are to be given one catalog card, but the number, not the mineral name or anything else, is what represents the specimen in the catalog. (Okay, you have to stick numbers on your specimens. Get to work. The *MINLOG* manual discusses ways of numbering specimens, but that topic could be the basis of a whole article.)

Enter the number first, then click on the down arrow (called a "combo box" in the program) next to the "mineral name" field. This activates a mineralogy reference database, and as you type the mineral name, a panel below the entry field scrolls through minerals, following the letters you type. You can type the entire mineral name (orthoclase), or just a distinctive enough first part (orthoc). When you enter it, the database automatically completes the name, enters the mineral group (such as feldspars), if any, the crystal system, the chemical class (such as tectosilicate), and the chemistry (K aluminosilicate). There is a tremendous amount of work in this database, and it is a welcome feature of the program. I did find an occasional error—silver is isometric, not hexagonal, and hyalophane contains barium—but overall, it is an excellent addition to the program. You can even use a routine to enter new information in the database, if you have species that are not represented—about 600 are.

The locality information is broken down into fields for site, town, township, county, state, and nation. Details about the site (540 stope, ninth level) can be entered under comments, or entered in the site field. There is another combo box for the states of the United States and Mexico and the provinces of Canada. By typing a few letters of the state or province name and clicking on the box, you get the full state name and the nation automatically entered.

Acquisition data include fields for origin, cost, date of acquisition, value, and other information. If you have heirs who someday will have to dispose of your collection, the cost and value information is important, and value should be kept updated. Your heirs will thank you.

Association information includes matrix rock, associated minerals, and another combo box that gives occurrences, such as "Alpine fissure vein," in alphabetical order; this allows you consistency in labeling types of occurrence. It can also be educational, helping you to think about the details of the occurrence. There are fields for dimensions, brief description, comments and key words, including a code for showing storage location and the size of the box the specimen is in.

If you want to edit a "card," you type the catalog number and the entire data record is displayed. It can be edited and saved in its new form. If you want to print a particular data record, the print screen command in the main database is easy to use.

The great strength of computer-based catalogs is the ability of their underlying database programs to retrieve and organize data. *MINLOG* can organize the catalog in any of dozens of ways and print a variety of reports, which include all or portions of data records arranged numerically, alphabetically by mineral name, or by chemistry, mineral class, crystal system, occurrence, or collecting locality. It can also generate customized labels in a variety of formats. A new upgrade, included in the program or available for $10 as a retrofit, allows you to print micromount labels.

To search data, create a report, or print labels, click on the "Print Control Menu" box on the Main Menu; "Print Control" is actually the report organizer. The print control menu shows a combo box with the coded name of a report listed, and the nature of the report explained on the screen. The report is generated by clicking on the "print report" box. It takes a few seconds to generate the report and display it on the screen; then you can scroll through the report with the mouse. If you want to actually print it, there are options for printing the entire report or only a portion.

I found it a little harder to generate reports than enter data, but half an hour's reading the user's manual and fooling around with the mouse was sufficient to get me going. A list of the report options in an appendix of the *Users Manual*, and a good explanation of them is included with the demo disk. The intent of *MINLOG* is to be easy to use, so that the beginner can start entering data and generating labels and reports quickly.

The ease of use and level of organization of *MINLOG* has some disadvantages—there are uses which it will not accommodate. At present, there is no way to enter formulas (rather than elemental information) or tie the catalog to videodisk images; Jim has said he may work on these problems if there is a demand. Information that does not fit one of the fields of the card is hard to enter. For example, a museum could not enter information on research specimens for which chemical analyses or other data is available, or which have been the subject of publications. However, a newly available *MINLOG* upgrade will allow users to flag specimens with as many as thirty user-defined keywords (whether based on locality, history, occurrence, habit, acquisition, etc.); and the specimens can be selectively retrieved from the database using reports which query specifically for the user-defined keywords. This provides some flexibility, which Joe Nagel's *Museum Database System* is designed to address exactly. It is a common problem with computer programs that ease of use and complete flexibility of applications are mutually hostile, and the programmer must make many choices. *MINLOG* has been organized around ease of use; most collectors will appreciate this choice.

Jim Beaver, the developer of *MINLOG*, is enormously enthusiastic, and willingly answered any questions I asked. His telephone number is on the main menu of the program as well as in the *User's Manual*, and he is happy to talk about the program and its operation any evening. He also publishes a quarterly newsletter, free to buyers of *MINLOG*, with information about updates and tricks of getting the most out of the program.

If you have ever thought about computerizing your collection catalog, get the *MINLOG* demo disk. *MINLOG* may be just what you need. It has a low price, is easy to use, and contains abundant mineralogical information in the lookup databases. I predict it will become the mineral collectors' standard.

Peter B. Leavens
Department of Geology
University of Delaware
Newark, DE 19716

Les anciennes mines de Padern-Montgaillard (Aude): Geologie, Histoire et Mineralogie

by Michel Deliens, Christian Berbain and Georges Favreau. Published by Association Française de Microminéralogie, c/o J-C Leydet, 2 avenue de la Porte des Lilas, 75020 Paris, France. Softcover, 92 pages (in French), 100 FFrs plus 7.5 FFrs postage.

The Association Française de Micromineralogie is a society of micromounters in France. Over the years, the Association has distinguished itself with a number of publications on the minerals of various French localities—particularly those featuring unusual species available in microcrystals. The current volume, the latest in the series, is a remarkably polished and informative production.

The Association is essentially an amateur group, but the senior author, Michel Deliens, is a professional mineralogist with the Mineralogy Section of the Belgian Royal Institute of Natural Sciences. North American readers may remember him as the featured speaker at the Mineralogical Symposium in Rochester, New York, in 1992. Dr. Deliens specializes in the mineral occurrences of southern France.

The area covered by the book lies in the far south of France, in the Mouthoumet Massif, roughly at the center of a triangle formed by three cities: Narbonne, Perpignan, and Carcassonne. The massif consists of four rock suites, mainly sediments, ranging in age from Ordovician to Carboniferous. A fifth suite of later material lies to the east and south. The massif was modified extensively during the Mesozoic, with periods of submergence, uplift and erosion, and was reworked during the Alpine orogeny. Quartz, barite and siderite veins penetrate the rocks, and karst conditions with bauxite development are major modifying features.

Minerals related to the five suites were introduced at varying times, and range from large barite deposits to silver and copper sulfides in the quartz. The major cations are Ag, As, Ba, Cu, Fe, Sb, Pb, RE, V and Zn. With such a selection of elements, and the extensive oxidation and reworking of the rocks, it is not surprising that the minerals bear a close resemblance to those of the American Southwest. The book lists 14 sulfides and sulfosalts, 5 oxides, 11 carbonates, 8 sulfates, 15 arsenates and 4 silicates.

The authors have done their research into the geology and mining history of the area. The large format of the pages (29.5 x 21 cm) has given them space for plenty of maps and photographs illustrating rock types, mineral localities and cross-sections of underground workings. Geological and historical information occupies the first 44 pages. For the collector, however, the meat of the volume is the section with descriptions of the minerals. Sixty-four species (including three unknowns) are described, most with technical crystal drawings, sketches of actual specimens, and SEM photographs. The habit drawings, by Laure Marchal and Raymond Pulou, are reminiscent of those by Fisher and Glenn in *Micro Minerals of Mont Saint-Hilaire, Québec.* They provide a welcome aid to identification. A further aid for identifications is provided by the last four pages, which contain 32 photomicrographs in color by Robert Vernet.

One interesting and useful addition to the descriptive material is a simple chart listing the minerals, and describing where each was found, whether it was crystalline or massive, and how it was identified. Identifications are shown as RX (X-ray), R (Raman spectroscopy), D (documentary—specimen not encountered during the study period), or NA (found, but not analyzed—i.e. quartz). The "D" designation is refreshing. Too many current guidebooks neglect to mention that a mineral may have been reported from a locality in 1860, but has not been seen since.

Although the text is in French, the mineral names are essentially the same, and the drawings and photographs are excellent guides to identification. This book would be a worthwhile addition to the library of any micromounter, particularly one who does much trading with European partners. The cost, roughly $20, is reasonable.

Quintin Wight

Los minerales y la minería de la Sierra Albarrana y su entorno. ["The Minerals and Mining of Sierra Albarrana and Its Surroundings"]

by Benjamin Calvo Perez, Jose Gonzaléz del Tánago Chanrai and Jose González del Tánago y del Rio. (In Spanish). Published (1991) by Fundación ENRESA, c/o Emilio Vargas, 28043 Madrid, Spain. Softcover, 24 x 27 cm, 203 pages, price: free for the asking. ISBN 84-88196-00-8.

This handsome guidebook is the kind of reference that every collector likes to have. It can be used as a working tool, as a compendium when identifying minerals from this area, or in planning a field trip (however, the reader is reminded that some minerals can no longer be found or are scarce at the moment).

Sierra Albarrana and its surroundings have an impressive history of minerals and mining. In the Sierra Albarrana area, a well-known mineral locality in Cordoba province, pegmatites, hosted and related to metamorphic rocks, yield the largest and best *brannerite* and *andalusite* crystals in the world. Moreover, those pegmatites boast *bastnasite-(Ce)* and *magniotriplite,* minerals so far found in Spain only at this locality.

The volume is composed of seven sections. The introductory chapters contain a brief explanation of regional geology and mining. From page 47 through page 163 the authors give descriptive information about the minerals which have been found, arranged alphabetically by species, with chemical composition, plus photographs and crystal drawings. Finally, the closing chapter on mining history describes the mining work in that region from prehistoric times to the present.

The book has plenty of good photographs, including three previously unpublished which have historical value. The bibliography, with 63 entries, is a useful tool for collectors.

ENRESA publishes and delivers this book free of charge.

Juan R. Párraga

Mineral & Erz in den Hohen Tauern

conceived and organized by Dr. Robert Seeman. Published (1994) by the Naturhistorisches Museum Wien, Burgring 7, A-1010 Vienna, Austria. Softcover, 21 x 29.5 cm, 149 pages, price: 30 DM excluding overseas postage (from Bode Verlag, Dürnberg 2, D-45721 Haltern, Germany). ISBN 3-900-275-48-3.

Geology and formation of the High Tauern area of Austria are covered in the opening chapters of this well-produced, multi-author compendium. Readers will also find much of interest in the accounts of early mineralogical studies, while others will turn to the chapters describing the minerals themselves. The Hohe Tauern has produced fine gold crystals, quartz, epidote (from Knappenwand), garnet and sphene, among others. Each chapter has a list of references. The large page format, high-quality paper, excellent printing and elegant layout make this a handsome volume.

Michael O'Donoghue

Die Mineralien und Erzlagerstätten Osterreichs ["The Minerals and Ore Deposits of Austria"]

by Exel Reinhard. Published (1993) by the author, Malborghetgasse 31/7, A-1010 Vienna, Austria. Hardcover, 447 pages, no photographs, but with text figures, tables and maps; price: 1,250 Austrian schillings; ISBN 3-9500-213.

Though illustrations of specimens would have been welcome, this is an excellent and long-awaited review of the mineralogy of Austria. This is a country whose geographic subdivisions have often had their own separately published mineralogies, which are now quite rare, though some have been reprinted in recent times. Perhaps not since Zepharovich's *Mineralogisches Lexicon für das Kaiserthum Österreich* (1859–1893) has the country as a whole been treated so thoroughly.

The present work opens with a historical survey covering the earliest accounts of geology and mining up to the present time, with short biographies of notable Austrian mineralogists. Next come chapters on mineral production, collecting and regional geology. Most readers, however, will turn first to the descriptive mineralogy section (about 100 pages); each species entry includes an up-to-date reference where available, often with crystal diagrams; locality information is also given. The book concludes with a dictionary of Austrian mineral species and a really first-class, 45-page bibliography.

Michael O'Donoghue

Die Mineralien von Hagendorf und ihre Bestimmung ["The Minerals of Hagendorf and their Identification"]

by J. Kastning and J. Schlüter. Published (1994) as Band 2 of the Schriften des Mineralogischen Museums der Universität Hamburg by Christian Weise Verlag, Orleansstrasse 69, D-81667 München, Germany. Hardcover, 21.5 x 30 cm, price DM 70 excluding postage.

Discovered in 1894, the now-famous pegmatite at Hagendorf-Süd in Bavaria, about 20 km east-southeast of Weiden, was a major supplier of feldspar to the European ceramics industry until its closure in 1983. A total of 170 mineral species including 76 phosphates have been recorded there; of these, 12 were new to science: carlhintzeite, hagendorfite, jungite, keckite, laueite, lehnerite, parascholzite, phosphoferrite, pseudolaueite, scholzite and wilhelmvierlingite.

The Hagendorf pegmatite forms part of the Upper Palatine quartz-feldspar pegmatites linked to Variscan granite massifs dated at approximately 293 million years old. The pegmatites themselves are included in assyntic gneisses (620–600 million years old) forming part of the Moldanubian bedrock of the Bohemian Massif. The phosphates can be divided into pegmatitic to high-grade hydrothermal primary phosphates, *in situ* transformational products, and secondary phosphates.

The book describes all the minerals from the location, with many very well illustrated in color; there is a good account of the geology and mineralization, with a first-class bibliography.

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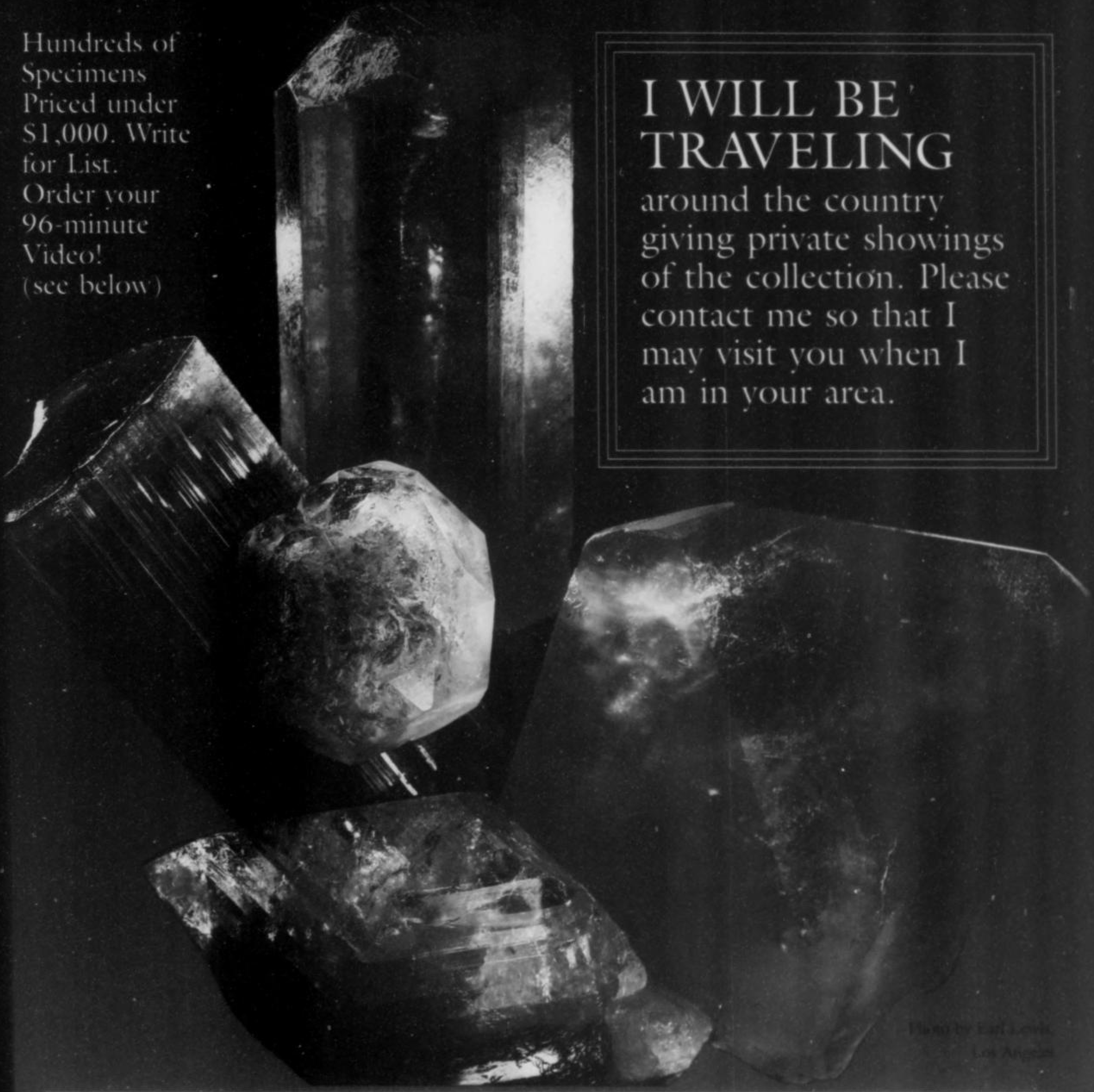

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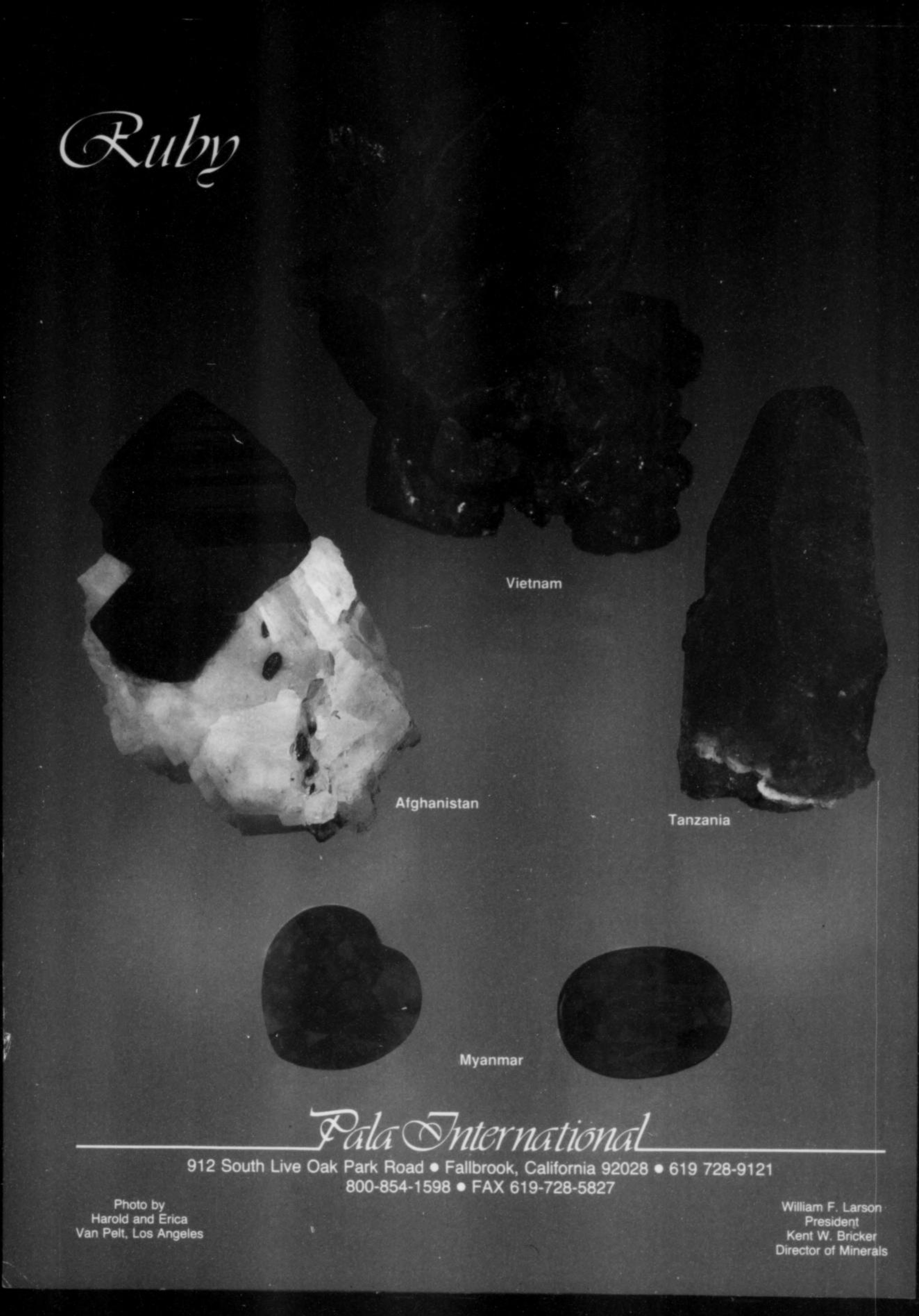
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