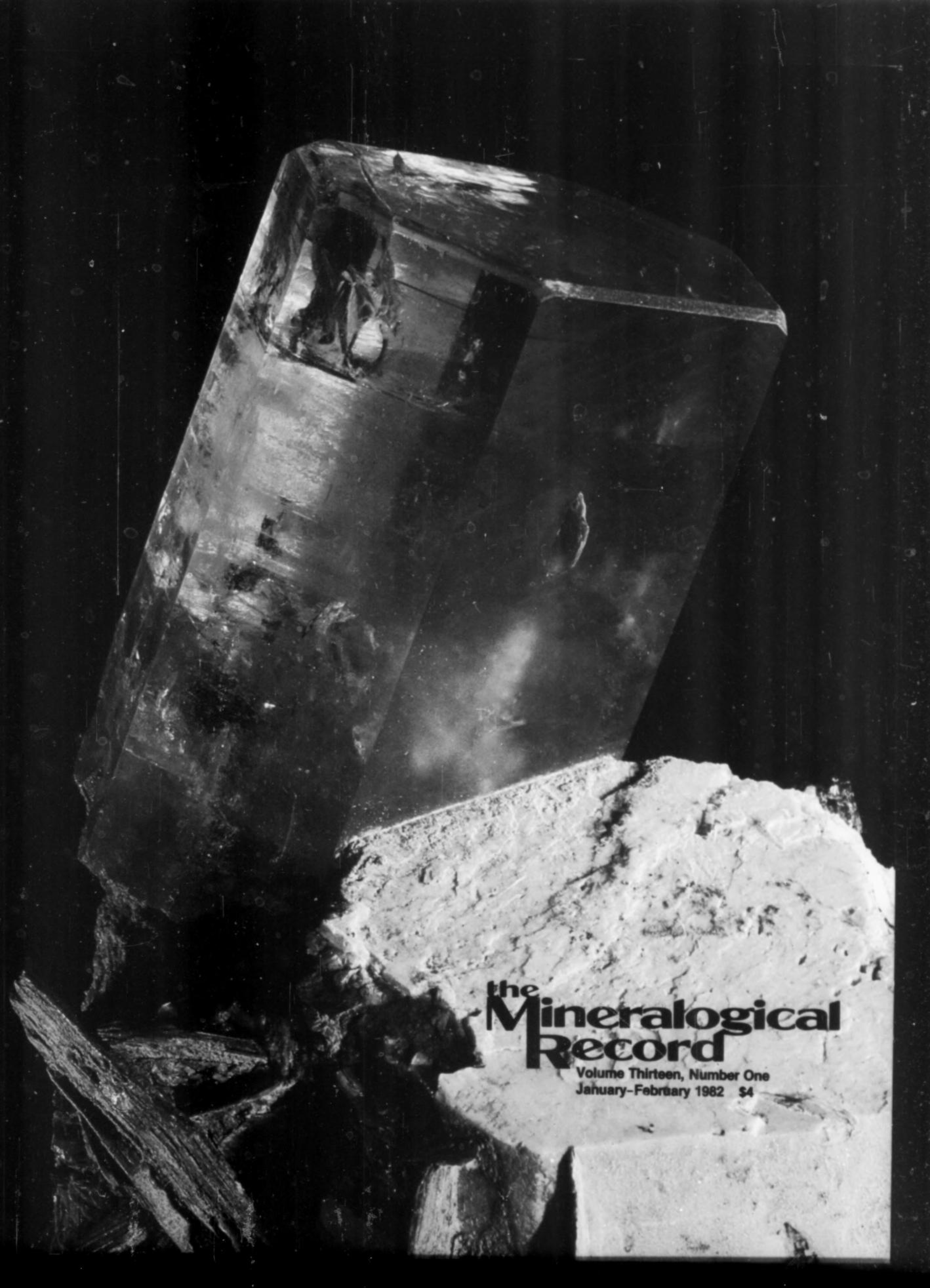

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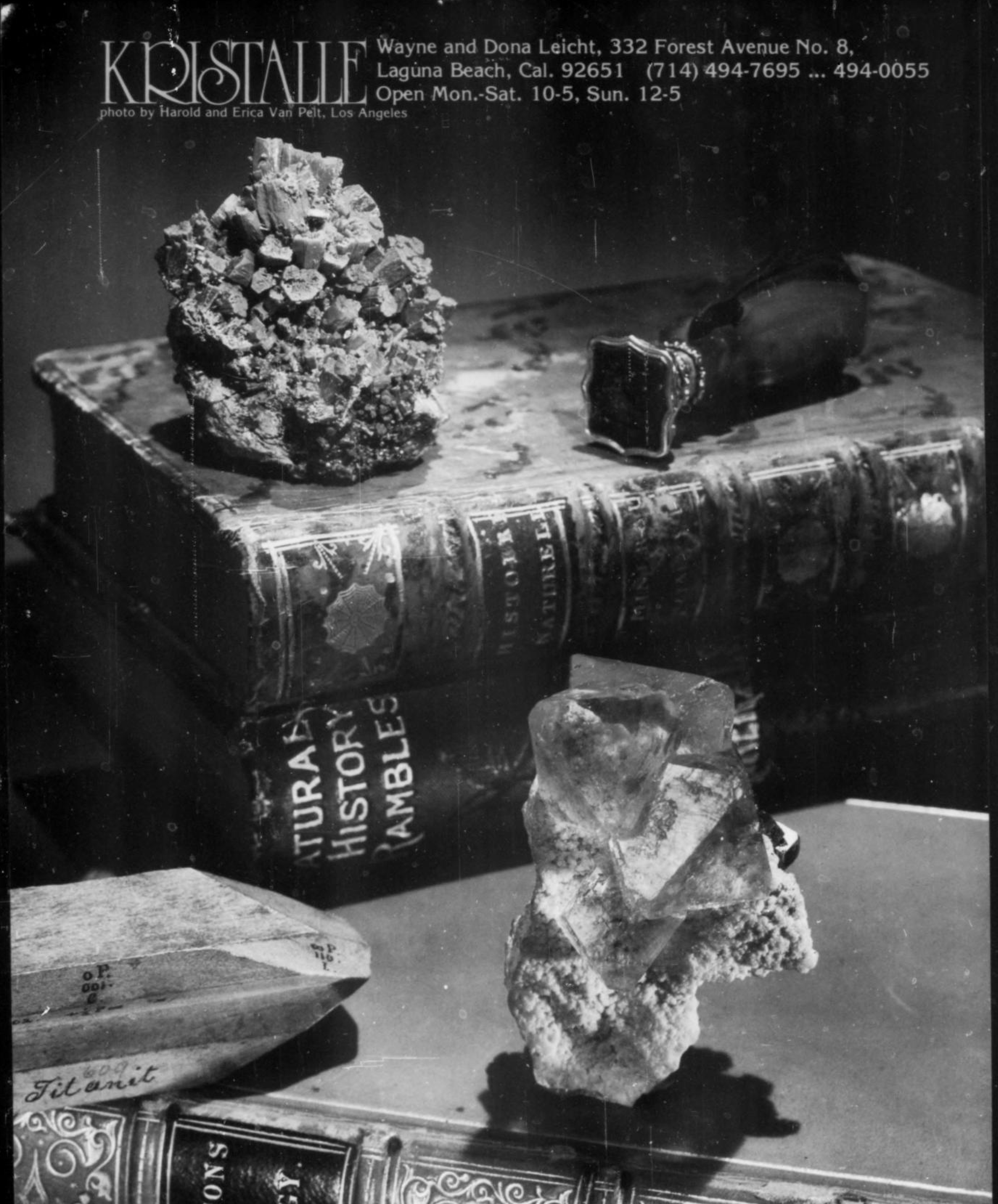

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Volume Thirteen, Number One
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notes from the EDITOR

IT'S THAT TIME AGAIN

We were hoping to be able to put off a subscription increase for another year (it's been two years since the last one). However, our printer recently boosted our printing cost, and other increases are threatening to nudge us off our precarious balance between the black and the red. So, effective January 1, 1982, our prices are as follows:

$20 for 1 year
$37 for 2 years
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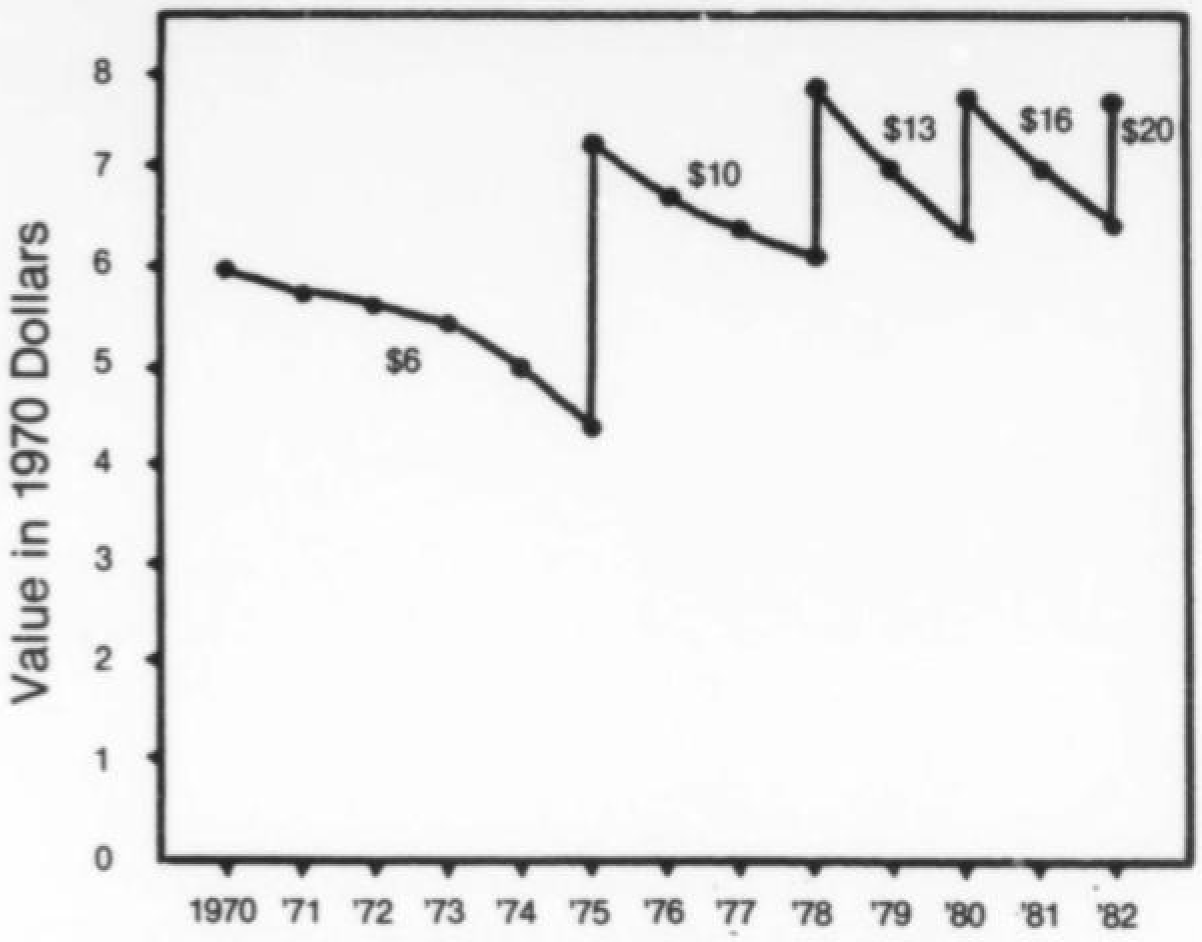
In terms of purchasing power of the dollar, this increase is nominal. The graph shows the value of the U.S. dollar, in 1970 dollars (our first year of publication), in terms of our subscription cost over the years. The present increase brings the real value of our subscription cost back up only to what it was in 1978 and 1980.

There will always be some subscribers who are very unhappy with such increases, and will consider dropping their subscription. But first consider which you'd rather have: a $20 mineral specimen, or a whole year of the *Record.*

OLD COPIES OF *The Mineralogist* AND *Rocks and Minerals*

Sharon Cisneros (*Mineralogical Research Co.*) recently wrote that she has a large number of old copies of *The Mineralogist* and *Rocks and Minerals* available, some dating back to the 1940's. People who are trying to fill out their collections of these publications should write to Sharon requesting her list of copies available. Many of those early issues are almost impossible to obtain these days, so this is a real opportunity. Sharon, incidentally, has just added a line of microscopes to her stock, and 36¢ will get you a catalog and price list.

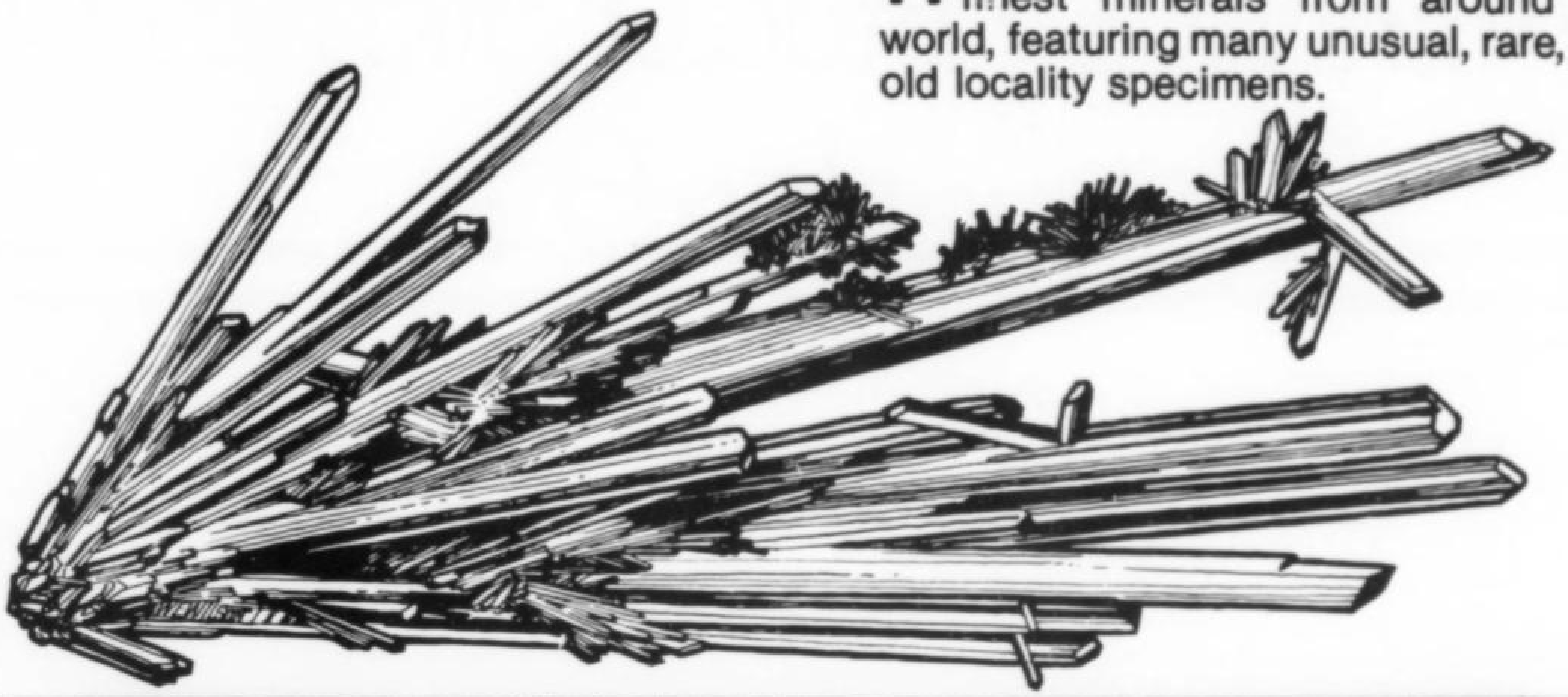


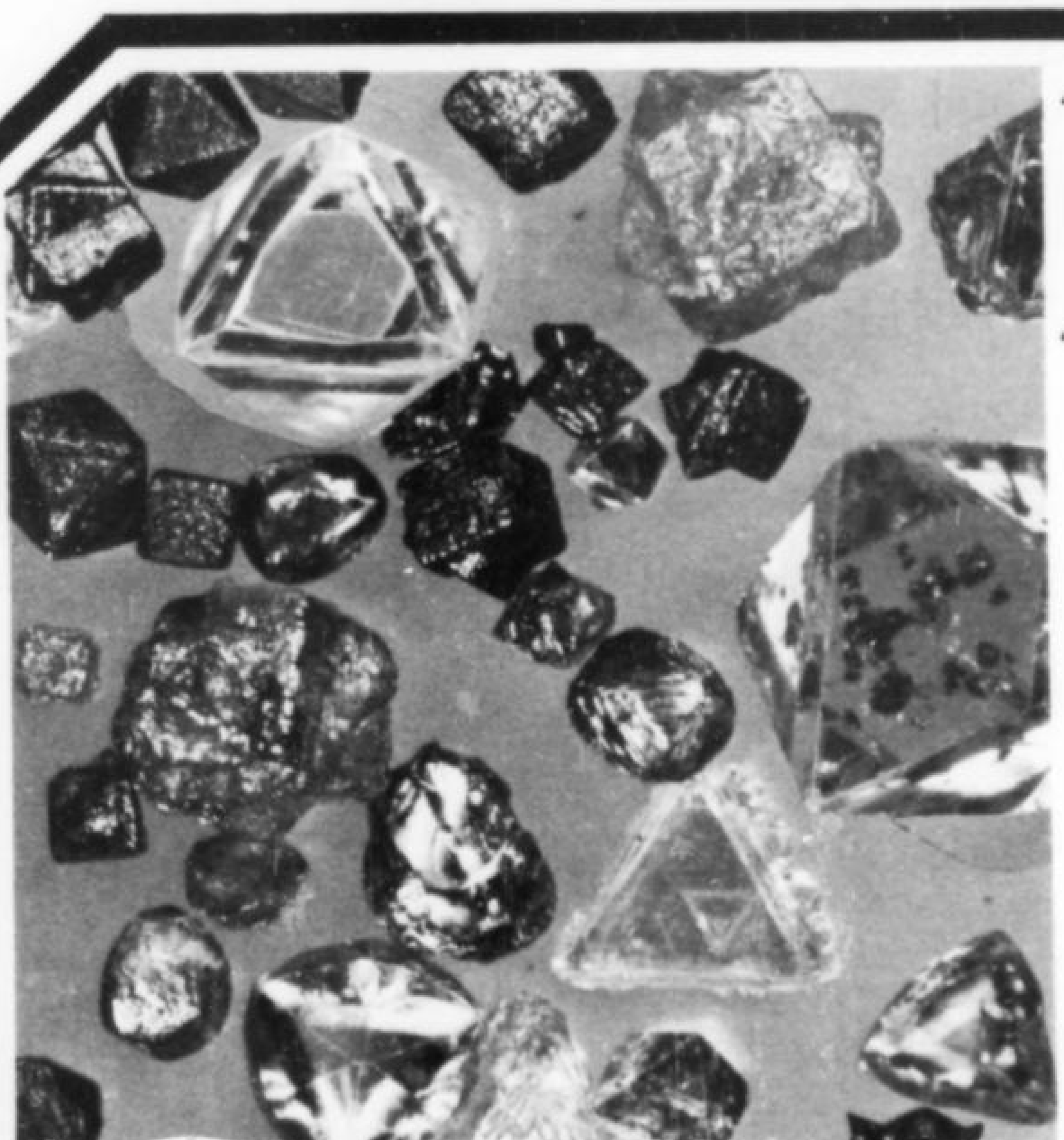
The effect of inflation on the value of the subscription price of the *Mineralogical Record* (data courtesy of the Department of Statistics, Washington, D.C.).

MINIATURE MINER'S LAMPS

An interesting sub-speciality in the collecting of miner's lamps is the miniature category. Miniatures were not made to be used as lamps, so few actually work. They were generally made as toys for the children of miners, as tie tacks or tie bars for miners, as give-away promotional items for use by mining executives, as part of sculptures depicting miners, or simply as little art objects and curiosities. Fine examples exist of many types including safety lamps, oil-wick or sunshine lamps, candleholders, frog lamps, and carbide cap lamps. Most are around an inch in size, though Ken and Betty Roberts (*Roberts Minerals*) know a jeweler who makes functioning carbide cap lamps around 2 inches tall.

Now two more examples, finely crafted by a Tucson artist, are available. The first is a miniature carbide cap lamp modeled after the Autolite brand, about 4/5 inch tall, in polished yellow bronze with a sterling silver reflector ($37.00). The second is a miniature miner's candleholder 2 inches long, nicely detailed, in sterling silver ($32.00). (Include $1.50 additional per item for postage and insurance.) Both items are available with attached loop for use with a neck chain, or with a tie tack back, or plain (for the purist) . . . be certain to specify which you want. Order from Peggy Francisco, 7702 E. Fayette St., Tucson, AZ 85730 (602-747-5143). Custom orders considered.





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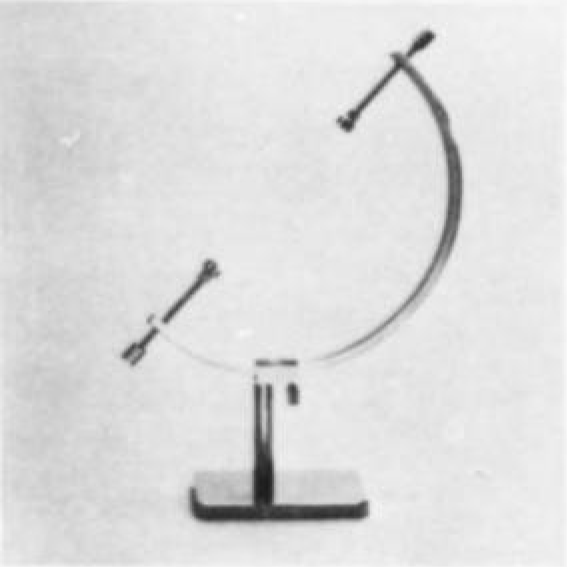

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the Boltsburn mine Weardale, County Durham, England

by **Robert J. King**
Department of Geology
The University of Leicester
LE1 7RH England

Weardale fluorite specimens, in large sizes and many colors, grace the collections of almost every museum and major private collection in the world. Since the 1800's, fine specimens have issued from the Boltsburn mine and are still occasionally available today.

INTRODUCTION

The name Weardale conjures up images of beautifully crystallized and exotically colored fluorite groups, renowned for their dramatic reaction to ultraviolet light. There are few important museums in the world which do not prize fine specimens from Weardale. The name Weardale is often synonymous with Boltsburn, for it is from the flats* in this famous mine that so many of the fine specimens came. Although the mine has been abandoned now for nearly 50 years, the wonder of its mineralogical treasures remains. This article is an attempt to make the mine more of a reality to collectors and mineralogists, rather than just a name on a label.

LOCATION

The Engine shaft, the former principal access to the workings of the mine, is situated in Rookhope Village in Weardale, County Durham, England, at National Grid Reference NY 937438. Although the headframe is now removed, the site of the former shaft (now capped) and the waterwheel pit may be found opposite the village school on the southwestern side of Rookhope Burn.

HISTORY

The date at which lead mining commenced in Weardale is unknown. The Romans, though accomplished miners in Britain, left no direct evidence of any mining or smelting activity in the area There is evidence of their former presence in Weardale, however, and Hadrian's Wall, built in A.D. 122, corresponds with the northern limits of the northern Pennine ore field.

Positive evidence that mining was actively in progress immediately following the Norman Conquest may be found in references to it in the Pipe Roll, dated 1130 A.D. One, for example, refers to the Carlisle silver mines which historians identify as the mines of Alston Moor and south Northumberland (Wallace, 1890). Weardale then belonged to the Bishops of Durham, following the establishment of the Palatinate in 1072, and was used by them as a hunting forest as well as a source of raw materials. The access gates are still recognizable in the two Weardale villages, Eastgate and Westgate. Numerous references to mining in this forest area occur in the Durham archives, including one reference to a lead and iron mine in Rookhope (Egglestone, 1882).

By the end of the 17th century most of the Weardale lodes had been discovered, but the 18th century saw the greatest development of lead mining and smelting in the northern Pennines, for which two mining companies were largely responsible. The London Lead Company acquired its first leases on Alston Moor in 1692, continuing active mining and smelting until eventually surrendering its leases in 1882. About the same time as the London Lead Company acquired its leases, Sir William Blackett founded a company and commenced work in the Allendale area and, shortly afterwards, acquired leases in Weardale. This latter active concern was handed on

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*Flats are horizontal metasomatic replacement bodies which lie in limestone adjacent to veins.

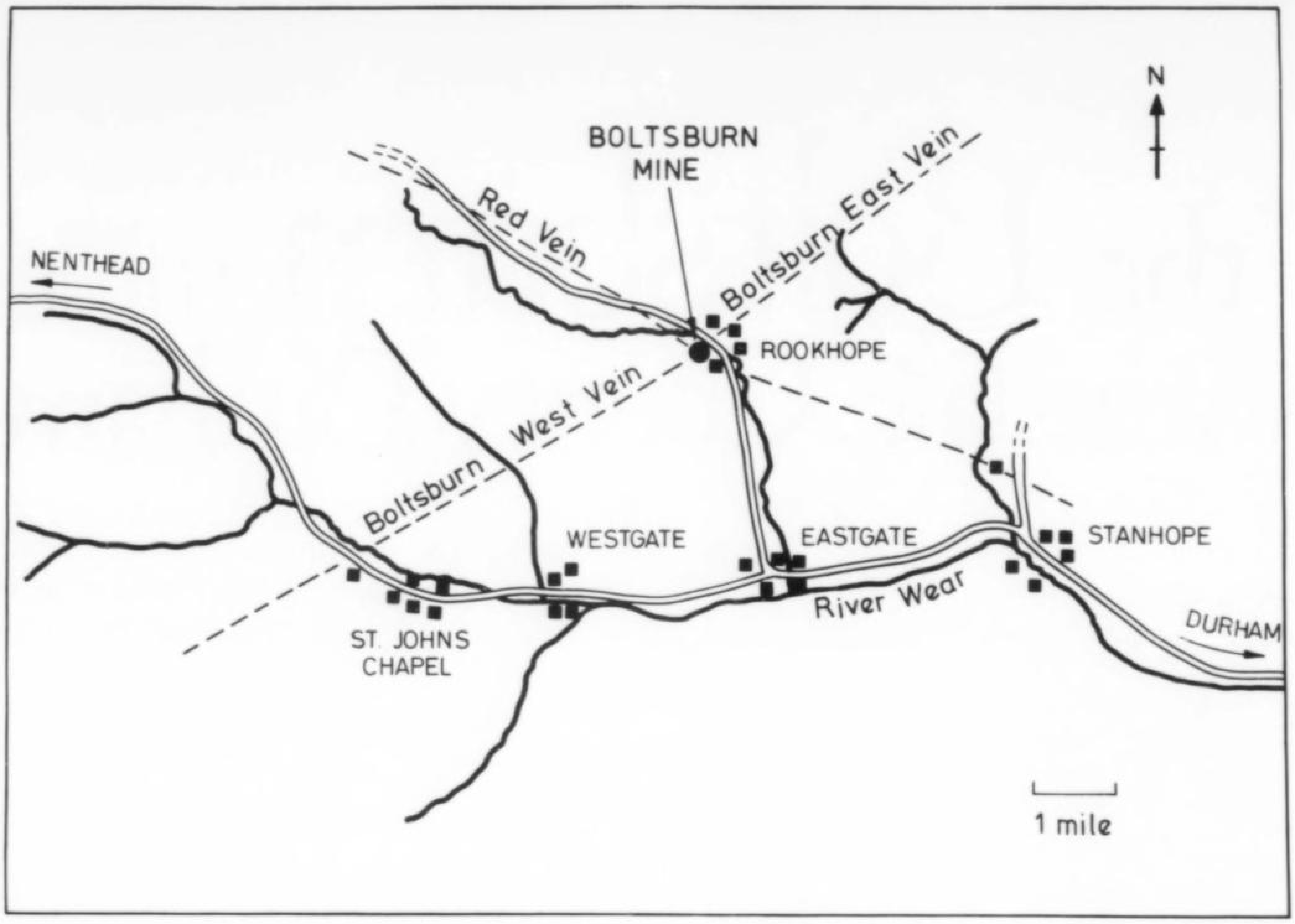


***Figure 1.* Location map showing the Boltsburn mine in the Weardale area.**

through Sir William's successors to the Beaumont family, receiving the title, by which it was subsequently known as the Beaumont Company, although it was not legalized as a limited company until much later. It abandoned its operations in Weardale shortly after the London Lead Company ceased work in 1884, believing that the end of profitable mining in the northern Pennines was in sight. In particular, its labors on the Boltsburn vein showed little profit.

Meanwhile, the Weardale Iron Company, commencing operations in 1842, was actively exploiting the relatively large reserves of oxidized ankeritic and sideritic ores present in the near-surface veins and flats. It has been estimated that 1,800,000 tons of iron ore were produced between 1842 and 1880 in the Weardale and Teesdale areas alone (Dunham, 1944). The Iron Company developed the Boltsburn West level for a distance of 4,200 feet from the portal at Rookhope, exploiting flats of limonite in the Great limestone. The oxidized zone was eventually "bottomed" and the unoxidized ankerite and siderite proved to be too poor to work as iron ores.

Following the cessation of activities by the Beaumont Company, the Weardale Lead Company took over the leases in Weardale, and was able to maintain a substantial output of lead concentrates up to 1931. The exploratory work done by this company northeast of Rookhope proved Boltsburn mine proper to be the most successful and profitable of lead mines operated in the northern Pennines during the 20th century.

The Horse or East level, driven by the old Beaumont Company, commences at an elevation of 1,058 feet, and continues for 5,800 feet to the northeast, commencing in the top of the Great limestone, and finishing above the Little limestone. The main workings, or Watts level, driven from Boltsburn Engine shaft on the southwest side of Rockhope Burn, opposite the village school, commenced 179 feet below the shaft collar at 907 feet elevation at the top of the Four Fathom limestone, and was driven 10,950 feet on the vein to the northeast, ending above the Little limestone. As the strata dip gently in a northeasterly direction, underground shafts were sunk to command access to the vein in the Great limestone. They were driven at 4,730 feet from the Engine shaft (Fairless' sump); 6,170 feet (No. 1 shaft); 8,175 feet (No. 2 shaft); and 9,825 feet (No. 3 shaft) (Dunham, 1948). An additional winze was sunk in 1930 from the bottom level of No. 3 shaft.

Boltsburn East vein, on which the above works were driven, varied between 2 and 4 feet in width and was composed essentially of an intimate mixture of fluorite and quartz with ore shoots of galena. The foot and hanging walls were lined with a "liner" or cheek of siderite. The vein was hardly payable and, had it not been for the dramatic discovery of the remarkable and eventually world-famous flats, the mine would not have survived. In fact, the workings on the vein had extended far beyond the beginning of the flat ground before the first flat was discovered in 1892. The flats commenced in the vicinity of Fairless' sump and extended to the present northeasterly forehead of the workings.

The small cross-veins which intersect the Boltsburn vein northeast of Rockhope were tried, but none proved to be profitable.

Due to the complexity of underground haulage, the high costs of transportation of ore to the Engine shaft, and the low price of lead, the mine was abandoned in 1931, even though ore was present at the forehead.

The Weardale Lead Company continued its operations up to 1940 on the Boltsburn West vein, due mainly to wartime necessity, extending the workings southwest of Rookhope and discovering some profitable ore shoots in the Great limestone and overlying coal sills.

Table 1 shows the production of lead concentrates during the life of the mine. Fluorite in economic quantities was obtained principally from the vein, but it was from the flats that the unique crystallizations and colors of fluorite came, to become famous to museums and collectors over the world.

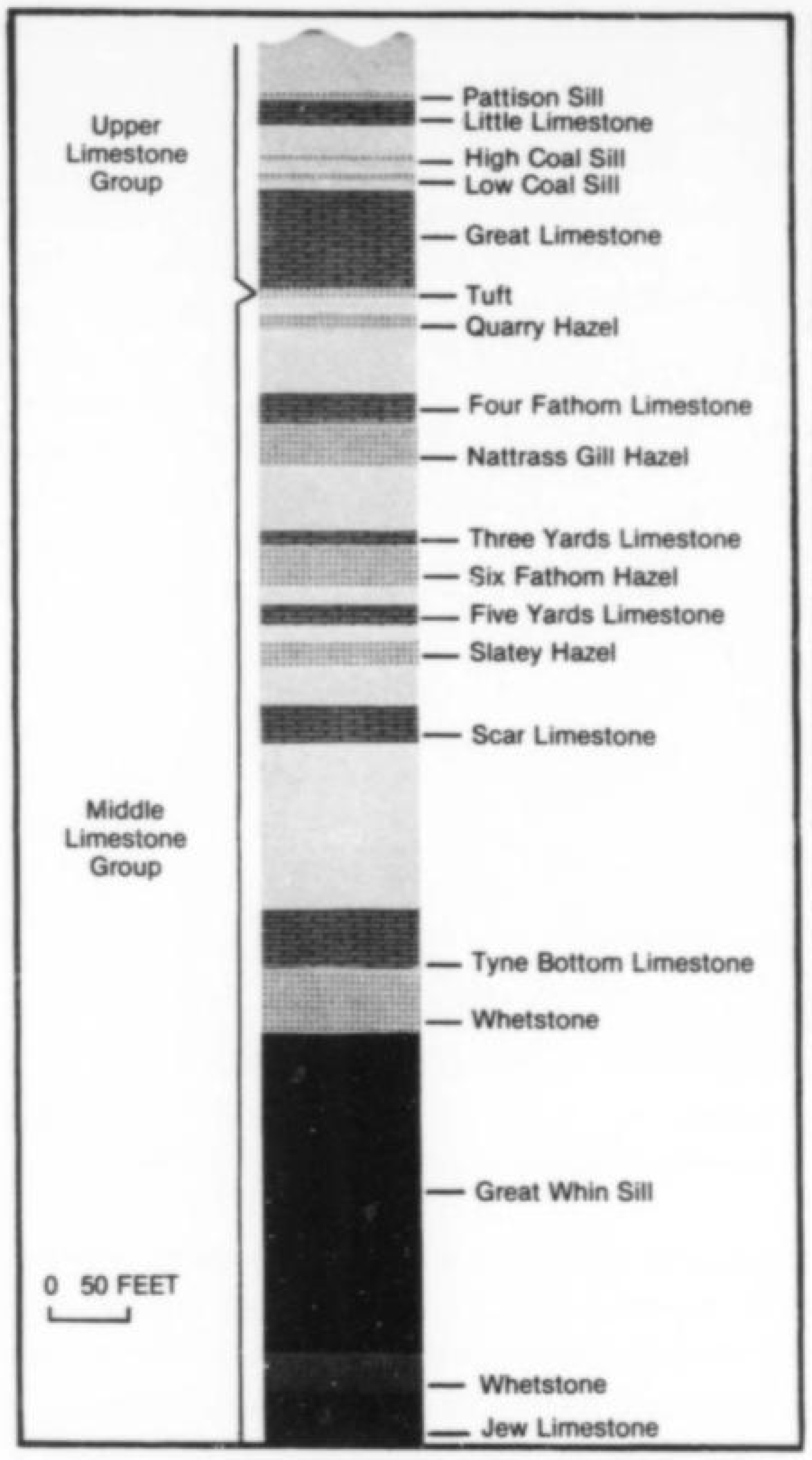


Figure 2. **General Lower Carboniferous geologic section in the area of the sketch map at left.**

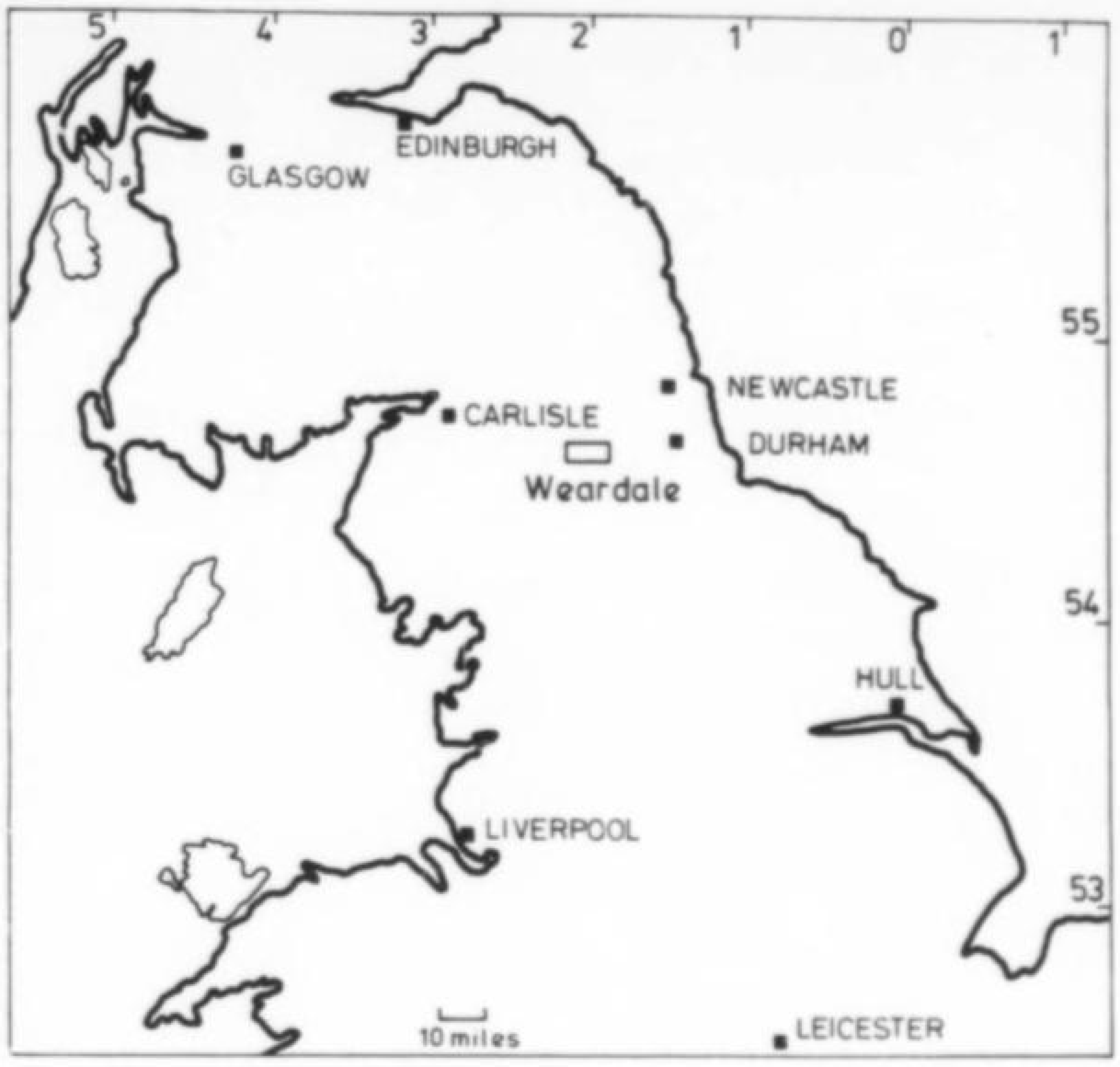


Figure 3. **Location map of the Weardale area.**

Table 1. **Production of the Boltsburn Mines from 1818–1940, following the production of detailed records by the Beaumont and Weardale Companies.**

Year	Company	Oreshoots	Tons Lead Concentrates	Tons Fluorite
1818–1880	Beaumont	Vein (East)	23,896	–
1884–1900	Weardale	Vein (mainly)	11,831	–
1901–1931	Weardale	Flats	89,320	–
		Vein (East)	–	7,299
1932–1940	Weardale	Vein (West)	2,738	–

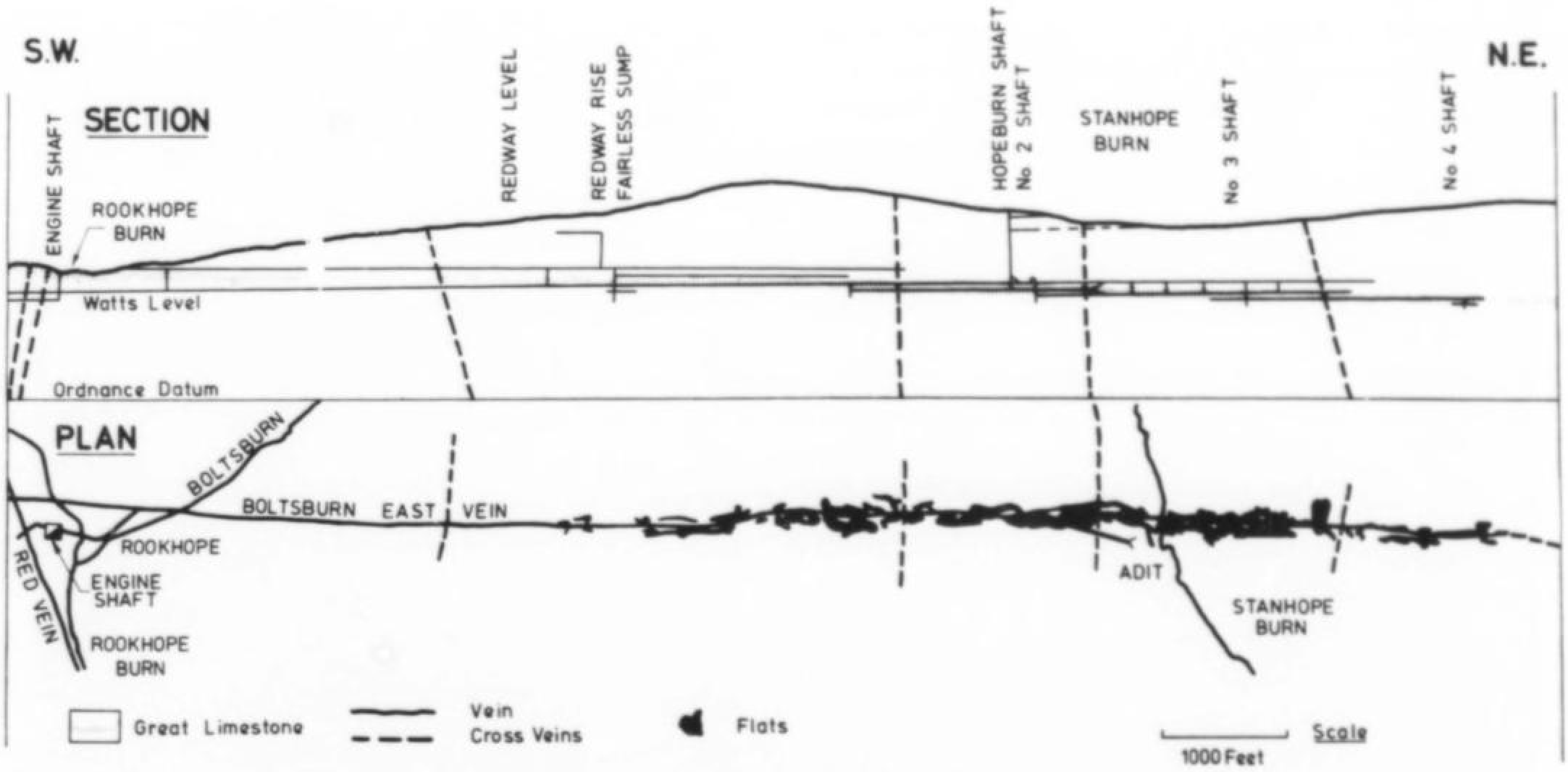


Figure 4. **Plan and section of the Boltsburn East vein (Boltsburn mine proper).**

Figure 5. **The Boltsburn mine in 1917 (Louis, 1917).**

GEOLOGY

Weardale is geographically situated in the northern Pennines, a wild moorland and upland area of central northern England embracing portions of the counties of Cumbria, Northumberland and North Yorkshire. Structurally the area consists of a fault-bounded block tilted to the east by Tertiary earth movements. The boundary faults are, however, of much greater antiquity and did much to control Carboniferous sedimentation, in which the ore deposits were subsequently deposited, by acting as hinge belts during the sedimentation. The Pennine fault block is divided by a shallow east-west synclinal structure, the Stainmore syncline. The northern half, which includes Weardale and the Boltsburn mine, is referred to as the Alston block, while the southern half is known as the Askrigg block. Both blocks contain important mining fields.

Pre-Carboniferous rocks are exposed in a few isolated, deeply cut valleys and have been discovered in exploratory boreholes, as in the Rookhope borehold put down to investigate the Weardale granite and its relationship with the mineralization (Dunham *et al.*, 1961).

Deposition of the Lower Carboniferous (Mississippian) or Carboniferous limestone "series" commenced in the Viséan stage and continued unbroken up into the Upper Carboniferous, though on the Pennine block Lower Carboniferous sediments nowhere exceed 2,000 feet in thickness, and are relatively thin compared to surrounding areas, as, for example, in the adjacent Northumberland trough. The sediments are essentially cyclothemic, a feature of considerable importance to ore prospectors over the mining field as a whole where the sedimentary rhythm from marine to lagoonal and coal swamp sediments changes repeatedly. Fissure veins produce

Figure 6. **The Boltsburn mine in 1978, viewed from the same direction as in Figure 1. The shaft collar, covered and fenced, is visible in the foreground. The building is the Rookhope village school.**

wider and more profitable ore shoots in competent beds. The Carboniferous limestone "series" is divided into four main groups. The lowest or Basement group includes basal conglomerates and other arenaceous beds which lie everywhere unconformably in a diachronous manner on the foundation rocks of the Pennine block.

The overlying three groups are referred to, especially in mining circles, as the lower, middle and upper limestone groups. The lowest limestone group contains massive limestones, including the thickest limestone unit in the whole succession, which is laterally uniform, indicating considerable peneplanation of the block to permit the spread of shelf-sea conditions. Following deposition of the dominantly calcareous lower limestone group, sandstones became more important in the succession, and stronger cyclothemic deposition developed, formerly described as Yoredale type sedimentation. Cyclic conditions of sedimentation persisted through the middle and upper limestone groups and into the conformably overlying Namurian, the base of which can be fixed only by the occurrence of Namurian goniatites. Many of the cyclothems are incomplete, but are represented ideally by the cycle below:

1. Coal
2. Fireclay or ganister
3. Sandstone
4. Shaley sandstone
5. Ferruginous shale
6. Calcareous shale
7. Limestone

Many of the local terms used to describe individual units of many of the cyclothems are old and used by miners long before geology demanded a more scientific approach. Figure 2 shows the general succession of the Weardale area, with many of the terms used in the text. Individual limestone units rarely attain a thickness greater than 30 feet, but the Great limestone, the basal unit of the upper limestone group, has been known to attain a thickness of 102 feet in the Lunehead mine (Dunham, 1948). The Great limestone is the most important limestone of the area. The bulk of the payable ore-bearing ground occurred in the Boltsburn mine at this horizon. Above the Great limestone, though the rhythmic alternations of sedimentation persisted, there was a gradual change of conditions. Shales, thick sandstones and grits were deposited to the exclusion of limestones, which became thin and eventually disappeared from the upper part of the upper limestone group.

There are two intrusive transgressive sills within the Carboniferous succession in Weardale. The lowest and thickest, the Great Whin sill, lies below the workings of Boltsburn mine in the Whetstone bed of the middle limestone group. It consists of quartz-hypersthene-dolerite (Holmes and Harwood, 1928). It reaches a maximum thickness of 240 feet and has been dated at 295 ± 6 m.y. (Fitch and Miller, 1967). It is therefore of late Carboniferous age. An additional sill of similar composition but nowhere thicker than 30 feet appears higher in the succession in the Three Yard limestone and was therefore also not seen in the workings of Boltsburn mine.

Underlying this area, at a depth of 1,281 feet from the surface, is a cupola of the Weardale granite. This Caledonian granite pluton, dated at 364 m.y. (Dodson and Moorbath, 1961), was discovered in the exploratory borehole at Rookhope (Dunham *et al.*, 1961). It was sunk in an attempt to correlate the zonal arrangement of mineralization seen in the orefield, with the areal limitation of a known negative Bouguer (gravity) anomaly immediately underlying it.

The Orebodies

In the Northern Pennine orefield, the orebodies may be classified under two main structural headings: fissure veins or lodes which occupy faults, and flats.

The veins are usually more or less vertical, of limited width and typically of considerable tabular length. They produce economic ore shoots of galena in the thicker and more competent lithologies of the Carboniferous succession, in limestones and sandstones alike, but are poor in values and generally split into strings in the less competent beds such as shales.

The flats are also tabular but lie in an approximately horizontal plane. They are not mineralized bodies which occupy pre-existing caverns, but are in fact bodies characteristic of Mississippi Valley type mineralization. This ankeritized or fluoritized limestone was commonly full of vugs, usually quite small but, where the metasomatism had been occasionally strong, linking flats together as cavernous voids full of superb and large crystallizations.

The minerals of the veins and flats in the Weardale area, in order of abundance, are: galena (most abundant), fluorite, quartz (often chalcedonic), siderite, ankerite, calcite, sphalerite, pyrite and chalcopyrite. The vein content was commonly banded or crustiform, being made up of successive encrustations of minerals. If central voids remained, crystallization of the several species occurred in places but could not match the beauty of form and color of crystals formed in the flat cavities. Siderite and ankerite are important constituents of many of the veins of the Weardale area, where they have developed at the expense of the remainder of the gangue. Where these minerals occur in the zone of oxidation they frequently acquire potential as economic sources of iron ore. Many mines, including the Boltsburn West level southwest of Rookhope, exploited the Boltsburn vein and the flats in the Great limestone which contained large quantities of limonite, especially in the vicinity of Red vein (Dunham, 1941). Galena was the mineral most sought after in the 19th century but fluorite, which was abundant and important in the veins, was a nuisance to the "old men" who stacked it as "deads" in abandoned workings. It was much rarer in the flats (though there it was usually well crystallized, whereas in the veins it was massive). There it was commonly intimately intergrown with quartz and/or chalcedony, and only occasionally crystallized.

The Old Fall-Scarsike-Boltsburn vein system occupies a normal fault which extends for a known distance of 7½ miles, from the south side of the River Wear near Ireshopeburn, and extends north 60–65° east to the northern side of the Stanhope Valley through the village of Rookhope. The downthrow is small, no more than 2 feet, usually to the southeast, but this is sometimes reversed. The dip is nearly vertical with a slight inclination to the southeast. The vein which occupies it varies greatly in width, from 1 to 5 feet, depending on the lithology it intersects. Unproven ground (where no ore has been discovered) occurs between the three sections of the system. There is for example, 1700 feet of unproven ground between the northeast forehead on Scarsike vein and the southwestern forehead of Boltsburn West level. The Boltsburn vein northeast of Rookhope (the Boltsburn mine proper) was originally the sole orebody exploited by the old Beaumont Company, but following the development of Watts level (the main level), the remarkable flats, which made the mine famous, were discovered.

As is often the case in many mining fields, the Boltsburn vein was poor in lead values (though not in fluorite) in the near vicinity of flats, and was said to be "robbed" by them. In fact, driving on the vein in poor ground extended far beyond the flatted area before its discovery. Small mineralized joints or "live leaders" ran from the vein through a belt of ankeritized limestone, up to 20 feet in width, to the flats, and were the principal means of their discovery. There is evidence that there was a stratigraphic control in the formation of the flats, suggested by the variation in the beds between the Great and Little limestones. Where the Coal sill sandstone was thick, both it and the underlying Great limestone carried ore shoots but no flats. Where the sandstone was thin and a great thickness of shales occurred between sandstone and the limestone, the vein was poor, but large flats developed in the same area.

At the Boltsburn mine separate metasomatic replacements occurred to form flats at three favorable horizons or "posts" within

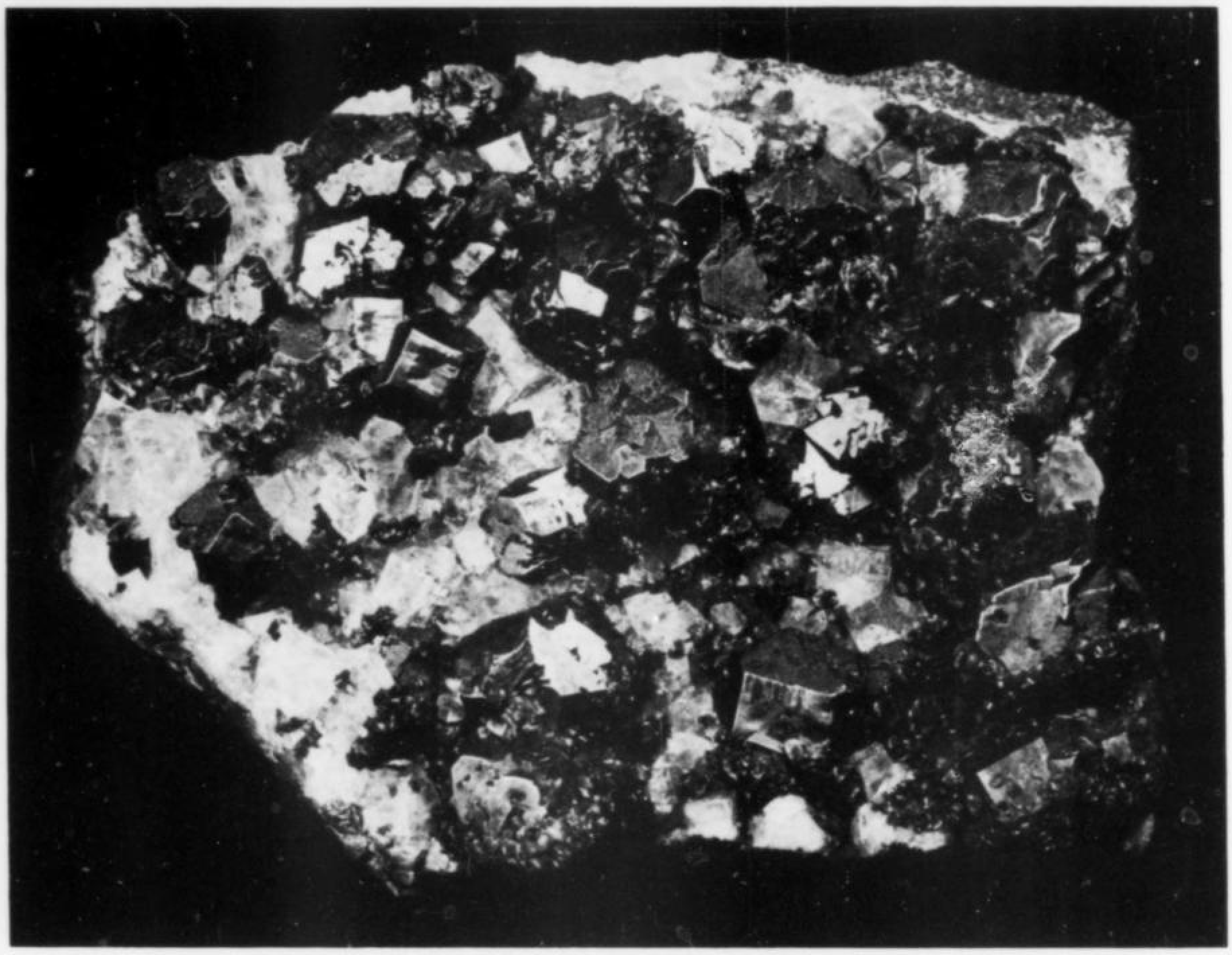


Figure 7. **Cuboctahedral galena modified by {311}, with associated siderite and pale purple fluorite. Size: 4 x 5 inches; No. 38, collected in 1917.**

the Great limestone (here 60 feet thick), but metasomatism was strong enough in places to link them together in depth. The top or High flat proved to be the most productive of the three, but when linked to the Middle and Low flats values were maintained throughout, and an orebody up to 25 feet high occurred there. From where they were first discovered near Fairless' sump, the flats extend for 7,700 feet to the northeast and have been known to extend up to 200 feet from the vein. The flats have no sharply defined boundaries within the Great limestone, but the strongly mineralized ground passes almost imperceptibly into barren massive limestone. Galena, in the strongly mineralized ground, occurs as irregular bunches or lenticular bodies up to 27 inches in diameter and rarely shows euhedral crystals. The limestone itself is typical of metasomatized ground and is frequently vugy and rarely cavernous. Watson (1904) eloquently described a visit he made to the Boltsburn mine and his impressions after entering one of the large caverns in the Top flat full of large crystals of fluorite. Irregular cavities up to 50 feet in length, 15 feet wide and only a few feet high occurred in the flats, especially in the High flat, and were completely lined with crystals.

There appears to be no set paragenetic order of mineral deposition in either the vein or flats at the Boltsburn mine, but the carbonates ankerite and siderite appear to be early in the sequence, while quartz is late in most situations. There was some modification of the orebodies, especially in the flats, contemporaneously with the introduction of quartz, which caused etching of both galena and fluorite followed by a late phase of quartz deposition. Some crustiform banding surrounded the cavities but it was highly complex and followed no obvious set pattern of deposition. Each mineral phase was terminated by perfectly euhedral crystallization, to be subsequently masked by the next phase.

An additional feature of the mineralization in the Boltsburn flats was the development of stalactitic structures on the floor of the larger cavities. They were composed principally of annular-ring-like growths of quartz and fluorite, but some had inner cores of siderite. A central tubular hole occurred in each. They were formed, not by the generally accepted mechanism of stalactite formations in cave systems, but probably by processes of metasomatism.

The age of the mineralization in the northern Pennine orefield is still controversial. Based on geological factors, it is certainly post Lower Carboniferous in age and most likely to be Permian, and therefore possibly related to Hercynian orogenic activity. It postdates the intrusion of the Whin sill, which is dated at 295 m.y. (Fitch and Miller, 1967), for the veins which intersect it altered it to white clay minerals. A geochronological survey employing argon-40/argon-39 age determinations on this so-called white Whin suggests that it was produced by pulsations of hydrothermal activity embracing the period 284 (± 40) m.y. to 170 m.y., that is from late Carboniferous time until well into the early Jurassic (Dunham *et al.*, 1968). The mean lead isotope model age of Pennine galenas of 280 ± 30 m.y. (Moorbath, 1962) supports these determinations.

The presence of the Weardale granite beneath the Alston block suggests a structural rather than a genetic relationship between the granite and the mineralization. The granite is of Caledonian age, the mineralization Hercynian. The roof region of the granite cupola, though geographically corresponding with the inner high temperature fluorite zone, merely acted as a localizing mechanism for the upward flow of hydrothermal fluids into the overlying Carboniferous sediments (Dunham *et al.*, 1961). Sawkins (1966), from his study of fluid inclusions in some of the ore minerals in the northern Pennine orefield, has suggested that fluorite deposition occurred between a temperature interval of 200° and 100°C, fluorite from the Boltsburn flats giving temperatures between 140° and 148°C.

Dunham (1937) has presented a strong case for a temperature-controlled zonal arrangement of fluorite in the Alston block based on color distribution. In the central zone fluorite crystals are domi-

Figure 8. **A single crystal of pale purple flourite measuring 7 inches across a face. No. 5467; collected in 1924.**

nantly purple in color and occasionally green. The outer zone is characterized by yellow or amber-colored fluorite, usually accompanied by barite. The Boltsburn mine must therefore lie within the central higher temperature zone for its fluorites are dominantly purple and less commonly green in color.

Active prospecting into the economic potential of remaining or undiscovered deposits of fluorite, principally for use in the steel industry, is currently being undertaken (Greenwood and Smith, 1977). There is, therefore, just the possibility that additional exploration work could take place at Boltsburn. This is unlikely, as flats persisted to the forehead of the northeasterly extension of the mine, and flats were notoriously poor in fluorite, though conversely rich in galena. In addition, with advanced techniques of mechanical mining which makes possible the economic extraction of lean ore deposits, together with the lack of sympathy for preservation of fine specimens, the further extraction of delicate groups of fluorite under such conditions appears to be a forlorn hope.

THE MINERALS

Galena

As the mineral most sought after by the "old men," galena was present in the Boltsburn mine in quite rich though sporadic ore shoots in the vein, and as enormously rich metasomatic replacements in the flats. In the 30 year period from 1901 to 1931 the Weardale Lead Company extracted 513,609 tons of ore from the flats, recovering 89,320 tons of lead concentrates; that is a tenor of 17.4 percent (Dunham, 1948). It occurred in the vein as coarsely crystalline bands standing more or less vertically in the gangue. In the flats it was disseminated through the metasomatized limestone occurring in the siliceous, ankeritized or fluoritized ground as tiny anhedral or subhedral masses, or as flat lenticular masses with little or no surface expression. In places the forehead was so rich as to appear to be of solid galena.

Figure 9. **Pale olive-green flourite crystals with curved crystals of siderite. The specimen measures 4 x 6 inches; No. 5537, collected in 1917.**

Though not rich in silver, galena from the Boltsburn mine was worth desilverizing. For example, an assay on galena from the Western flats gave values of 8.2 ounces of silver per ton of lead metal (Dunham, 1948). The silver is present in solid solution inclusions within the galena structure. No silver minerals are visible, but they can be revealed at the microprobe level of resolution.

Where the ground was vuggy, especially in the flats, the whole gangue crystallized freely into euhedral forms. The size of crystals is related to the size of the vug or cavity in which it had developed. The average size of a galena crystal is 1⅛ inches across but occasionally larger crystals occurred, up to 2¾ inches across.

The forms present include the octahedron {111} and the cube {100}, with the octahedron dominant. The additional and comparatively rare form {311} was common at Boltsburn, producing a hopper-face modification on the cube face. Many crystals are com-

Figure 10. **Amber-colored flourite on sphalerite with curved siderite crystals. The specimen is 3 x 5 inches; No. 60, collected in 1898.**

posite and made up of many individuals, the latter apparent only by reflection of light at certain angles.

When found in the mine, the luster of the galena was high and, in well-cared-for collections, it persists. Any or all of the members of the whole gangue could be present in association with the galena, but siderite, as scattered strongly curved crystals, is ubiquitous.

In places galena has shown a modest amount of etching, and this is accompanied by etching of associated fluorite and, in some cases, with the deposition of quartz to completely cover the original assemblage. It may be related to the development of epimorphic structures in accompanying fluorite.

Fluorite

Of all the minerals found at Boltsburn, fluorite is undoubtedly the most famous, being renowned for its beauty and variety of color, the attractive groupings of crystals and their associates, and for the occasional large and beautifully clear single crystals.

Although good crystal groups commonly lined voids in the Boltsburn East vein, the famous groups and more spectacular colors originated in the flats in the metasomatized Great limestone where they occurred in cavities and vugs in the heavily mineralized ground.

Single crystals are uncommon, but where they have formed they are atypically large, usually transparent, pale mauve in color and free from flaws. They are usually perfect cubes showing no modification and no suggestion of twinning. The largest crystals found do not exceed 9 inches across the cube face. These perfect crystals were hand-picked and sold to the Zeiss optical instrument company for the manufacture of apochromatic lenses in microscopes. Much larger crystals have been reported which attain a maximum of 15 inches across, but they are always composite and rough.

The crystals making up groups are much smaller in size (average width across cube face: ⅞ inches) and are inevitably interpenetration twins on {111}. It is these crystals which show the diversity of color. Modification by the octahedron {111} is unknown at Boltsburn, but the tetrahexahedron {210}, though rare in the mine, is occasionally strongly developed in localized areas. Crystals possessing this modification are small and of a greasy luster. Striations are common on the cube face, produced by the growth of vicinal faces.

Although the large majority of fluorite from the Boltsburn mine is pale purple in color, there are some notable exceptions. A characteristic color is pale olive-green, but yellow and amber colors also occurred. The latter, as in the specimen shown, was frequently associated with sphalerite, itself a relatively rare mineral in the mine.

Color zonation of crystals was not a strong feature of the mine and where it occurred it usually took the form of shade differences. Early depositions of green fluorite were frequently followed by purple, but they took the form of individual distinct generations. There were no dramatic color changes within crystals as seen in other mines in the Alston block, for example at Rotherhope mine near Alston. The color of fluorite has been the subject of research for a considerable length of time, but it is generally accepted that (in the English Pennines at least) color, fluorescence under ultraviolet light, and the presence of rare earth elements in solid solution within the fluorite are closely related. *(Ed. note: See the article on Peruvian pink fluorite elsewhere in this issue for references to the work on color in fluorite.)* The presence of europium and yttrium causing disturbance in the cubic lattice has been shown to be directly related to color and fluorescence. Dunham (1952) gave an analysis of a fluorite from the Boltsburn mine East vein which showed the presence of 0.03 percent yttrium and 0.005 percent europium. He pointed out that the presence of yttrium and europium incite a blue fluorescence, while europium alone incites green. Bill *et al.* (1967) confirmed these statements, but suggested that the green varieties of fluorite from Weardale also contain the elements samarium and gadolinium in solid solution within the fluorite lattice.

Much of the fluorite from the Boltsburn mine is strongly thermoluminescent. In their studies of this phenomenon, Rogers and Sears (1978) have shown the importance of the presence of yttrium in the make-up of Weardale fluorite.

The wide spectrum of colors of the fluorite being such a remarkable feature of this old mine, it is unfortunate that access to the flats is no longer available. A study of color distribution in relation to trace element chemistry, the wall rocks and associated minerals might then have been possible.

The development of epimorphic structures is readily understood in oxidation zones, where leaching by modified meteoric waters is expected, but in the Boltsburn mine the flats lay below such influence. Nevertheless, epimorphism has taken place in the flats and the surface impressions of pre-existing fluorite are common. From

Figure 11. **An olive-green flourite group, 5 x 7 inches, encrusted with quartz and a later generation of sphalerite. Slight etching is present on some fluorite faces. No. 3779, collected in 1917.**

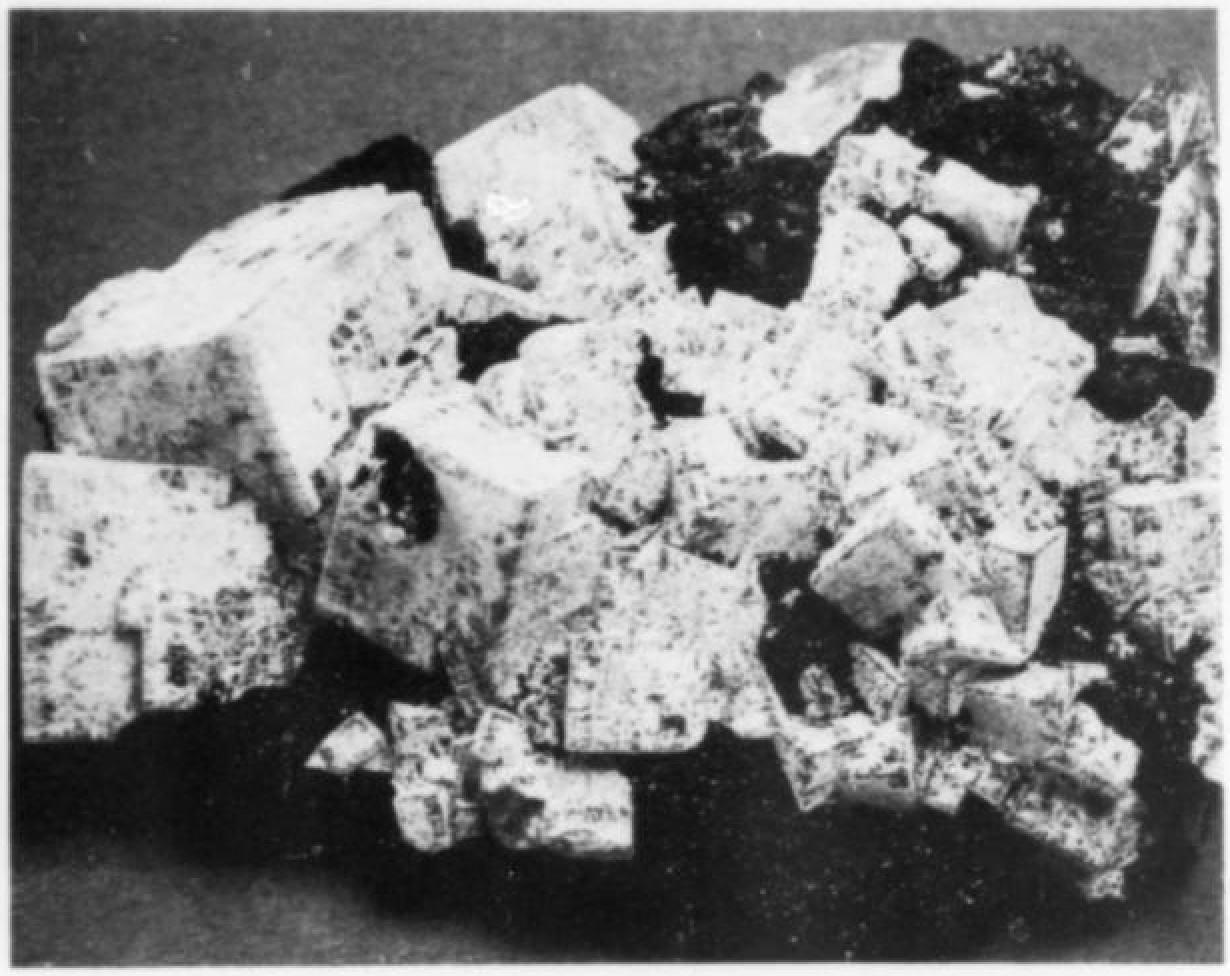
Figure 12. **The reverse side of the specimen shown in the previous figure, No. 3779, showing the heavy encrustation of quartz on the epimorphic fluorite.**

the examination of many specimens it seems likely that there was more than one mineralizing event which saw the destruction of preexisting fluorite and the development of epimorphic structures. The events are usually cogenetic with quartz deposition and are late in the paragenesis. The early stages of epimorphism of fluorite are indicated by degrees of etching with corresponding loss of luster and color. The normally purple or green colors become dull and white, which surfaces, under high magnification may be seen to be covered with minute, triangular etch pits.

Quartz

Silica (in the form of alpha or low-quartz and chalcedony) is an important constituent of the gangue in the lodes and flats of the Northern Pennine orefield, and opal occurred in the Rotherhope mine near Alston.

In the Boltsburn vein both quartz and chalcedony were abundant in crustiform banding alternating with fluorite and galena. The quartz is white or colorless and often coarsely crystalline. The chalcedony, which appears to pre-date deposition of the fluorite,



took the form of thin brown veinlets. The wall rocks of the vein were often highly silicified, except in the region of the flats where iron carbonates were predominant. Much of the metasomatized ground of the flats was also highly silicified and closely resembled chert.

In the vein, and in the early stages of silicification of the limestone of the flats, euhedral crystal development was poor or at best represented by only minute crystals. It was not until much later in the paragenesis, that is in the late stages of metasomatism in the flats, that well formed crystals were deposited on pre-existing members, accompanied by etching of fluorite and sulfides and the development of epimorphic textures.

***Figure 13.* Strongly ethed and whitened purple fluorite on heavily oxidized siderite; the galena at top right has also been strongly etched. Size: 5 x 6 inches; No. 3790, collection date unknown.**

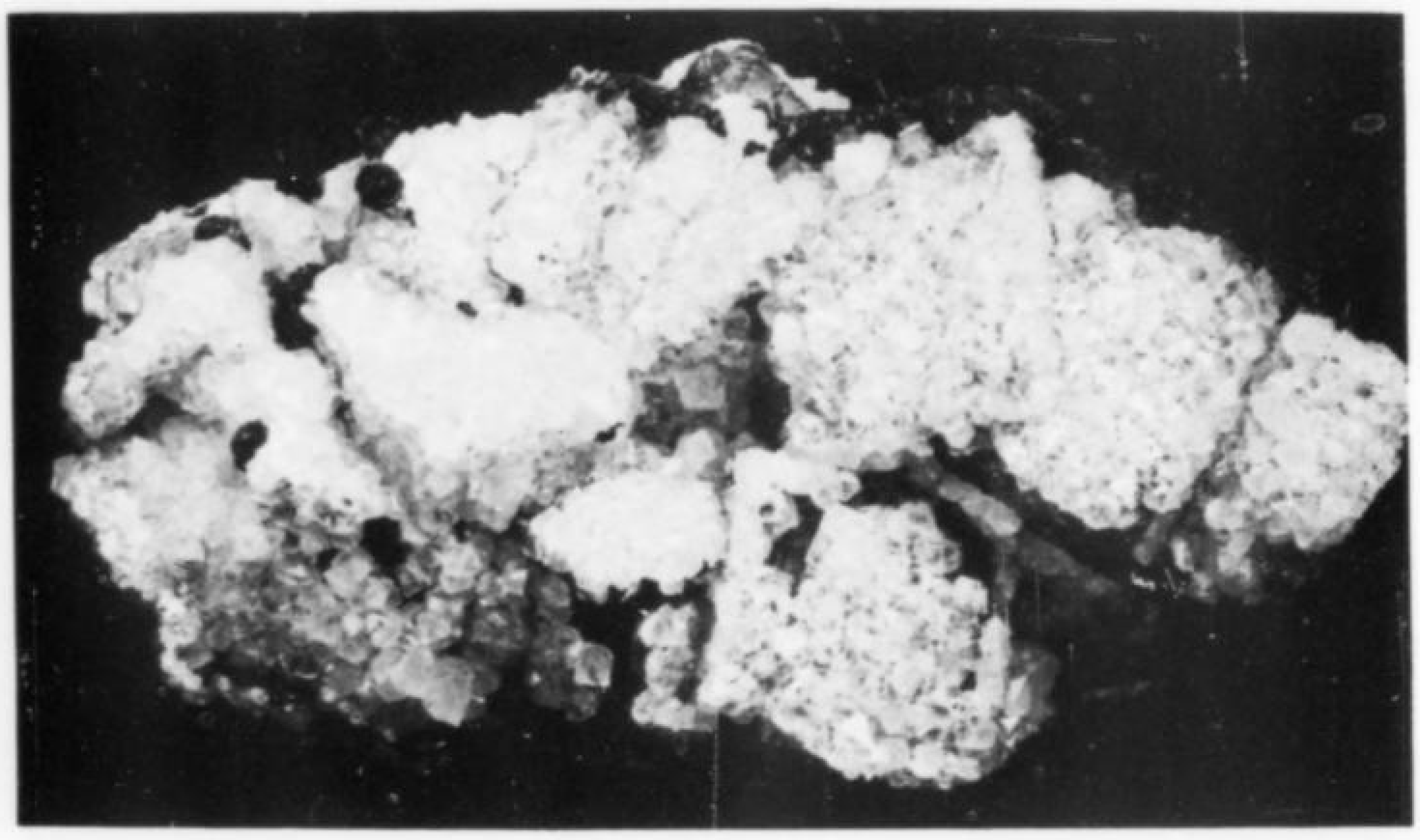
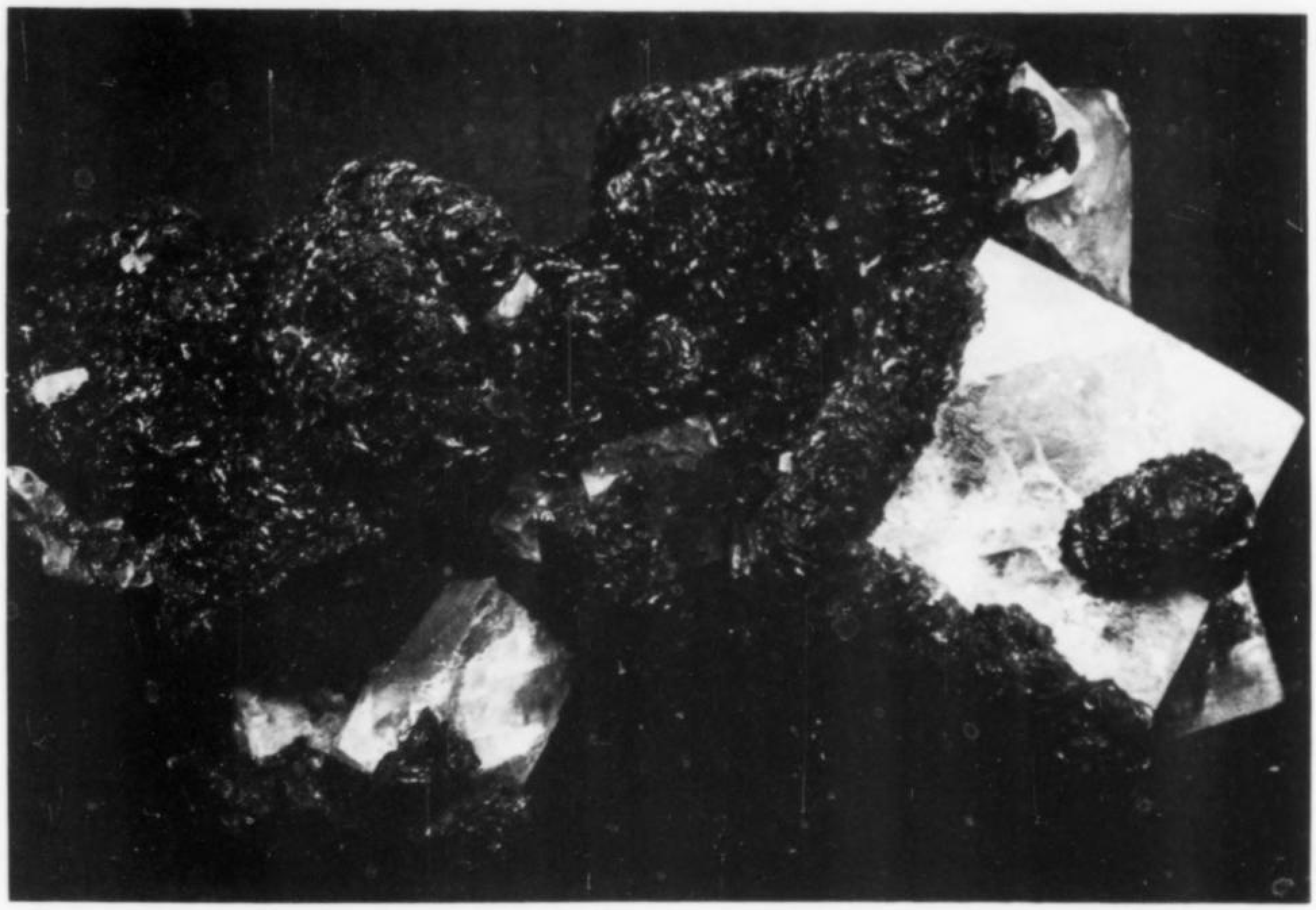


***Figure 14.* Colorless and transparent quartz purple fluorite with minor rosettes of siderite. Size: 4 x 7 inches; No. 5532.**

***Figure 15.* Colorless and transparent quartz on pale purple fluorite measuring 6 x 7 inches. No. 5540.**



These younger crystals were most commonly pseudo-bipyramids (actually two combined rhombohedrons) well formed, perfectly colorless and transparent. The largest crystal observed was 9/16 inch in length and 5/16 inch wide, but the size range is great, ranging from minute but perfect pseudo-bipyramids dusting the surfaces of fluorite crystals, to the size quoted above. The prisms are usually strongly striated at right angles to the *c* axis and the pseudopyramids, though sometimes slightly malformed, carry no additional faces. Irregular interpenetration twinning is common, visible along the prism length, and there sometimes are tiny re-entrant faces at the base of the termination.

The presence of these brilliant, highly lustrous quartz crystals dispersed on the surfaces of many groups of fluorite crystals greatly enhances the esthetic value of the specimens.

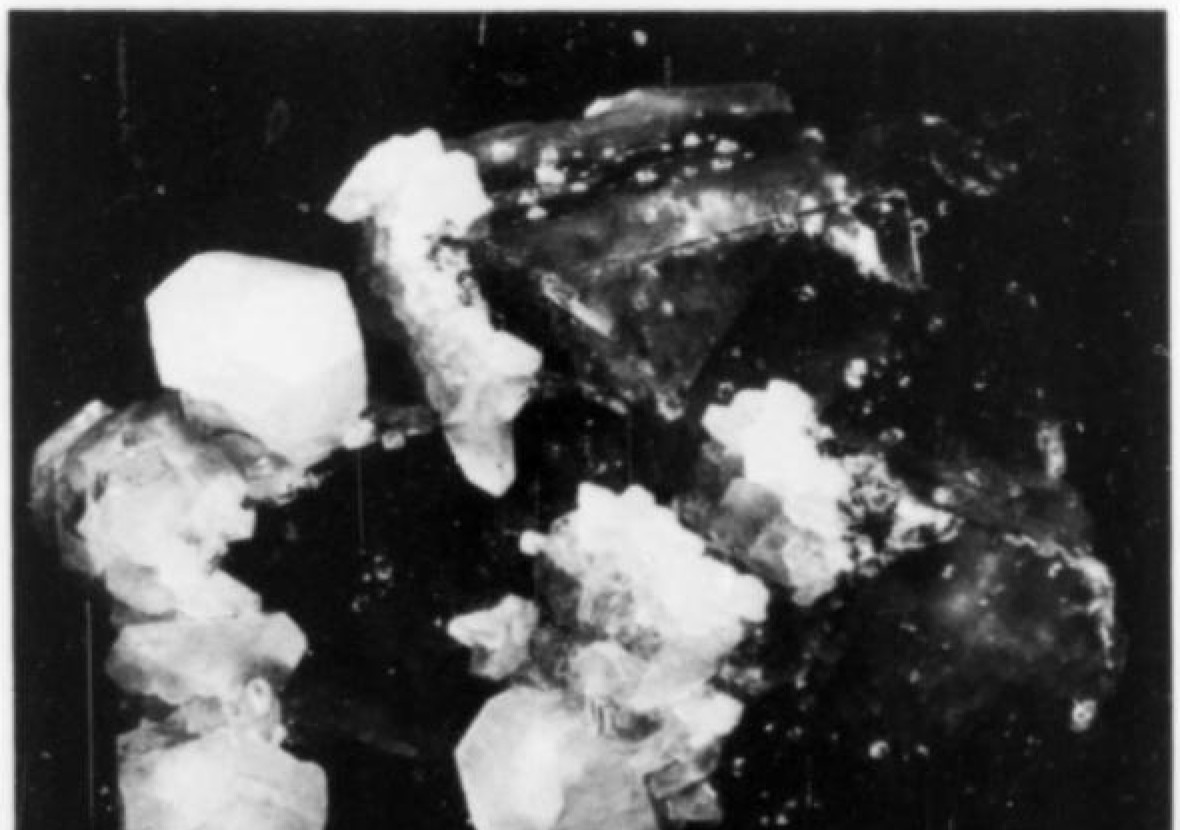


Figure 17. **Pale purple flourite with white calcite and a sprinkling of small quartz crystals. The calcite shows the rhombohedral termination $\{01\bar{1}2\}$ and prism. Size: 3 x 4 inches; No. 1980, collected in 1930.**

Figure 16. **Purple flourite heavily encrusted with siderite. Size: 3 x 6 inches; No. 4311, collected in 1904.**

Siderite

Although siderite occurs throughout the Alston block mining field, it was far more abundant in the area east of the important fault belt, the Burtreeford Disturbance, which runs in an approximately north-south direction immediately to the west of the Weardale area. It was, in fact, an important constituent of the primary iron ore of the Boltsburn West mine.

It was nowhere near so abundant or important in the Boltsburn East vein, the strongest developments flanking the vein in the region of the flats. Here, associated with ankerite, it formed a belt of iron carbonate-rich metasomatized ground up to 20 feet thick. Where this ground was porous the cavities were invariably lined with crystals but the better developed ones occurred in the flats where they represented the late emanations of iron carbonate mineralization. In this situation they occur dispersed on fluorite, sometimes heavily so. There are not many specimens which are completely free from them.

On fracture surfaces fresh siderite is white, but the crystals are always oxidized to varying degrees and then become shades of yellow or brown, occasionally with a slight iridescent tarnish. The crystal faces, which never attain great size (the maximum observed being ½ inch across) are always strongly curved, often composite and are commonly grouped together in rosette-like forms.

Ankerite

Previous to 1947 many workers described dolomite as an important mineral in the Northern Pennines, and many specimens in old collections bear labels referring to dolomite in association with fluorite.

More recent work (Smythe and Dunham, 1947) has shown that most, if not all of the supposedly ferroan dolomite was in fact ankerite and was more abundant than any other mineral in the unoxidized metasomatic deposits. Their work suggested that solid solution mechanisms prevailed in the variability of iron and magnesium, and that this fact was born out by the crystal habit. When

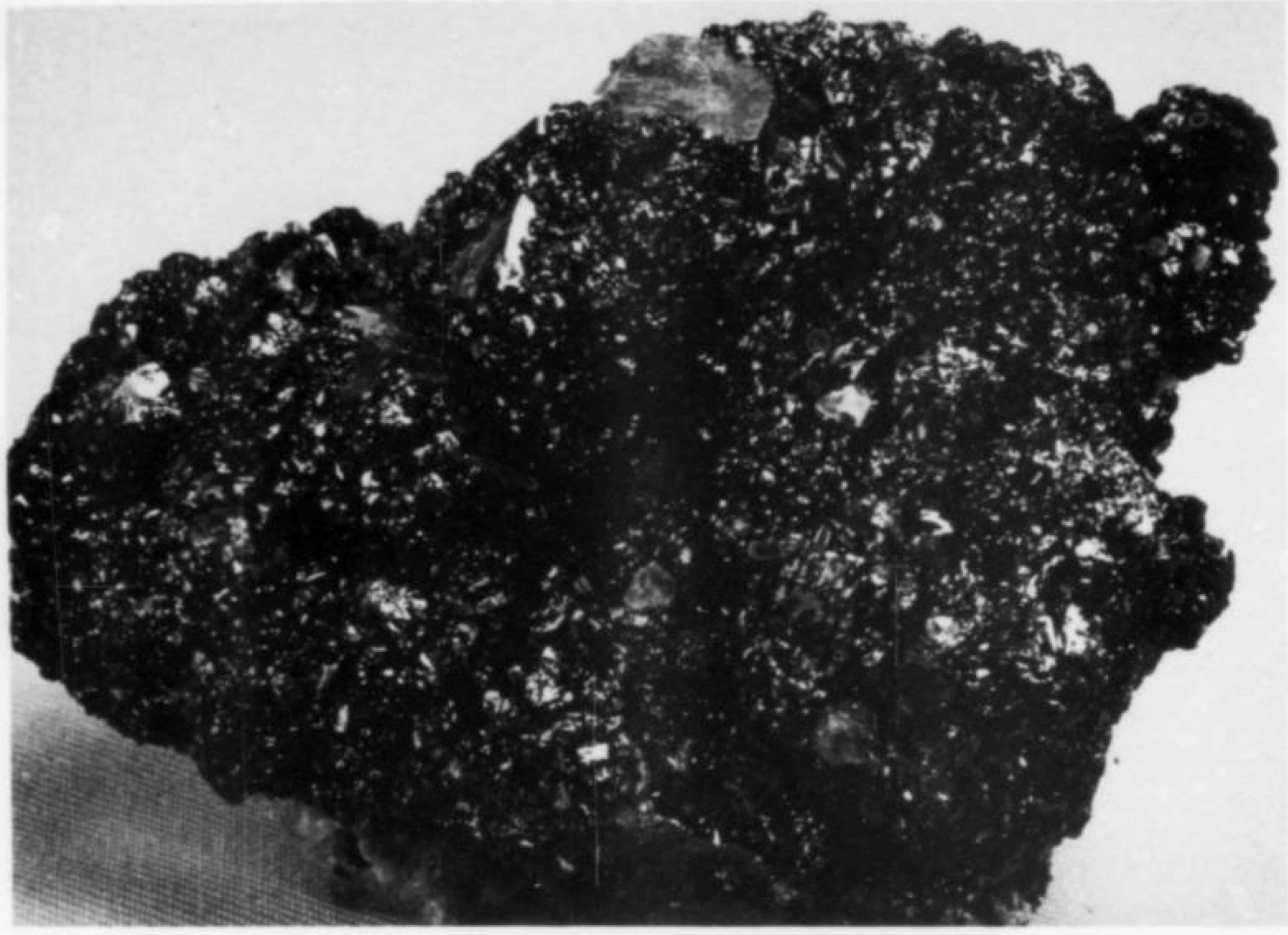


Figure 18. **Black, highly lustrous, tetrahedral crystals of sphalerite with rounded faces and contact twinning, on galena. The three pale purple fluorite crystals show strong development of the tetrahexahedron {210}. Size: 4 x 5 inches; no. 475.**

Figure 19. **Cubic crystals of pyrite encrusting pale yellow fluorite. Size: 3 x 4 inches; No. 5542, collected in 1917.**

iron was dominant the rhombic crystal faces were flat and lacked the curvature shown by the crystals when magnesium was dominant.

In addition, magnesium-rich members were comparatively rare in the inner high temperatures zones of the mining field, in which the Boltsburn mine is situated, appearing in abundance only in the outer cooler zones.

Ankerite was rare in the Boltsburn flats, being largely restricted to the belts of metasomatized ground adjacent to the vein in the region of flat development, where it was accompanied by siderite. Where it did occur in the flats it was obviously early in the paragenesis, being frequently masked by younger minerals. Cavities in the ankeritized ground were lined with white or yellowish rhombic crystals, but when associated with fluorite the crystals were oxidized and were then shades of brown.

It was more abundant in the Boltsburn West vein and in adjacent flats in the Great limestone where it was intimately associated with siderite. Here both minerals in their oxidized state were worked by the Weardale Iron Company.

Calcite

Calcite crystals were never abundant in the Boltsburn mine and were restricted to the flats, where they occurred sporadically throughout. Scalenohedral forms were extremely rare, and the so-called "nail-head" type, showing development of the hexagonal prism $\{10\bar{1}0\}$ and the negative rhombohedron $\{01\bar{1}2\}$, was the dominant habit. Superb colorless and transparent crystallizations were discovered from time to time, either showing the above simple combination, or subparallel aggregates of it where the individuals were stacked vertically. The latter was a remarkable feature of the mine and was described as a stalagmitic phenomenon. Watson's description of it (1904) is worthy of repetition here:

> "Another, is a remarkable deposit of pure calcite, 2 feet thick in places, found abutting on the prevailing fluorite. From its surface rose hundreds of stalagmitic spikelets, hollow like the stem of a pipe and about the same thickness, but tapering to a point sealed and terminated by nail-head crystals. Some of these spikes were plain, others had been seized upon by Nature to demonstrate the deftness of her fingers in the way of graceful ornamen-

Figure 20. **Large, composite cuboctahedral crystals of galena to 3 inches on purple fluorite. All specimens pictured in this article are from the collection of the author. No. 3914, collected in 1917.**

Figure 21. **Dark purple flourite group with minor siderite, measuring 6 x 8 inches. No. 5531, collected in 1917.**

tation. When broken off at the base the central hole was seen descending into the parent mass, which was somewhat vesicular near its upper surface, indicating the origin of the stalagmitic formation to be due to the pressure of gases from beneath. In conclusion I would say the student cannot fail to observe, in the mine as on the surface, how largely the idea of beauty enters into the plan of Creation."

Sphalerite

Sphalerite was relatively uncommon in the Boltsburn mine, the mine being out of the principal zinc-bearing zone centered on Nenthead, but fine specimens occurred sporadically through the flats, especially in High flat. Here it was found commonly associated with yellow fluorite, but groups of crystals associated with galena were also occasionally met with. Crystals are always black and highly lustrous, but never exceed 5/16 inches across. They are basically tetrahedral {111} in habit, but are commonly complex; curved faces are common and contact twinning is ubiquitous.

Pyrite

Pyrite was a rare mineral in the Boltsburn mine, but several fine specimens are known. They show a profusion of highly lustrous, simple cubic crystals and interpenetration twins encrusting yellow fluorite crystals. The largest crystal observed is 1/8 inch across. To date these specimens have proved to be stable and have shown no sign of the onset of "pyrite rot," even under conditions of relatively high humidity.

Chalcopyrite

Chalcopyrite was a rare member of the association at the Boltsburn mine. Unlike the paragenesis of the Red vein, which intersects Boltsburn vein and which has produced appreciable quantities of chalcopyrite from mines along its length, the Boltsburn vein was virtually barren of any copper mineralization. Nevertheless, minute tetrahedral crystals dispersed on fluorite and quartz have been recorded from time to time.

Marcasite

The dimorph of pyrite, marcasite was extremely rare in the mine but minute single crystals encrusting quartz have been observed. It presumably results from the final emanation of the mineralizing events.

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famous mineral localities:

the Virgem da Lapa pegmatites

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During the years 1974-1975, a small pegmatite area in northeastern Minas Gerais, Brazil, began to produce uncommonly fine specimens of tourmaline, topaz and associated minerals. Beautiful gemmy blue topaz and splendid long crystals of elbaite on cleavelandite and lepidolite were encountered first. Then followed magnificent purple hydroxyl-herderite and large greenish apatite crystals. Today these specimens are the pride of important collections and museums around the world.

THE PRINCIPAL MINES AND THEIR LOCATION

The pegmatites are located in an area west-northwest of the town of Virgem da Lapa, on the northern slope of the São Domingos high plain which is west-northwest of Aracuai and east of Montes Claros in northeastern Minas Gerais, Brazil. Brasilia is 600 km to the west-northwest and Rio de Janeiro is 700 km to the south-southwest.

The main production centers are Limoeiro, Xanda, and Toca da Onça. The name of the town of Virgem da Lapa means "virgin of the cave" and was named for religious statuary located in a small grotto near the town's church.

Limoeiro mine ("lemon tree" in Portuguese) (also known as Limoeiro de Baixo)

Access from the town of Virgem da Lapa is by way of the Diamantina road until the first junction at the top of the high plain (*chapada*). Two km from the junction, on the road that goes to Coronel Murta, is a sandy track on the left which leads, in 2.8 km, to a eucalyptus plantation. There, a second fork to the left leads, in 1 km, to another junction at the edge of the chapada. To the right, a track continues another 7.5 km to the mine.

Toca da Onça mine ("lion's cave" in Portuguese)

One km before Limoeiro, a track forks to the right and runs for 2 km to the mine.

Xanda mine (formerly called Souin, also Lavra do Bruno)

From the second junction at the edge of the chapada on the road to the Limoeiro mine, a road runs to the right for 4.2 km directly to the mine huts.

The mines are accessible to most private cars, but usually only by four-wheel drive vehicles during the rainy season, which lasts from mid-October to April. The first mining in the pegmatites was for industrial beryl and began near the Xanda workings in 1939. Production was sporadic over the years until 1974, when the area was deluged by hundreds of garimpeiros, licensed miners who can work on any "non-patented" mineral discovery. The work was economically rewarding due to the increasing world demand for well crystallized minerals, some of which were of gem quality at Virgem da Lapa.

As the most accessible pocket zones were exploited, the mining activity diminished due to high mining costs and lack of organization. Today there are only small attempts to mine the unaltered formations; the high prices of fuel, dynamite and mining equipment are a hindrance.

PHYSIOGRAPHY AND LOCAL GEOLOGY

Hills undulating to the horizon are typical of the Virgem da Lapa area. The region is dry several months of the year, and vegetation consists of low bush vegetation alternating with small pastures and poor cultivated lands. The chief drainage of the area is the perennial Jetinquinhonha River. To the south a great plateau spreads towards Diamantina, as an immense high plain with scattered low hardwood trees and high grass. The chapada São Domingos is a northern outlier.

Above the hills, the slope of the cuesta where the mines are

Figure 1. **A large hydroxyl-herderite crystal measuring 6 by 7.5 by 8 cm., perched on another crystal, from Virgem da Lapa. DuPont collection, University of Delaware; Dane Penland photo.**

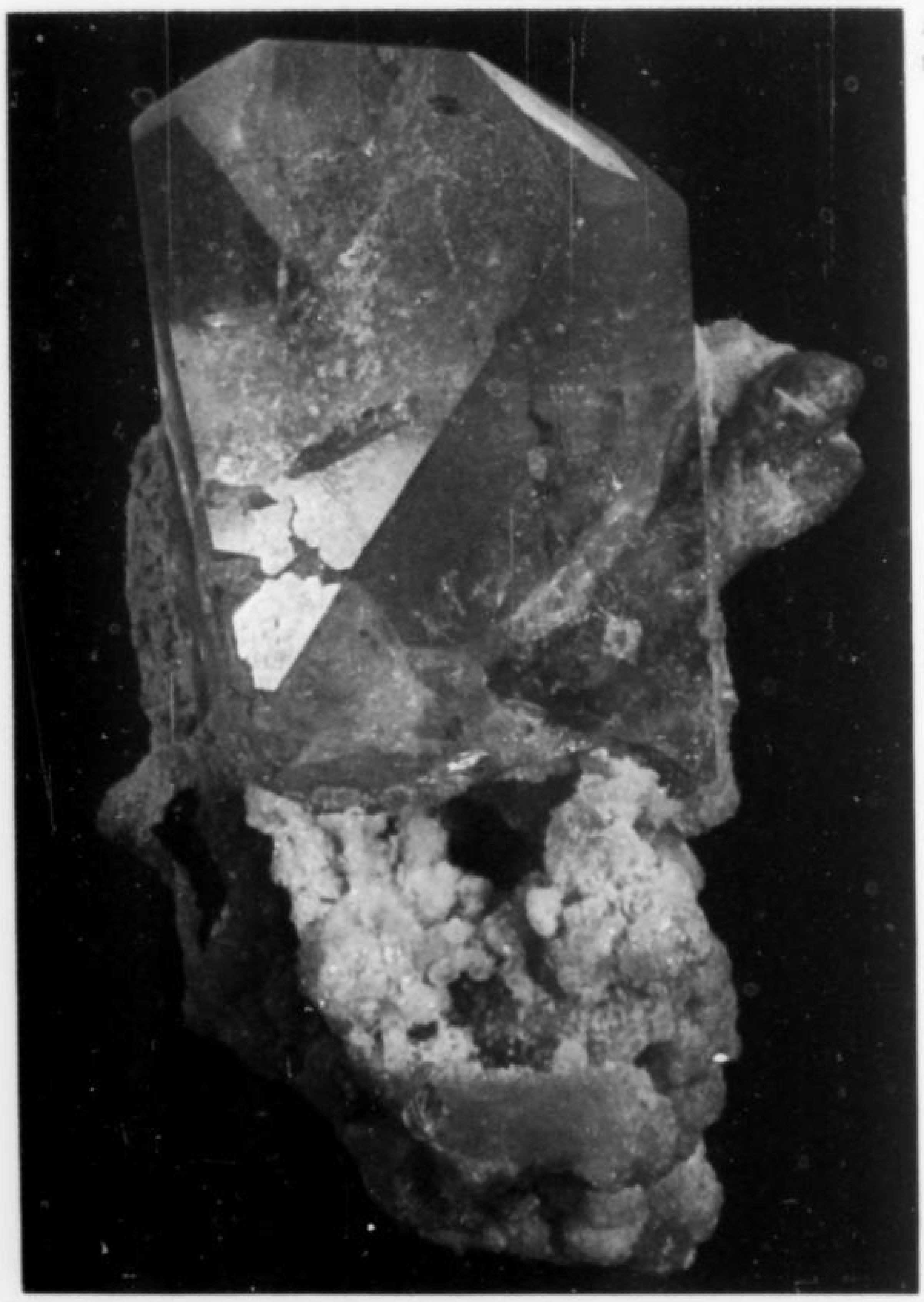


Figure 2. **A 7-cm topaz crystal on albite from the Xanda mine.**

Figure 3. **A 7.5-cm elbaite group with albite from the Xanda mine.**

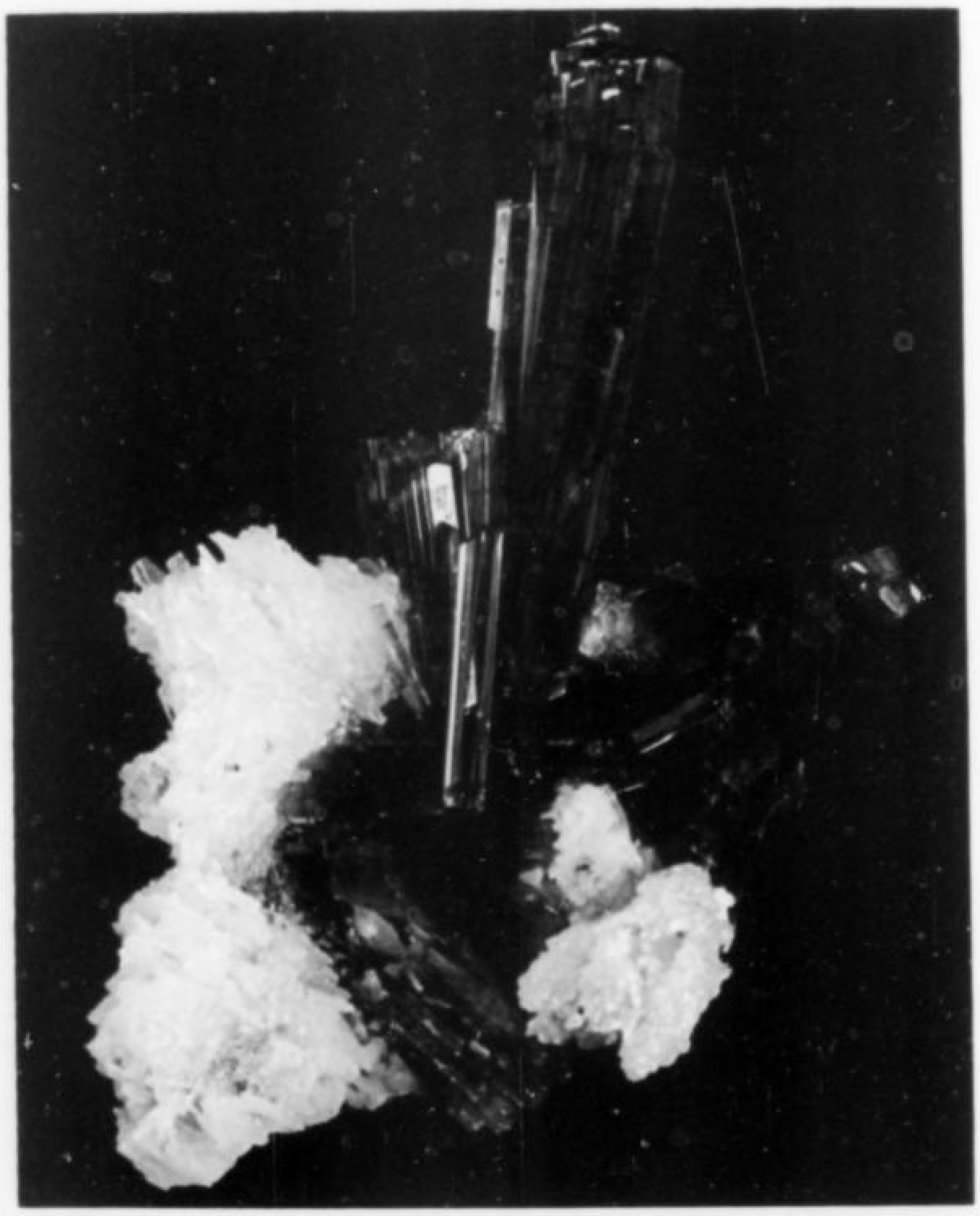


Figure 4. **The Xanda mine in 1976. Shacks where miners live are visible above the white dumps.**

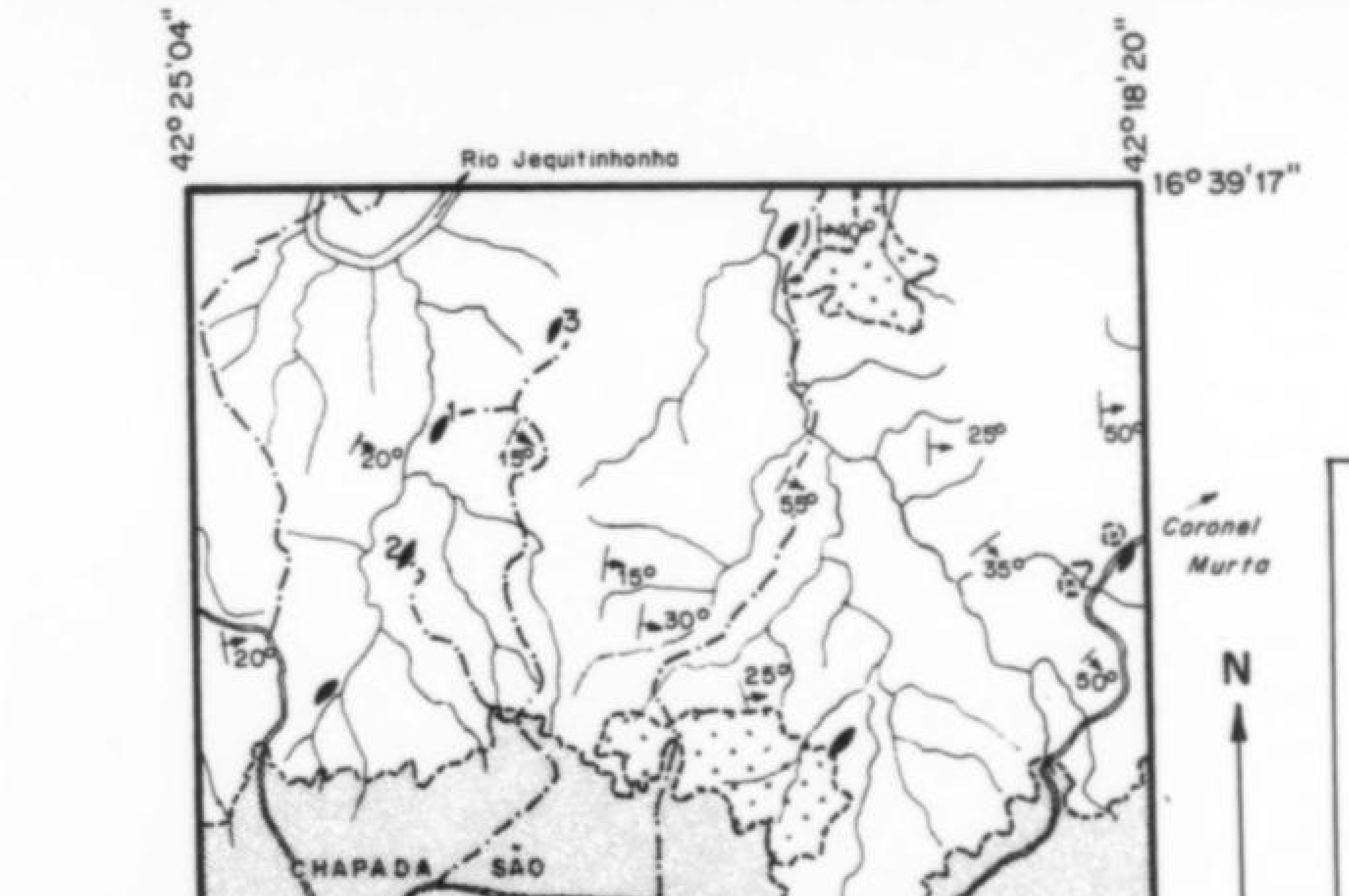


Figure 5. **A geological sketch of the pegmatite area.**

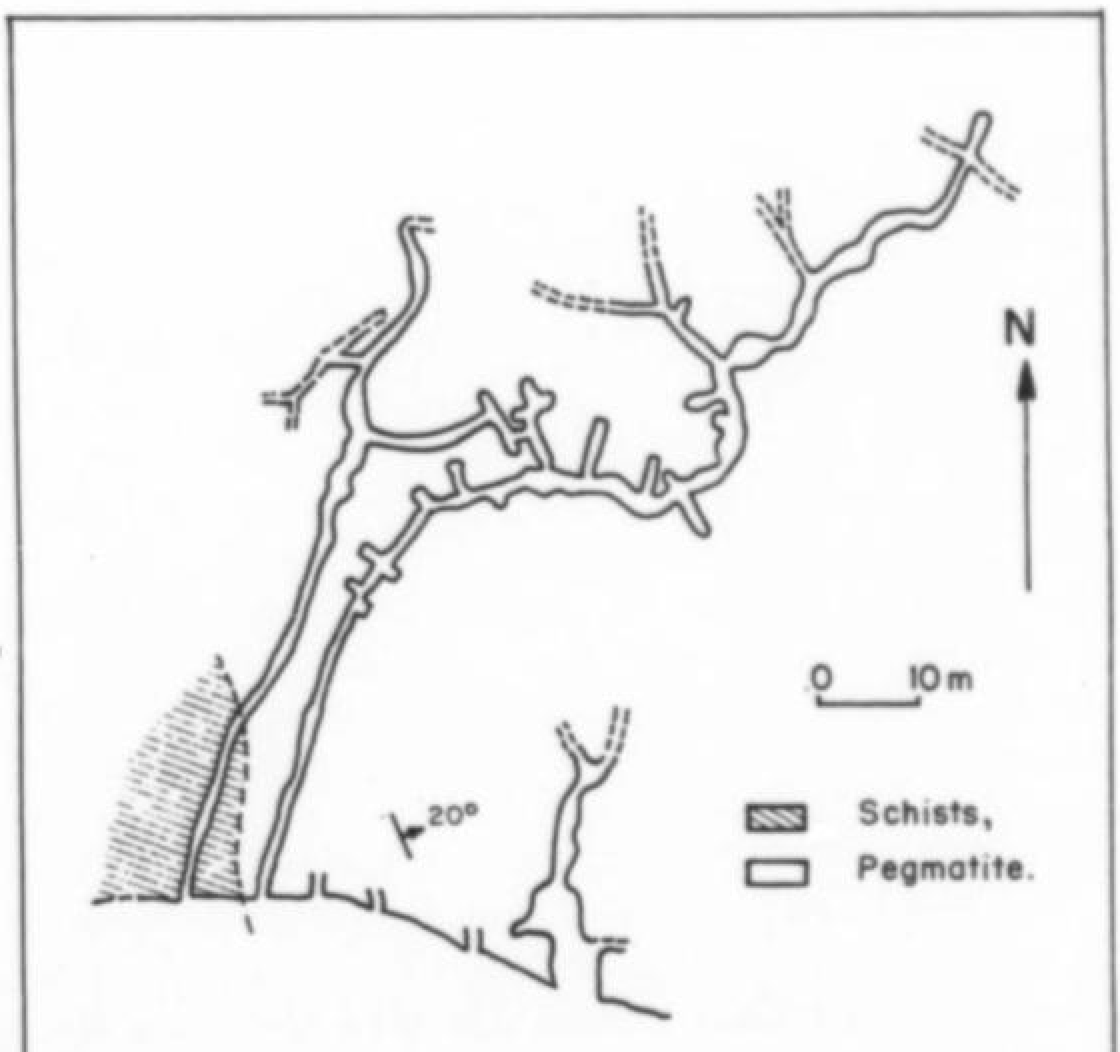


Figure 6. **Western adits of the Xanda mine, where honeycombed workings have resulted from unorganized exploitation.**

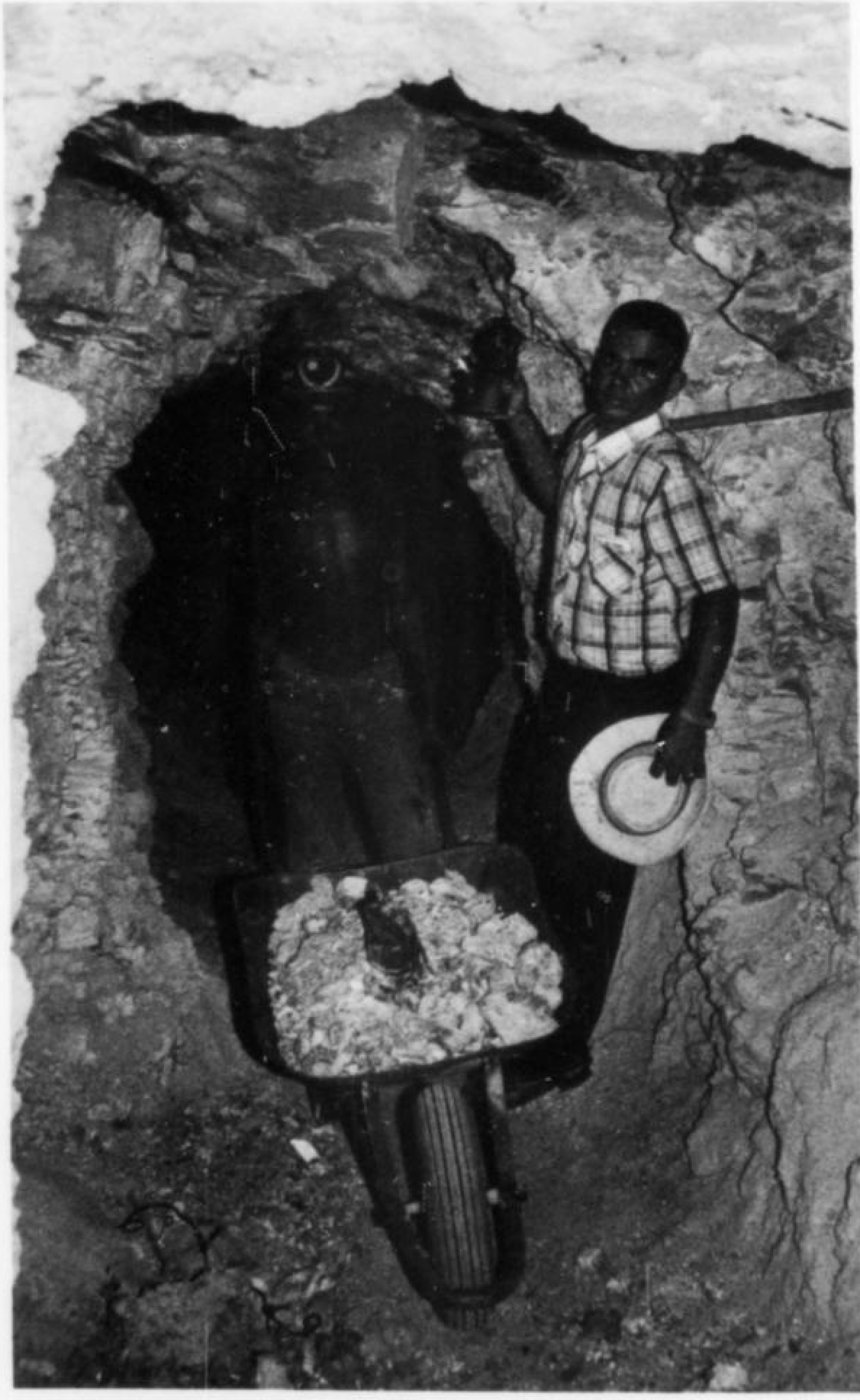
Figure 7. **Adits of the Xanda mine. The first Xanda mine specimens were found here. Note the pinchout of the pegmatite.**

located is a little more humid with a mixture of caatinga and low tropical forest. Because of the scarcity of water the population is concentrated in the valleys and near some small reservoirs, and lives by farming, ranching, and small scale mining of pegmatites and alluvial diamonds. Indeed, the famous pegmatite localities of Taquaral, Rio Piaui, Barra da Salinas, and Araçuai are only a few tens of kilometers away (see Cassedanne and Cassedanne, 1980).

Geologically, the terrain near Virgem da Lapa is composed of Precambrian metamorphic rocks forming a basement complex which, to the south, is disconformably overlain by reddish argillaceous or silty sandstones of Cenozoic age. The basement, transected by mafic dikes, is a complex of mica schists and gneiss with quartzitic beds near the base. It is intruded by granitic cupolas which outcrop as rounded, steep inselbergs or "sugarloafs" as a part of a main batholith, and by many pegmatites arranged in groups and frequently located in mica schist roof-pendants. The granite is 520-510 million years old and the pegmatites are about 490 m.y. old (Dirac and Ebert, 1967; Sá, 1977; Afgouni and Sá, 1977). The mica schists, about 650 m.y. in age, belong to the San Francisco supergroup, Macaubas group (Pflug and Renger, 1973; da Costa and Romano, 1976). They are mainly quartzitic, with biotite, sericite, accessory cordierite, garnet and andalusite. They are oriented northeast-southwest with a regional northwesterly dip. They were deposited as clastic sediments more than 2000 m thick in a geosyncline along the border of the Esphinhaço mountain range, after its consolidation about 1,000 m.y. ago. Later they were metamorphosed with a polar intensity increasing from the São Francisco craton towards the east margin of the old geosyncline where they reach the amphibolite facies with kyanite. Granites and pegmatites are intrusive in the upper part of the Macaubas group (Gorlt, 1972).

From a geochemical point of view, the pegmatites of the Itinga-Araçuai belt are characterized by a high lithium content resulting in economic concentrations mined for spodumene, amblygonite, lepidolite, and petalite (Cassedanne and Cassedanne, 1978). On the other hand, the pegmatites of the Salinas-Araçuai belt, including those of Virgem da Lapa, are characterized by an abundance of gem minerals (tourmaline, topaz, and beryl) and a relatively low lithium content.

Figure 8. **On the right is Servio Tulio Ursine (nicknamed "Xanda," after whom the mine was named); he is head of the family which owns the Xanda mine.**



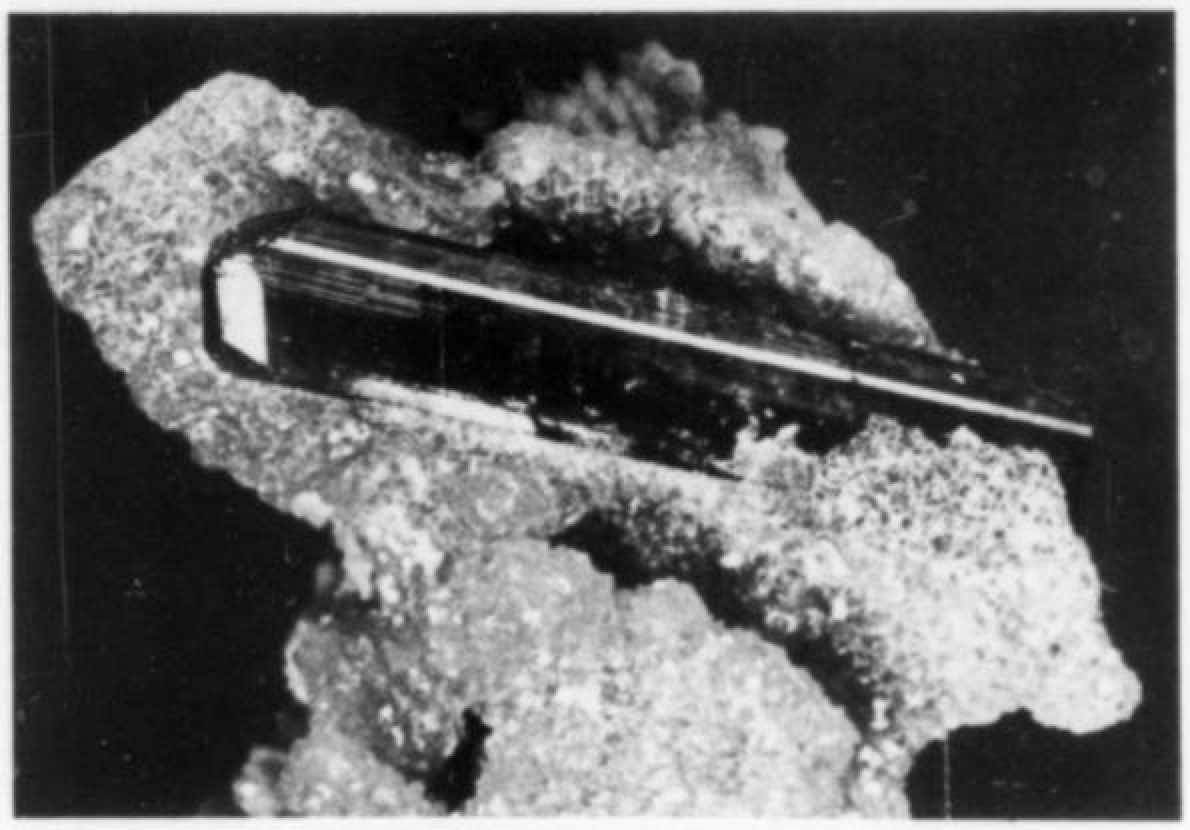
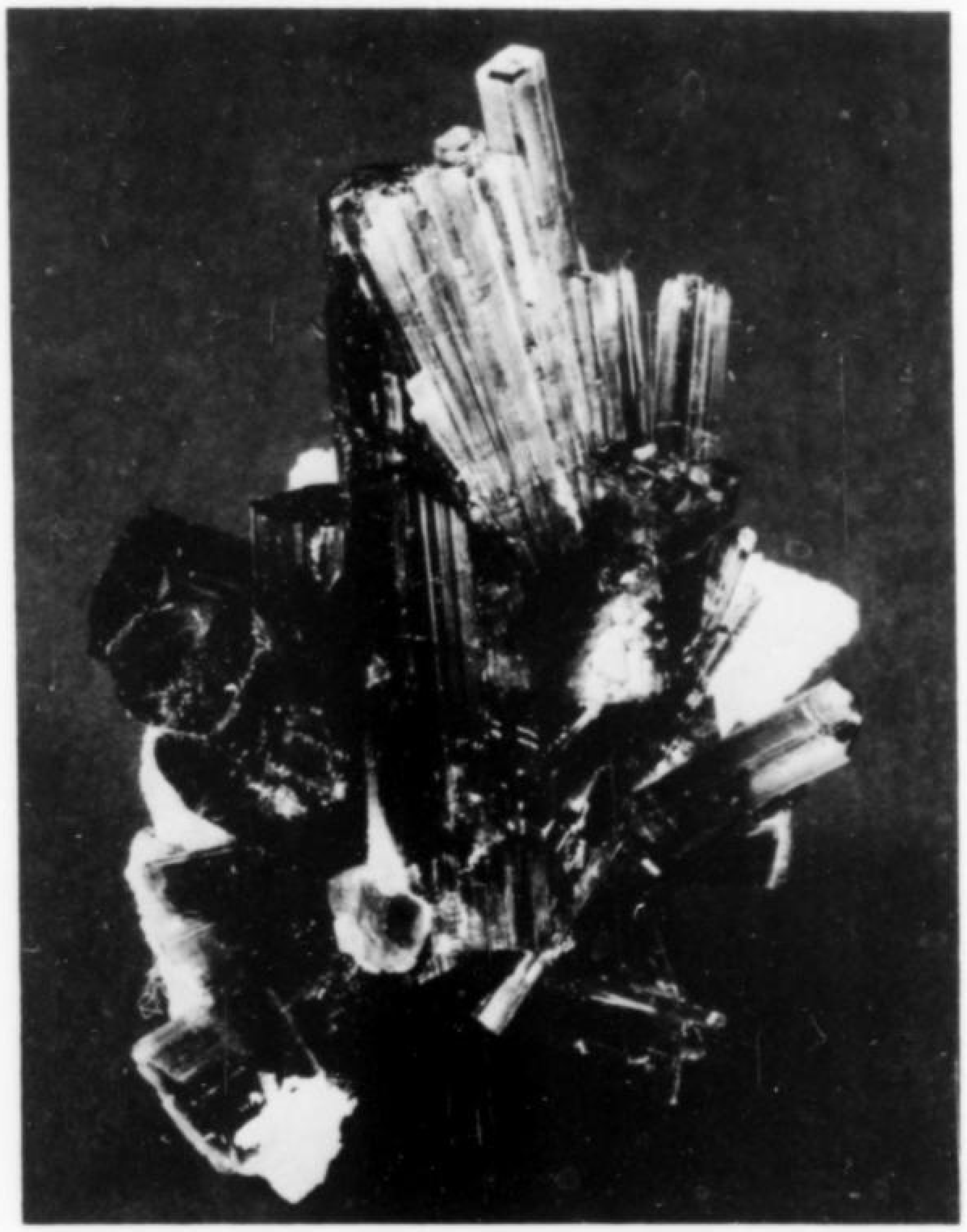


Figure 9. **Gemmy green elbaite in pale lavender lepidolite from the Limoeiro mine. The crystal measures about 5 cm.**

Figure 10. **Gemmy, greenish blue elbaite crystals with albite from the Xanda mine. The group measures 7.5 cm tall.**



THE MINES

Limoeiro mine

The mine is presently abandoned and covered by the dumps made by chaotic bulldozer stripping. No adit is presently accessible (October, 1980). Description will be made from a previous publication (Cassedanne and Cassedanne, 1976). The occurrence, on the northwest slope of a steep valley, is a flattened lens-shaped pegmatite running N30E, with a low northwesterly dip and a thickness of 2 to 4 m. Workings near the 530 m elevation level extend for about 200 m in length. They are small, parallel, sinuous adits with low gradient, following the pegmatite; all except one are perpendicular to the outcrops. The opening of irregular rooms then allowed the unsystematic working of the mineralized zones. The bulk of the waste was carried out, but a part was used as backfill, making any quick investigation impossible. Workings started from outcrops. Some shafts were sunk to reach below the pegmatite and connect with the adits, but no geological research was ever done to investigate the ore body.

The pegmatite is in dark gray quartzitic biotite schist, finely banded. The hanging wall contact with schist is frequently exposed in the adits; the footwall contact is practically never visible. Xenoliths, mainly north-south in orientation, are scattered in the pegmatite mass. A light thin layer of muscovite crystals occurs at the contact with the schists. Next, a feldspathic zone 10 to 40 cm thick (perthite, Na-plagioclase, quartz, and muscovite) occurs being fine grained and increasingly coarser in the direction of the core. This core zone contains milky quartz, always in lenses of reduced extent. Below the core the preceding sequence, inverted, is repeated down to the schists. Minerals for collection are confined to a narrow

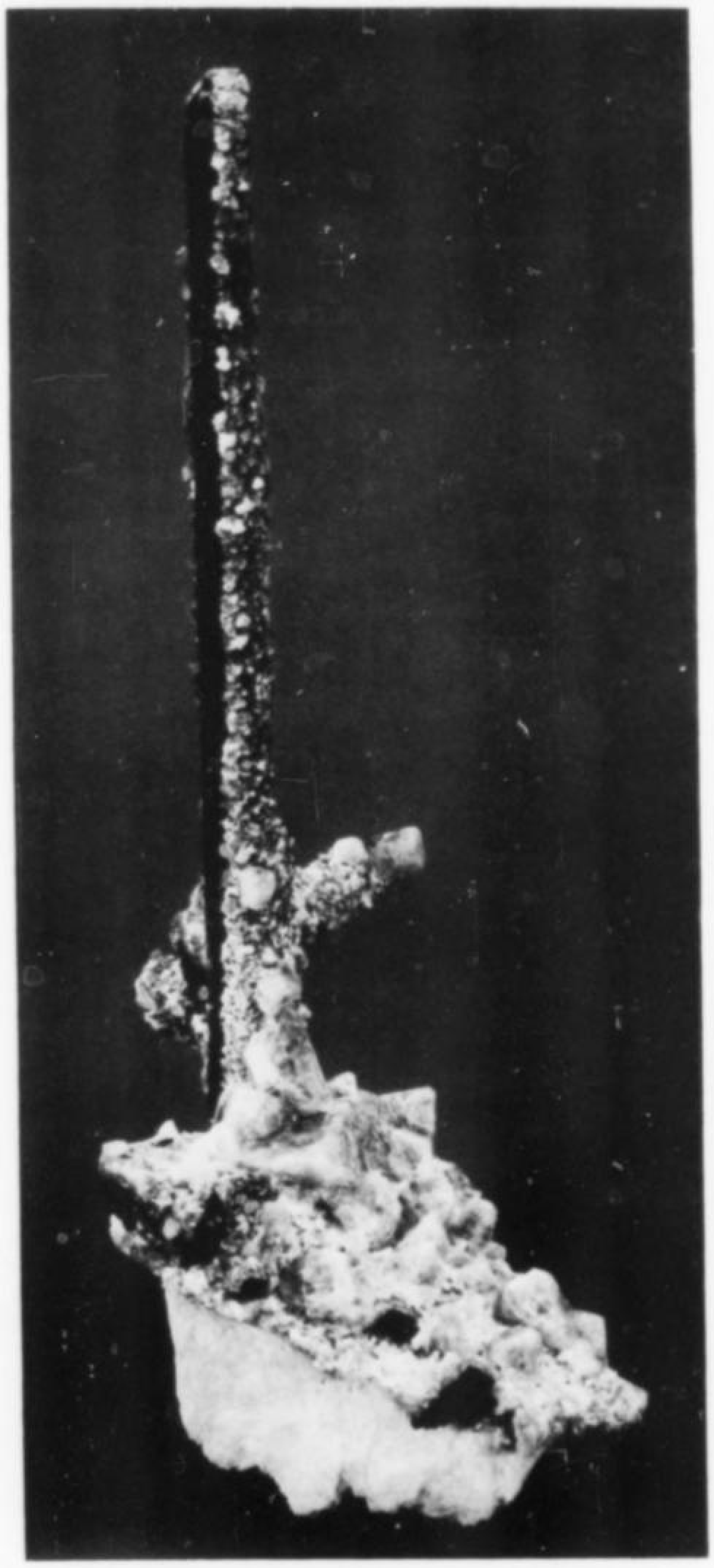


Figure 11. **Small lepidolite crystals and blocky hydroxyl-herderite on dark green elbaite and white albite, from the Xanda mine. The specimen is 14 cm tall.**

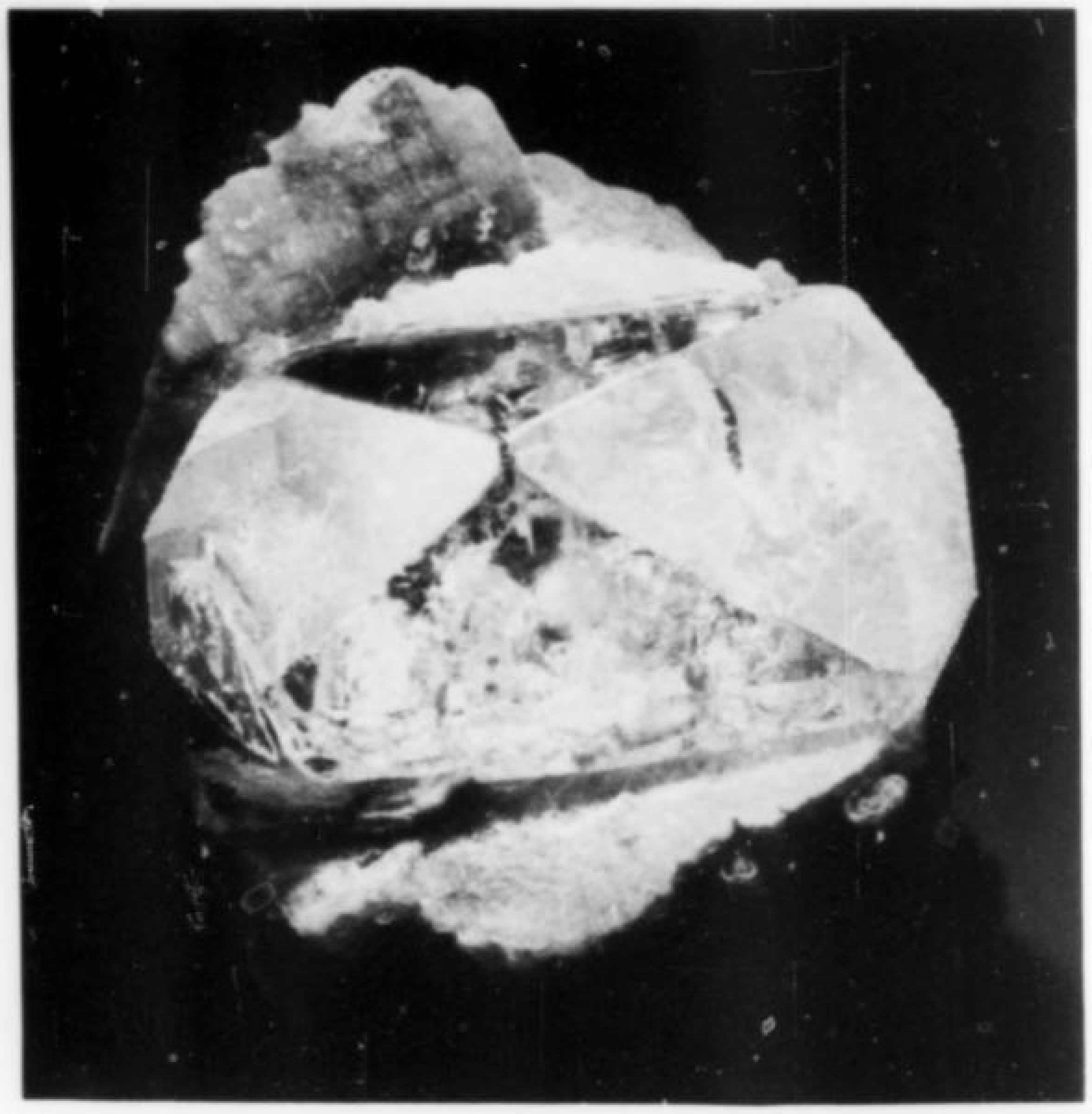


Figure 12. **Doubly terminated blue topaz crystal 3 cm across, perched on a single lepidolite crystal. Wendell Wilson collection.**

drusy zone of the coarse grained pegmatite in connection with replacement bodies posterior to the primary zoning.

The pockets are exceptionally common; on the average one for each square meter. They are lined with quartz, feldspar and/or lepidolite crystals, elongate elbaite or beautiful blue topaz crystals, and in some cases other well formed species. Their shape is unpredictable, and size is variable from a few centimeters to more than 2 m along the larger dimension. Imbedded schorl and albite (cleavelandite), common around the druses, are considered to be a guide by the miners. A structural control of the cavities exists: they are always located either near small faults running north-south and strongly dipping, or below undulations of the schist roof related to small overturned folds of which the axial plane is more or less horizontal.

The degree of weathering of the pegmatite is minimal (5 to 15 m deep), probably due somewhat to the sub-horizontal attitude of the pegmatite. Mining in the hard rock requires the use of explosives, making the recovery of large, undamaged specimens quite difficult.

A work force that had consisted of 200 garimpeiros in 1975 had shrunk to about 30 in mid-1976. In October 1980 only two unfortunates were hand-picking the waste.

It is here at the Limoeiro that the finest blue topaz specimens were produced.

Xanda mine

This mine is south-southwest of the Limoeiro mine; its adits rise in tiers between 500 and 520 m in elevation along a 150-meter-long outcrop. A lens-shaped pegmatite with northwest strike and northeasterly dip of 20-25° and average thickness of 7 m was mined by tortuous adits and irregular rooms. The southeastern part of the orebody is presently caved in by a massive landslide; in the center are new small workings in a graphic zone of feldspar intergrown with quartz. To the northwest the adits where the bulk of the gem minerals and other crystallized minerals were produced are today filled with waste and are inaccessible. Interbedded with the pegmatite is a quartz-biotite schist and contacts are quite sharp. The following description is from Neves *et al.* (1980) which may be consulted for a geochemical report.

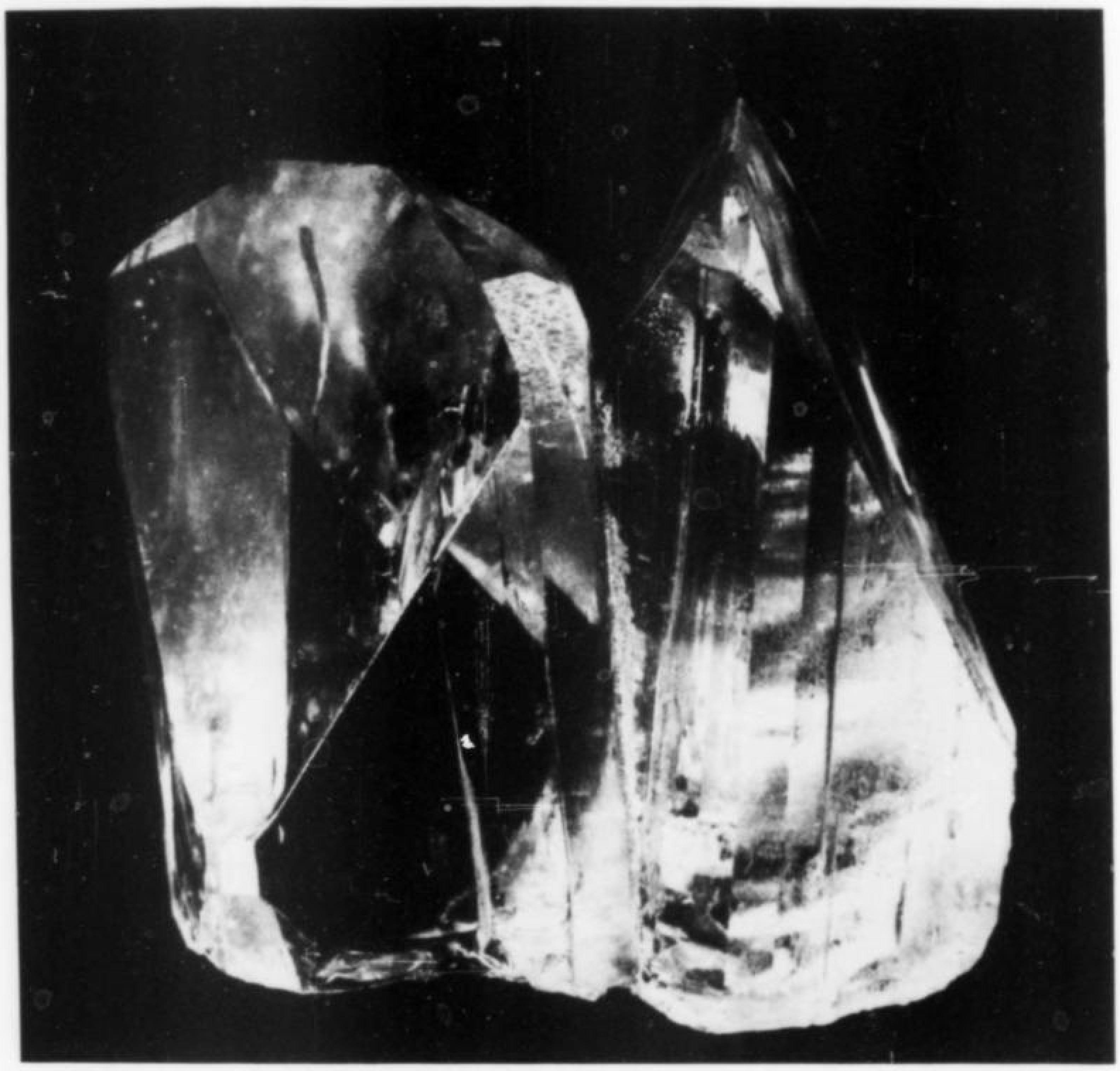


Figure 13. **A pair of pale blue topaz crystals 8 cm tall.**

At the contact with the tourmalinized schist, a narrow discontinuous rim consists of perthite, Na-plagioclase, quartz, muscovite, and a small amount of biotite. The border zone presents a well developed fine-grained graphic structure (perthite-quartz) with tourmaline, muscovite, biotite, and pink garnet. The inner zone, coarse to giant in grain size, consists of perthite and quartz with the same accessory minerals as the border zone, with beryl near the core. This lens-shaped zone is composed of milky quartz. Drusy replacement bodies are restricted to the inner zone. Their size,

Figure 14. **A large, white microcline crystal with platy albite and a quartz crystal.**

Figure 15. **Quartz crystals with microcline in place in a pocket in the Xanda mine.**

shape, and mineralogy are similar to those at the Limoeiro mine.

This mine has been the steadiest producer of the three pegmatites studied and it is here that the majority of the hydroxyl-herderite has been produced. Little or no mining is going on at this time, but the potential for new pocket discoveries is good. The dumps have been thoroughly picked over.

Toca da Onça mine

The structure of this pegmatite is very similar to that of the Limoeiro. The mine has very similar mineralogy with the notable exception that no topaz or hydroxyl-herderite has been found here. The mine has been worked infrequently.

MINERALOGY

The three pegmatites studied for this article have similar mineral assemblages, with few exceptions. All the mines have produced elbaite, albite (cleavelandite), quartz, microcline, lepidolite, muscovite, schorl, fluorapatite, beryl, cassiterite, and columbite-tantalite. Topaz and hydroxyl-herderite are important occurrances except at the Toca da Onça mine. Additional species have been observed and will be noted. The abundance of open pockets and lack of weathering has resulted in the production of very well formed crystals, many in colorful, esthetic associations. Unfortunately the garimpeiros kept no record of their finds. Therefore we can report here only the more common features and characteristics of the various minerals.

Tourmaline

The species present are schorl and elbaite (green, pink, blue, or colorless, often multicolored. Anhedral black schorl occurs mainly in the massive zones, whereas elabite is found in the pockets associated with all the other minerals. Crystals shape and form is varied but in most cases one termination is a simple basal pinacoid and the other termination consists of one or two sets of trigonal pyramid faces, one set being quite minor. Many elbaites are doubly ter-

Figure 16. A purple hydroxyl-herderite crystal 3 cm tall, on white microcline, from the Xanda mine.

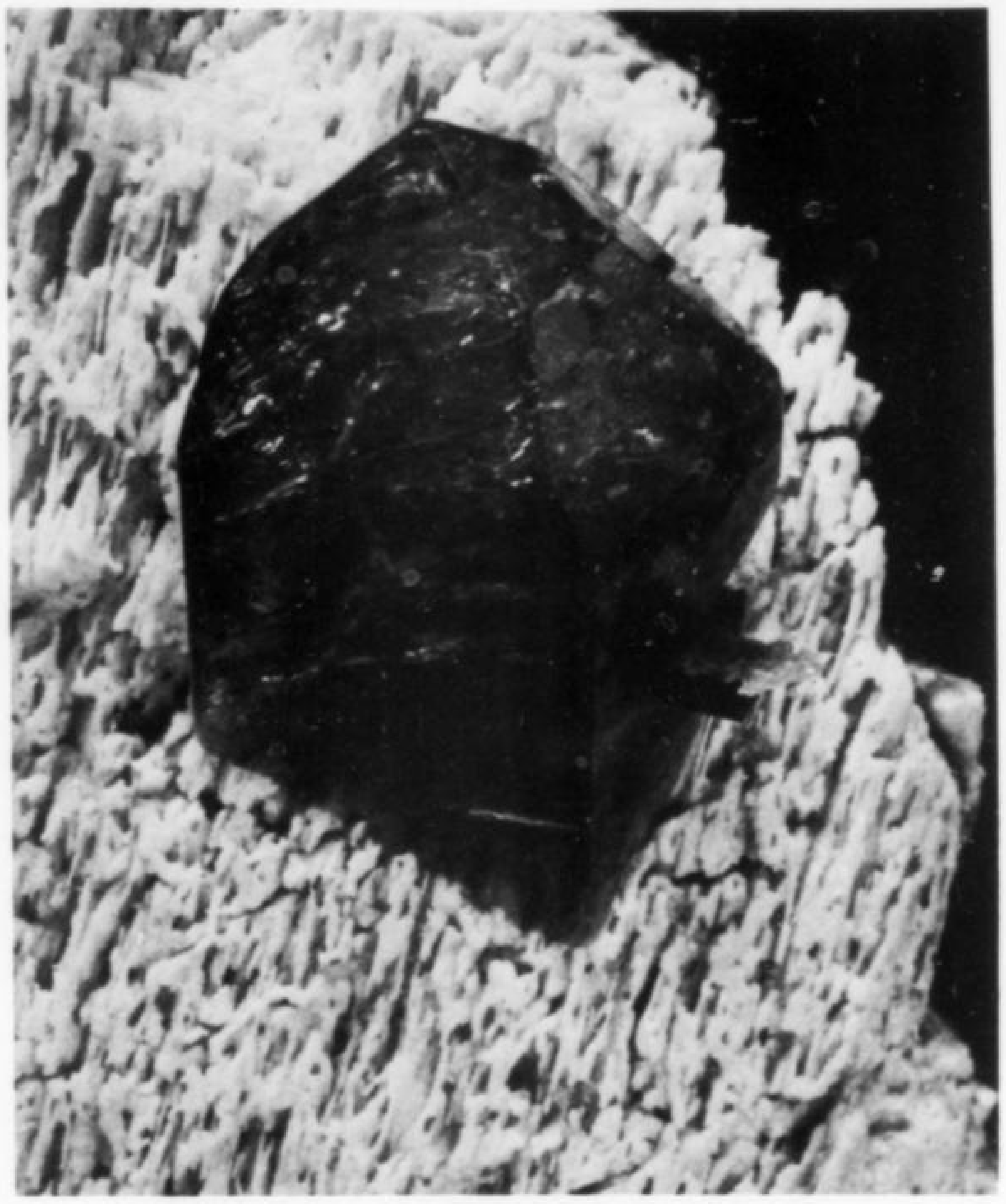


Figure 17. A purple hydroxyl-herderite crystal measuring 6 by 3 cm, on white microcline. David Byers collection.

Jack Lowell photos and specimens except as noted.

Figure 18. Dark green lbaite crystals piercing a pale purple hydroxyl-herderite crystal 5 cm long.

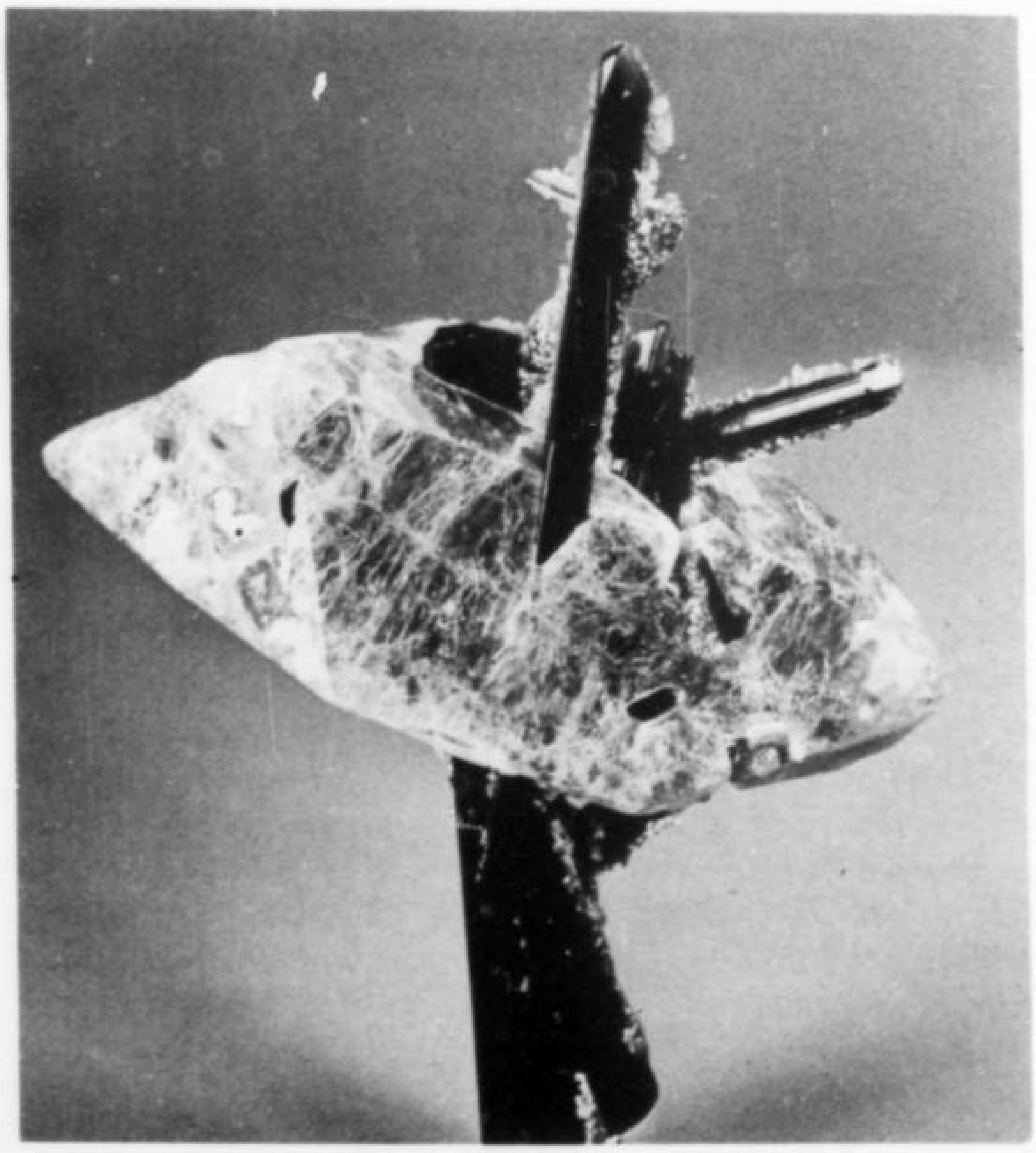


Figure 19. Pale purple hydroxyl-herderite crystals to 6.5 cm perched on a dark green elbaite crystal. Albert Chapman collection.

Figure 20. **Pale yellow microlite crystals to 1.9 cm, in pale lavender lepidolite. Smithsonian specimen.**

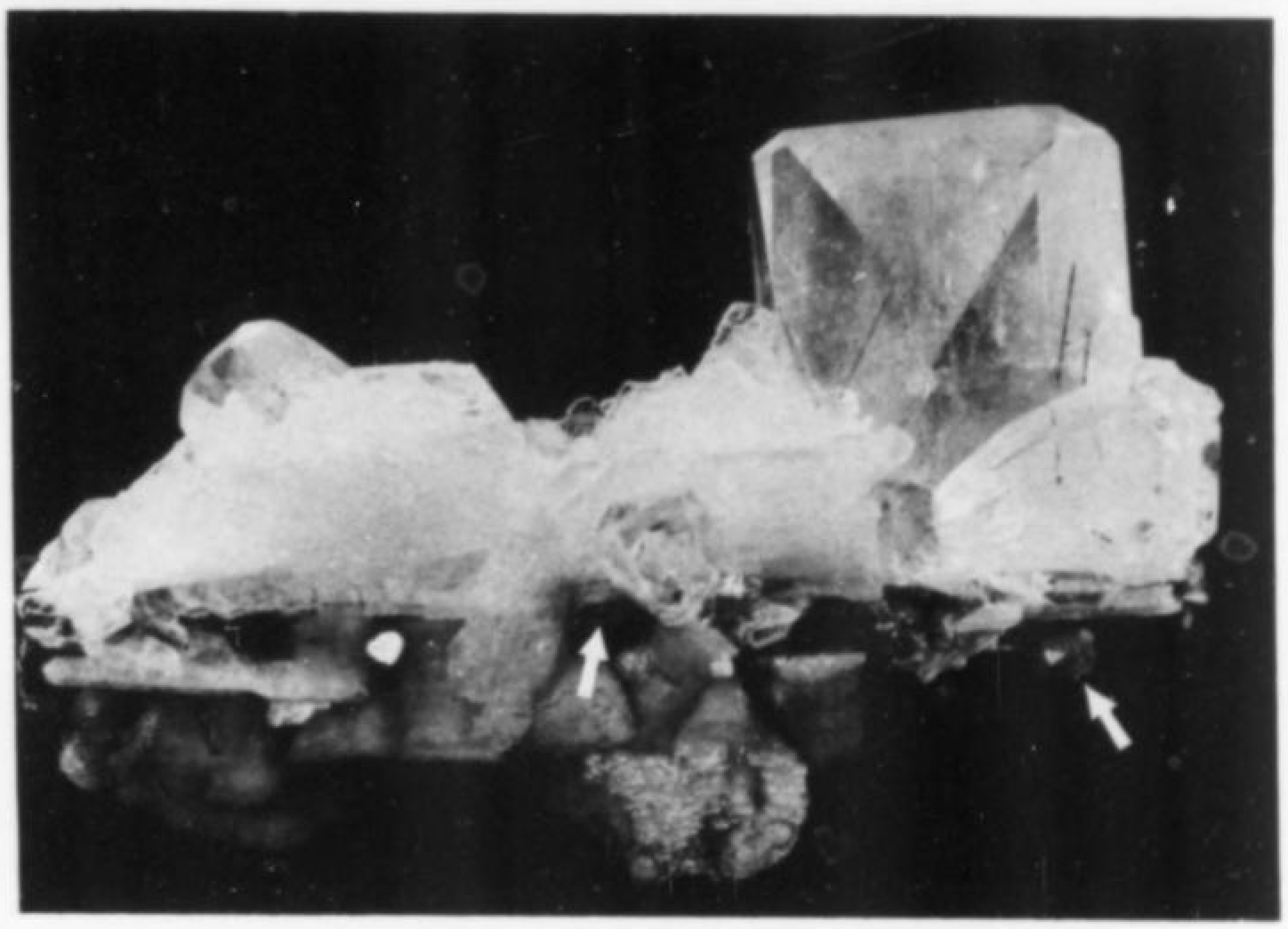


Figure 21. **A superb, 4-inch specimen consisting of a dark green elbaite crystal resting on pale purple lepidolite crystals, topped by platy white albite crystals and a fine blue topaz crystal, and also having two yellowish microlite crystals attached (arrows). From the Xanda mine.**

minated "floaters" and crystals up to 1 meter in length have been found. Many crsytals are extremely elongated and commonly show parallel growth or a slightly divergent fan-shaped habit. In many cases elbaite is coated with fine grained lepidolite, and sometimes the crystals are distorted or broken and rehealed. Almost every crystal is striated along the prism and has a brilliant luster.

Topaz

Colorless to medium blue crystals are common at the Xanda and Limoeiro mines and are characterized by their extreme sharpness of habit, usually a wedge shape due to prominent prism {021} faces. At the Limoeiro mine, the crystals are frequently heavily etched along the prism faces and have a deeper blue color. Single crystals up to 26 kg, 20 by 25 cm, have been found and most of the topaz is attached to matrix of lepidolite, cleavelandite, microcline, quartz, or rarely elbaite associated with microlite. One remarkable, light blue euhedron 4 kg in weight has a 4-cm crystal of elbaite grown on a finished prism {021} face. The topaz sometimes has inclusions of green elbaite or lepidolite, or fractures filled with iron oxide which cause those crystals to appear yellow in color.

Microcline

Well-formed crystals, beige, gray, tan or flesh-colored, and up to 30 cm in size occur in the pockets, and are typically skeletal due to heavy etching. Crystals of albite, elbaite, lepidolite, hydroxylherderite, or rarely topaz have formed on the microcline faces in some specimens.

Albite (variety Cleavelandite)

Albite occurs in blades up to 12 cm in length. Generally milky, it is sometimes transparent, always sharp-edged. Twinning is commonly visible without a lens. Beautiful and perfectly bladed pieces are not uncommon and are actively sought by collectors. Frequently the albite is associated with elbaite, lepidolite, topaz, microcline or quartz.

Quartz

Well formed crystals occur, usually attached to microcline, lepidolite, or albite. Most crystals have a dull, frosted surface. Rarely they are smoky in color, but generally are colorless. Some crystals have green elbaite attached or included. Prismatic crystals to 50 cm can be collected on the dumps.

Hydroxyl-herderite

Perhaps the world's finest specimens have been produced at the Xanda and Limoeiro pegmatites. A detailed description has been published in the *Mineralogical Record* by Dunn *et al.* (1979) and should be consulted. Crystals as large as 15 cm long have been found though most are from 1 to 5 cm long. The gray to bluish violet prisms are generally bright with sharp form, terminated by a prism, commonly complexly modified. Yellow to waxy beige and purple/straw-yellow bicolored crystals are also known. Most crystals have abundant internal fractures, and are associated with dark elbaite, microcline, zinnwaldite and albite.

Fluorapatite

Generally fluorapatite forms brilliant, complexly modified crystals with tan, yellow, blue, purple, green, or rarely black color and strong color zoning. Matrix, where preserved, is albite and sometimes lepidolite. At the Toca da Onça mine, spectacular, brilliant, doubly terminated, tabular crystals up to 15 cm were found on a matrix of albite.

Beryl

Beryl occurs in the pockets as gemmy to opaque euhedral crystals up to 8 cm long, on euhedral microcline with albite, muscovite and schorl. The color ranges from colorless to yellow and pale green. The usual form is a very sharp prism with a pinacoidal termination modified by pyramidal faces. A fine example is shown on the cover of this issue.

Microlite

Sharp octahedrons reaching 3 cm in size and pale yellow, beige or tan in color are found scattered on lepidolite, albite, quartz and elbaite.

Cassiterite and **Columbite-Tantalite**

Occasionally brilliant cassiterite crystals to 2.5 cm and columbite-tantalite crystals to 4 cm occur on albite, lepidolite, or elbaite matrix. Both columbite-tantalite and cassiterite are also found as irregular grains scattered in the massive pegmatite.

Geocronite

An exceptional geocronite specimen was found in 1976 at the Xanda mine and was at first thought to be columbite-tantalite. This V-shaped twin consists of two individuals, each about 7.5 cm long,

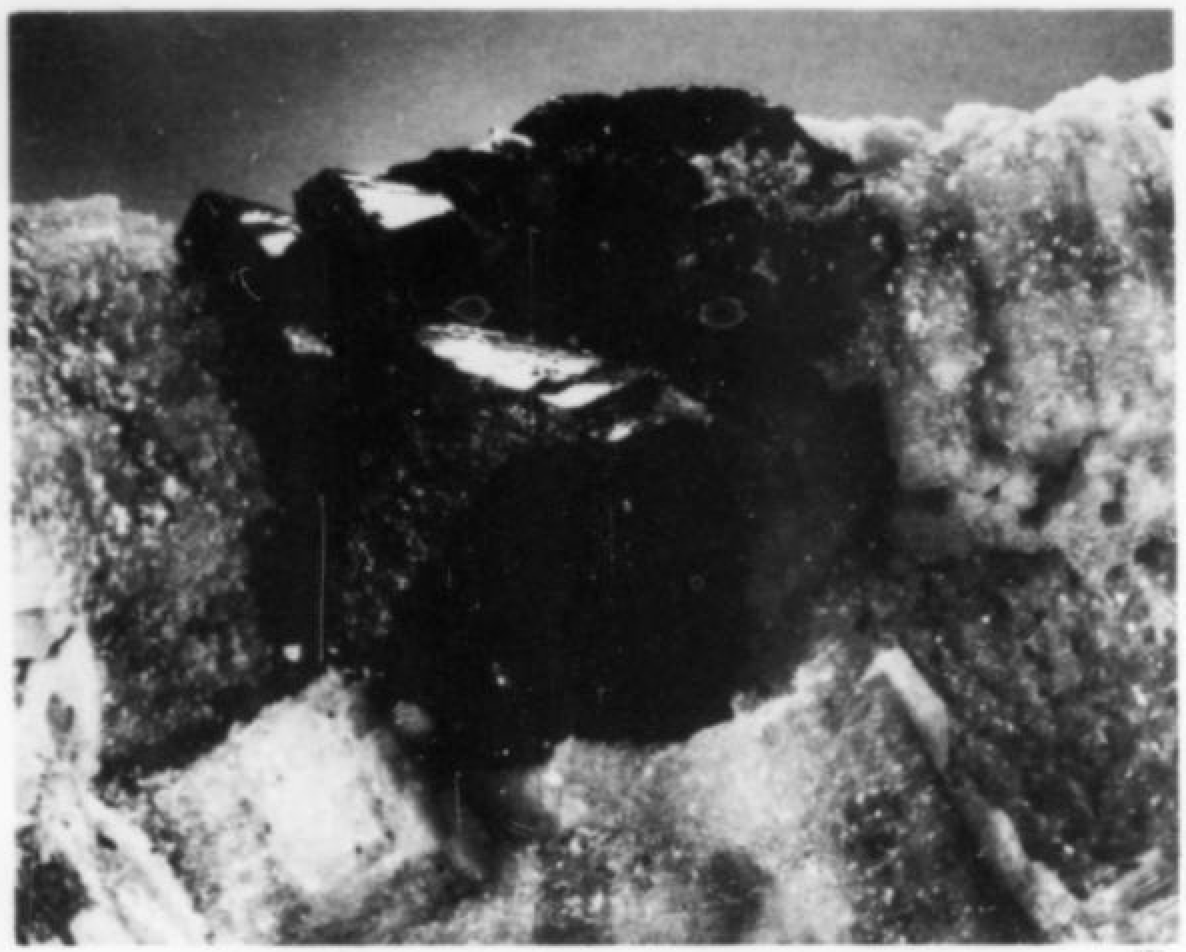


Figure 22. **A 4-cm group of black cassiterite crystals in pink and lavender lepidolite. Smithsonian specimen.**

Figure 23. **Columbite-tantalite crystal 5 cm tall on white albite.**

and it is by far the finest geocronite ever found. This material is highly bismuthian and is currently under study (P. J. Dunn, pers. comm.).

Muscovite

Muscovite occurs as anhedral masses up to 20 cm in dimension, in the massive portions of perthite-quartz-rich zones.

Zinnwaldite

Zinnwaldite is present as large crystals, later formed than albite, and is frequently twinned in an irregular shape reaching 15 cm in size. Cleavage is easy and produces thin sheets with a bronze colored glint. This mica is commonly associated with hydroxylherderite and albite and is often surrounded by small parallel lepidolite prisms.

Lepidolite

Lepidolite occurs most frequently in a short prismatic form made by the coalescence of parallel crystals having longitudinally stepped faces. Often the crystals have a belt of darker color as a stripe around their circumference. The basal faces are rounded and the scaly appearance due to the aggregated crystals is obvious. The core is pink or pale purple. Size of each crystals varies from a few millimeters to more than 10 cm. The matrix of many fine collection specimens consists of groups of these crystals, sometimes with albite. Topaz in combination with green elbaite adorns many of these pieces. Large single crystals of lepidolite, lilac-colored and lustrous, occur with clusters of smaller crystals scattered on the crystal faces.

Garnet

Garnets, pink to orange-brown in color, are common at the Xanda mine, but do not interest collectors as they are cracked and partially decomposed.

Nontronite

Ten-cm patches are common at the Xanda mine.

Pyrite

Irregular masses are found associated with very dark colored tourmaline at the Xanda mine.

CONCLUSION

The district of Virgem da Lapa will always be considered to be one of the finest localities in the world for well crystallized minerals. In a period of about two years, mineral collectors were exposed to the finest array of pegmatite specimens ever discovered. Topaz, elbaite, hydroxyl-herderite and the associated minerals from these pegmatites are, in many instances, the world's finest. The area has great potential for future production, but mining is now restricted principally by economic factors. Though the mines have been heavily worked, and are presently nearly abandoned, one can expect specimens of great interest to be found if mining is again undertaken.

ACKNOWLEDGMENTS

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Pink Octahedral Fluorite from Peru

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For many decades the most celebrated and sought-after specimens of fluorite have been the pink octahedrons from the Swiss Alps. Recently pink octahedral fluorite equalling or exceeding the quality of Swiss specimens has been found at the Huanzala mine north of Lima, Peru.

LOCATION

In November of 1980, some extremely fine specimens of pink octahedral fluorite were found at the Huanzala mine, Huanuco Province, Peru. The Huanzala mine is located near the town of the same name, approximately 240 kilometers north of Lima, and exploits an orebody consisting of a sulfide replacement in Jurassic limestone. The mine produces copper, lead and zinc ores, which are concentrated on the site. Access to the mine is possible by automobile via the Pan-American Highway north of Lima, and then east through the town of Conococha, over unimproved dirt roads. No tourist facilities exist in Huanzala.

OCCURRENCE

Fluorite is frequently encountered at Huanzala, commonly as light green, crude octahedral crystals as large as 3 cm. However, dark green fluorite octahedrons, some of which are as large as 10 cm, have also been found at Huanzala. Chalcopyrite crystals as

***Figure 1.* Octahedral fluorite with pyrite from the Huanzala mine, Peru. The specimen measures 10 x 7½ x 5 cm. Smithsonian collection; photo by Dane Penland.**

large as 2 cm commonly occur on this type of fluorite.

The pink fluorite occurs in randomly distributed vugs which are found within the sulfide orebody. According to miners, the vugs are roughly spherical in shape and range in size from a few centimeters to approximately 40 cm in diameter.

The color of the pink fluorite ranges from almost colorless to hot-pink. Commonly, the crystals contain an ill-defined grass-green zone in the center. The crystals, usually well defined and possessing sharp edges and brilliant faces, are typically simple octahedrons commonly showing minor cube {001} faces, as well as minor dodecahedron {011} faces. Although the majority of the crystals are between 1 and 3 centimeters in size, some crystals as large as 5 cm have been observed. The pink fluorite fluoresces red and phosphoresces blue in response to shortwave ultraviolet light.

Minerals typically found associated with pink fluorite include pyrite, sphalerite and galena. The crystals of these minerals are commonly small when in association with pink fluorite.

Associated pyrite occurs as shiny, sharp, cubic crystals which are quite common from Huanzala. The largest crystals of pyrite associated with pink fluorite approach 3.5 cm in size whereas those without fluorite reach up to 10 cm.

Sphalerite occurring with pink fluorite specimens consists of both single and twinned crystals as large as 1.5 cm. The crystals are opaque, black and usually dull lustered.

Galena crystals found on pink fluorite specimens are small cubes up to 5 mm, and are a lustrous, bluish lead-gray color.

***Table 1*. Summary of recent theories on the cause of color in fluorite.**

Color	*Cause*	*Reference*
Yellow	Eu^{+2}	Przibaum (1938)
	Fe & rare earths	Przibaum (1953)
	OF_2 or OF^-	Neuhaus *et al.* (1967)
	O_3^-	Bill *et al.* (1978)
Yellow-green	Y/Ce associated centers	Bill *et al.* (1978)
Green	Colloidal calcium	Allen (1952)
	Fe^{+2} & (Mn,Cr,Ni or Cu)	Przibaum (1953)
	Sm^{+2}	Bill *et al.* (1967)
	Sm^{+2}	Neuhaus *et al.* (1967)
	Sm^{+3}	Bill *et al.* (1978)
Blue	Fe^{+3}/Fe^{+2} complex with Cu	Przibaum (1953)
	Colloidal calcium	Allen (1952)
	Colloidal calcium	Mackenzie *et al.* (1971)
	Y associated centers	Calas (1972)
	Colloidal calcium	Braithwaite *et al.* (1973)
	Y associated centers	Bill *et al.* (1973)
Violet	Colloidal calcium	Allen (1952)
Red (or pink)	Fe^{+3}	Przibaum (1953)
	Cr & Mn^{+3}	Przibaum (1953)
	YO_2	Bill *et al.* (1967)
	YO_2	Bill *et al.* (1978)
Orange	Mn^{+2}	Bailey *et al.* (1974)
Brown	Inclusions of organic matter	Calas *et al.* (1976)

OTHER OCCURRENCES

Fluorite is a common mineral which occurs in almost every color of the rainbow, but is "rarely rose-red, crimson-red or pink," (Palache *et al.*, 1951).

Very few localities have produced pink fluorite octahedrons, and usually only a few specimens are produced from any locality. Probably the most productive and well known localities are in the region of the Central Aar Massif of Switzerland. More than a dozen specific localities exist in this region. Here the fluorite occurs in cavities in granite. Associated minerals include colorless and smoky quartz, calcite, chlorite, and rarely apatite, hematite and stilbite. The color of the fluorite ranges from pale to dark pink and the crystals are typically between 1 and 3 cm in size. The faces are usually rough, composite and somewhat dull or frosted in appearance (Weibel, 1966), but may also be relatively smooth and lustrous.

Pink octahedral fluorite has been found at the Obira mine, Oita Prefecture, Kyushu, Japan. Here the crystals are deeply etched and very dull. The color ranges from colorless to pale pink, and the size up to 3 cm. The crystals occur with colorless quartz crystals.

Other noteworthy localities include Chamonix, France (where deep red octahedrons are generally less than 1 cm in size), and Villa d'Ossola, Piemonte Region, Italy (where pink octahedrons are generally less than 1 cm).

THE PINK COLOR

A question causing some understandable concern among owners of these pink fluorites is whether the color might fade. Two dealers, Rock Currier (*Jewel Tunnel Imports*) and David Eidahl (*Pala Properties*), and also Wendell Wilson (editor of the *Record*), report that they have placed pieces in direct sunlight for several days and observed no color change; if anything, the color intensified a bit. Rock then sent a piece to George Rossman at the California Institute of Technology in Pasadena. Rossman's optical absorption analysis indicated that the coloring agent for both the pink and the green zones is yttrium, the same chromophor that has been identified by others in the famous Swiss pink fluorites (none of which have been known to fade). The yttrium substitutes for calcium in the fluorite structure and, when a vacant fluorine site adjacent to the yttrium atom is occupied by a free electron, the green color results. If, on the other hand, two fluorine atoms next to a yttrium are replaced by oxygen atoms, one of which has lost an electron, the pink color results. In both cases the electrons are displaced (and the color created) by natural radiation. Rossman irradiated the sample from Currier and it turned an intense amethystine purple, which eventually faded back to the original pink color.

Richard Kosnar (*Mineral Classics*) reports different results. He reports that, after two days on his window sill, his specimen of pink Peruvian fluorite turned noticeably lighter. However, since all experimental efforts to induce fading have failed it seems likely that specimens prone to fade are rare, and that these crystals may not all be identical in their color stability. Many specimens were on display, under hot showcase lights, for three days at the Tucson Show and none showed any discernable fading, so it would appear that they are at least stable under incandescent light.

Hintz (1915) provides an excellent summary of early investigations into the causes of color in fluorite. Recent theories are summarized in Table 1.

ACKNOWLEDGMENTS

Thanks to George Rossman for sharing the results of his studies on the Peruvian fluorite chromophors, and to John White for providing the Dane Penland photo of the Smithsonian's Peruvian pink fluorite.

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(continued on page 38)

the Sorbonne Collection

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Begun by Hauy in 1809 and nurtured by such luminaries as Beudant and Delafosse, the mineral collection of the Sorbonne (University of Paris) achieved international stature with the acquisition of a part of the Vesigne collection in 1953. The beautifully engineered Exhibition Room, opened in 1970, does justice to this remarkable collection.

HISTORY of the COLLECTION

The mineralogy collection of the Faculty of Sciences, University of Paris VI at Jussieu, was first developed with the Chair of Mineralogy, created in 1809 by a decree of the Convention. The first titleholder was René Just Haüy who, at the time, was already Professor at the King's Garden (National Museum of Natural History) and at the School of Mines.

The collection was first housed in the laboratory of mineralogy at rue des Feuillantines and was only transferred to the Sorbonne much later toward the end of the last century. The successors of Haüy improved the collection considerably, in particular Beudant, and then Delafosse who, in 1847, drew the attention of the Dean of the Faculty to a remarkable private Swiss collection which finally was acquired for the sum of twenty thousand francs, current value at the time. Afterwards, several purchases were made from merchants and especially from specialists whose collections became available. Nevertheless, it was only after 1953 that the collection attained an honorable rank due to the acquisition of a part of the bequest of the great collector, Vesigné. Since that date, numerous collecting missions, and exchanges with foreign and French museums, have placed it among the great collections of the world.

Its newest presentation, since 1970 in the new building of the University of Paris at Jussieu, was inspired by the room of the Crown Jewels of Iran, and created by the same builders. The collection is situated on the RC (Rez de chaussée) level one floor below the open collonnade of the Jussieu level of Tower 25, indicated in large numbers visible from the entrance near the Metro station of Jussieu.

Since 1970, the interest of the public of all ages and backgrounds has grown continuously – the collection now receives more than 20,000 visitors per year. During the school year the collection is open to the public on Wednesday and Saturday afternoons. School and cultural groups can visit at other times and days if they make a special request.

THE COLLECTION

The exhibition room contains 24 panoramic showcases corresponding to the crystallochemical classification generally used in mineralogical museums: native elements, haloids, oxides, sulfides, borates, sulfates, chromates-molybdates-tungstates, carbonates, arsenates-vanadates-phosphates, silica, and eight cases of silicates.

A separation has been made between the working research collection of about 15,000 specimens and the display collection of about 2,500 specimens specifically for students and the public, which has the double advantage of avoiding disturbances to the researchers by visitors and obtaining a better presentation by not placing the classification drawers in the museum itself. The specimens shown represent about 700 different mineral species which are among the most beautiful and most important for the earth sciences and for industrial applications.

THE EXHIBITION ROOM

Visitors who enter the exhibition room for the first time are struck immediately by the luminous atmosphere pervading the room. This atmosphere serves the double function of not altering the exposed minerals photochemically and of enhancing the visitor's visual comfort. This is accomplished by avoiding infra-red and ultraviolet rays which are extremely harmful to the specimens, and by exalting the most delicate colors and most complex forms using a tailored lighting system without any annoyance to the observer's eye.

The best presentation of a mineral collection is guided by two im-

Figure 1. Showcases in the Exhibition Hall of the Sorbonne are carefully designed to eliminate glare, heat and dust, and to allow the viewer a 360-degree view of specimens. (All photos by Nelly Bariand.)

Figure 2. Golden amber-colored calcite crystals on black sphalerite from Elmwood, Tennessee. The specimen, measuring 20 cm tall, won first place for Tom Palmer (of *Crystal Cavern Minerals*) in the Tucson Show calcite competition in 1981.

Figure 3. The magnificent, 4-cm cumengite crystal (actually six crystals grown on the faces of a boleite cube), one of the showpieces of the Sorbonne Collection. It was found at the famous locality of Santa Rosalia, Baja California, Mexico.

Figure 4. Cuprosklodowskite (named for Marie Sklodowska Curie) from Musonoi, Shaba, Zaire. The 2-cm crystals are part of a specimen measuring 20 cm overall.

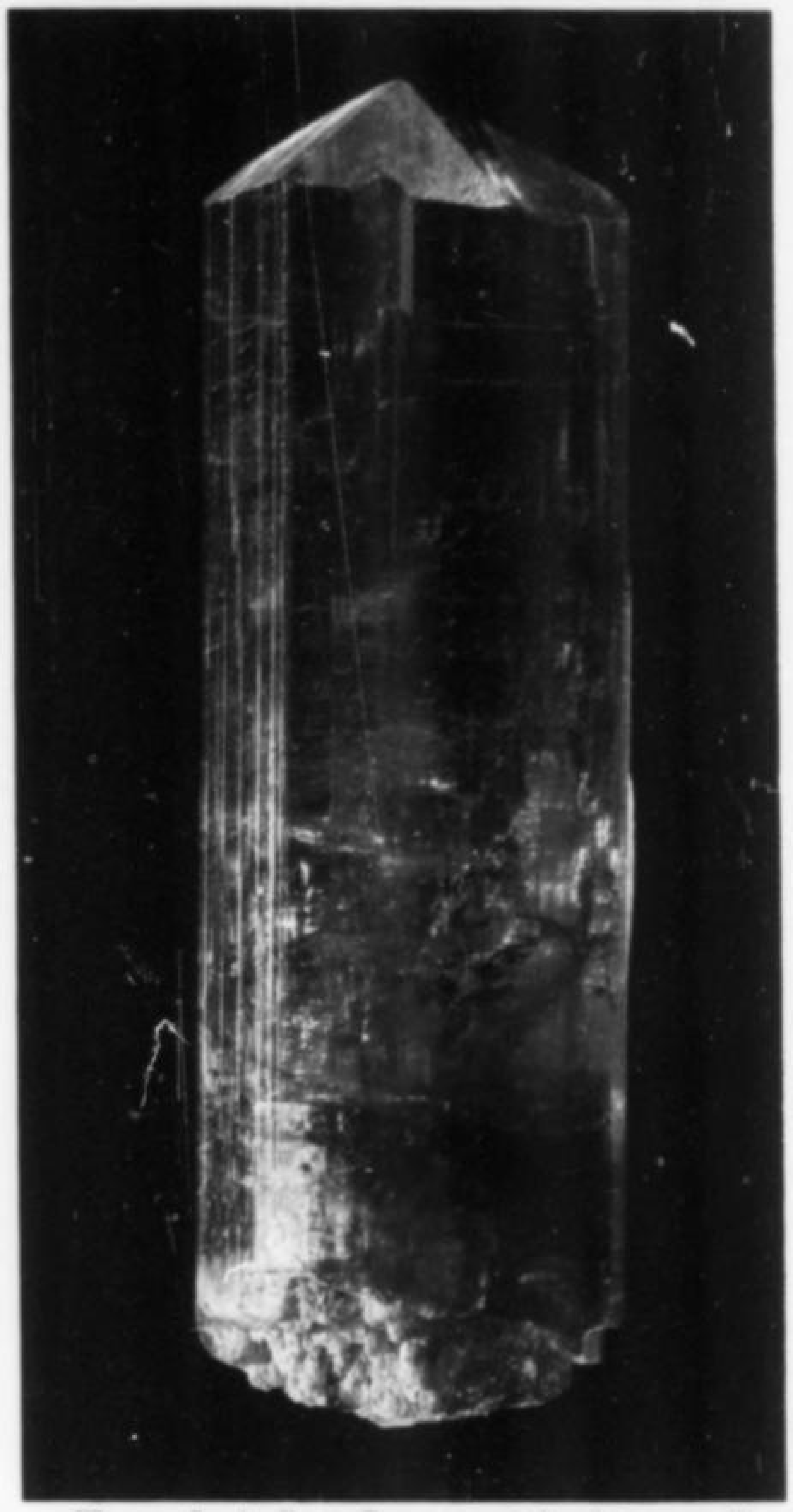

Figure 5. A fine, 7-cm crystal of tourmaline from Madagascar.

Figure 6. A superb, 10-cm specimen of metatorbernite from Margabal, Aveyron, France.

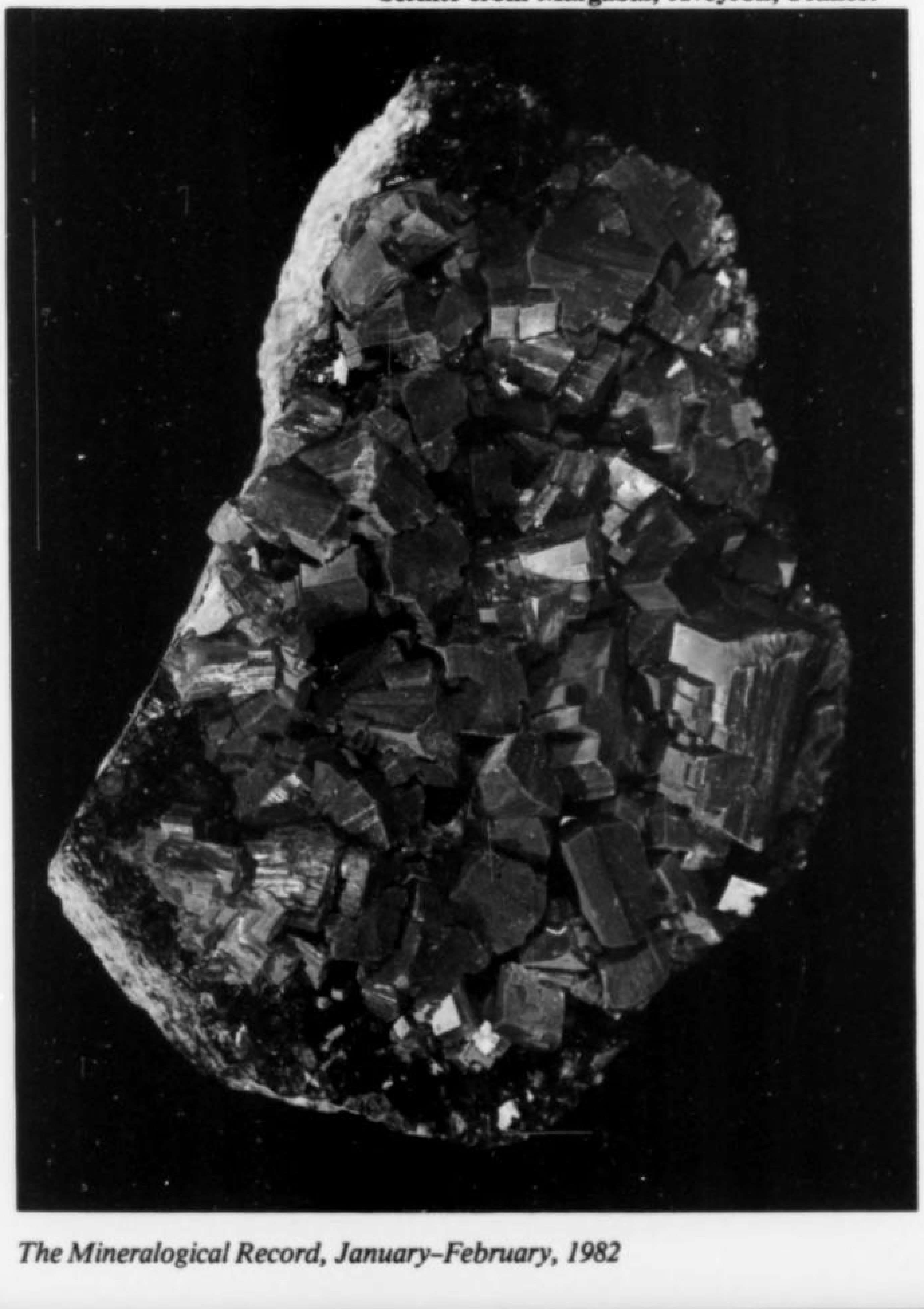

Figure 7. A 5-cm crystal of the uranium mineral novacekite, from the Brumado mine, Bahia, Brazil.

peratives: the artistic, accomplished by presenting the minerals in panoramic showcases so that the visitors can study each specimen by observing it from all angles, with the appearance enhanced by leaving the background in semi-obscurity; and the physical, accomplished by avoiding photodegradation due to ultraviolet rays and sunlight. It is well known that ultraviolet rays will cause irreversible deterioration of many mineral species by changing their chemical composition or color. The use of artificial light only permits control of both quantity and quality, and for this reason the room was chosen because there are no windows to let in sunlight.

The room, 13 by 21 meters with a ceiling height of 3.3 meters, was initially unimpressive, almost like the many parking spaces in the underground levels of the university. It was necessary to create a teaching and welcoming exhibition hall out of a room with many drawbacks: pillars, beams in evidence, pipes, air conditioning ducts, etc. After a very close collaboration between the curator, the Asselbur Company furnishing the display cases, and the Wendel Company responsible for the lighting, it was decided to leave three varnished brick walls without decoration, to use the pillars on the fourth side of the room to wall off a services hall which is used both as a technical room and to stock the undisplayed items, and to utilize the unattractive beams of the ceiling to shape recessed cornices in which the unusually effective lighting could be fixed. The ceiling is painted black in such fashion that the eyes do not stray from the display cases. The cornices are painted white and checkerboard the ceiling, thus breaking the monotony of a large ceiling by creating little cells in which the visitor has the impression of being in a limited space while participating in a larger whole. The floor is tiled in pale colors reflecting the subtle lights from the display cases, enhancing the contrast between light and dark.

The temperature of the room is maintained by air conditioning at an even 16°C (60°F) which is comfortable all year round. The humidity corresponds to that of the outside, which is 40 percent.

THE DISPLAY CASES

The collection is presented in two types of showcases: the 24 all-glass panoramic cases that fill the inner space of the room, and 4 wall cases with a total length of 16.5 meters (about 55 feet) along the full length of one wall of the room.

The panoramic display cases are dust-proof and well protected against variations of ambiant temperature, which is perfectly controlled and maintained. Their special construction protects effectively against theft. Their shape allows the display of specimens of different sizes side by side, which can be observed from all directions, a welcome contrast to the unfortunately too-frequent "table" showcases which lead to a standardization of the displayed objects and consequently a regrettable monotony.

The panoramic showcases are composed of two parts: the base and display shelves which are connected, and the protective all-glass cover box or "bell" which is separate. On a pedestal rising 95 cm (3 feet) above the floor rests the display base of 90 x 140 cm (3 x 4½ ft) covered with black cloth, from which rise two burnished steel columns supporting glass shelves of 60 x 115 cm (2 x 3¾ feet). The "bell," consisting of a plate glass top and four plate glass sides perfectly fitted and glued together with a bottom metal frame, rests on the display base. The "bell," which weighs about 200 Kg (440 lbs), is 85 cm (2.8 ft) high with a length of 1.4 m (4½ ft) and a width that tapers from one meter (3.3 ft) at the top, down to 90 cm (3 feet) at the bottom. This taper prevents any reflected light from bothering the observer.

The ingenious method of opening the panoramic showcases requires explanation as it solves the problem both of security against theft and of protection against dust, while being very simple to accomplish. It is done by means of a manually operated fork lift. On the two longer sides of the glass cover box or "bell" which has a metal frame at the bottom, are fixed two metal bars that serve as arm rests for the visitor. To open the case, the operator puts the fork lift prongs under these bars and lifts the bell case up into a ceiling recess by activating the lift.

After having lifted the "bell" to the required height and having locked it in position, the operator has full access to the display shelves. The "bell" is fixed to its base with a simple spring catch and all that has to be secured is the room where the fork lift is stored. Outside visiting hours, security is assured by an electronic alarm system linked to Central Security. Dust-proofing is assured by the perfect gluing of the glass plates forming the "bell" and by a nylon sealing joint on the base plate that is crushed tight by the weight of the "bell."

The wall case that forms the fourth wall of the room is actually three separate cases having a total length of 16.5 m (about 55 feet). On the visitor's side the case is faced with plate glass that cannot be removed. To the base of this glass is fixed a resting bar. Access to the shelves is from the service hall through the rear panels. The inner dimensions of the wall cases are 84 cm high by 40 cm wide (2.75 x 1.31 feet). The floor and back wall of the cases are covered with back cloth.

LIGHTING

The visitor entering the Mineralogy Collection room is immediately aware of the dramatic atmosphere in which the minerals are exhibited. After a few moments of surprise, he unconsciously feels the telluric mystery of the creation of minerals. This effect which is always felt, but not automatically analyzed, is due to the extraordinary lighting which bathes the exhibition room.

The proper display of minerals should not only highlight the most delicate colors and the most complex shapes by special lighting that is not aggressive to the eye, but also meet the standards of preservation of the specimens by the avoidance of ultraviolet and infra-red rays, which are so harmful. The lighting of the Mineralogy Collection Room meets rigorously all the requirements laid down by the International Council of Museums (ICOM) for the preservation of works of art and specimens exhibited in museums.

To fit all these requirements and especially to protect against photodegradation, international experts suggest that the level of light on exposed objects be limited to a maximum of 150 lux. This level of light might seem at first to be rather weak, but it is very efficient in showing, by contrast in semi-darkness, nuances and details which a strong light would obscure. Not only are the colors enhanced, but the crystals' tints are exalted without theatrical excess.

This lighting is achieved by the use of 96 Wendel eye projectors, four per case, hidden in the ceiling cornices, projecting their luminous beams through openings 12 mm in diameter. These discreet luminous points detach themselves like stars against the black ceiling, without ever dazzling the visitors, either directly or by reflecting from the glass of the display cases. Their light accurately frames the display shelves which thus encourages the viewing of the minerals. The projectors are placed so as to produce homogeneous lighting and their inclination is calculated to reflect the light from the showcases to the floor.

The projectors use halogen lamps of 100 watts, 12 volts, 2500 lumens, at 3000° Kelvin, that last about 2000 hours and deliver an intensity of 150 lux on the display shelves. The emission spectrum of halogen lamps is practically devoid of ultraviolet, and the infra-red is such that the temperature in the showcases is the same as the ambient temperature, due both to the room's air conditioning and to the distance of the projectors from the showcases. The side cases are lighted by a Wendel Optical Ramp equipped with 147 bulbs of 25 watts as 12 volts, reinforced by hemispheric mirrors, directed at the showcases through a diffusing lens, such that the intensity is 150 lux at the bottom of the case. A special 25-watt, 12 volt lamp is used in the wall case for back-lighting a lilac-purple transparent crystal of kunzite (spodumene). ⊠

Arsenate Minerals
of the Sterling Hill mine:
an Overview

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INTRODUCTION

In the past eight years the Sterling mine in Ogdensburg, Sussex County, New Jersey, has produced a remarkable series of crystallized arsenates. Although individual species have been studied in great detail, information on their origin and distribution is not well documented. This paper, while not attempting to answer all the pertinent questions, defines the arsenate minerals as three mutually segregated assemblages. The major arsenate minerals in the black willemite ore are species rich in iron and zinc, while those in the red willemite ore are rich in manganese and magnesium. The third assemblage is found outside of the ore and consists of picropharmacolite and guerinite. It is believed both the arsenic and metals originated from the decomposition of locally available minerals.

GENERAL DESCRIPTION

The arsenate minerals at the Sterling mine form a minute portion of the minerals present in the orebody and are of interest only to the collector and mineralogist. They occur along faults, shears, fracture seams and cracks as fillings which postdate the formation of the silicate-oxide ore minerals. The area has been fractured and faulted by several episodes of regional metamorphism. The individual arsenate species are usually microscopic in dimensions but are remarkable for their perfection and diversity of habits. Tables 1 and 2 list the arsenates and associated minerals found since 1973. They are tabulated according to the type of ore in which they occur. The black ore is characterized by dark gray to black granular willemite with fine to coarse grained franklinite and pale pink to white calcite. The dark willemite crystals are usually weakly fluorescent green under shortwave ultraviolet radiation only. In hand sample the carbonate and ore minerals are commonly segregated, with the willemite and franklinite occurring together as lens or pods in the carbonate gangue. Typical associated minerals are clear to yellow sphalerite and silvery loellingite which are scattered throughout. Red ore consists of irregular masses of orange-red to brown willemite, massive to granular franklinite, minor massive red zincite and greatly varying amounts of calcite. The willemite is usually strongly fluorescent green under shortwave ultraviolet light with a much weaker response under longwave light. Some willemite is also briefly phosphorescent green under shortwave ultraviolet light. The calcite is sometimes fluorescent and phosphorescent under shortwave ultraviolet light, the response ranging from red to purple in color. Typically the volume of calcite in the red ore is quite low.

Upon inspection of Tables 1 and 2, there appears to be a natural segregation of arsenic-bearing minerals dependent upon ore type, as there is no overlap of arsenate species except for the mineral brandtite. The mineral kraisslite, first described by Moore and Ito (1978) from Sterling Hill, is the most common arsenic-bearing mineral. It is found in most of the occurrences in red ore but has never been found in the black ore. Kraisslite has not been reported from above the 500-foot level of the mine and kraisslite-bearing assemblages are always found with, or in close proximity to, the minor ore mineral zincite. In every case, the arsenate minerals are found either directly in the franklinite and willemite ores, or in limestone blocks nearby. They have never been recognized from the adjacent ore-barren Franklin marble or other surrounding formations.

Perhaps the most significant assemblage found in the black ore was uncovered several times from adjacent working areas on the 340-foot level. Excellent sprays of koettigite sprinkled with green cubes of pharmacosiderite made the area well known to local collectors. Associated minerals included legrandite, scorodite, adamite and metalodevite.

The large variety of minerals found in the red ore continue to come from the mine in small amounts even today. Each mineral is not found with ever other on the list. The variety of associations and the perfection of the crystals makes the occurrence one of great mineralogical significance. Of special note is the variation of color and habit of sarkinite. Magnificent, translucent, blood-red to orange crystals to several millimeters may totally encrust slip surfaces creating crystallized patches to several square centimeters.

It is important to note that while there is a segregation of arsenate species as described above, there are no clearcut zones *per se* to which they are limited. The only prerequisites appear to be the presence of open spaces which allow entry of the mineralizing solutions and the proper conditions for crystallization.

The origin of the arsenates has not been well defined. Moore and Ito (1978) have stated:

> ". . . it is not clear if they are products of oxidation of preexisting arsenides and sulfarsenides or if they crystallized from

> late solutions from an entirely different source. The presence of arsenic-bearing minerals and of the borate sussexite may have originated from the reworking of an evaporite deposit, but the evidence is not clear."

Others classify the arsenates as simply secondary or late stage without any qualification. However, the formation of the arsenates is probably neither simplistic nor of a singular chemistry. Some insight into their origin may be gained from the description of several occurrences.

A working level between the 900 and 1000-foot levels adjacent to a garnet-rich shear zone produced loellingite veinlets in a fine grained white calcite. These dull gray metallic seams were in the process of alteration, and the boundaries of the seam as well as part of the interior were covered with, and replaced by, a scaly brown alteration product. Under magnification the brown areas were observed to be patches of minute reddish-brown plates resembling kraisslite and were subsequently shown to be an arseniosiderite-like mineral of indefinite nature by Pete Dunn of the U.S. National Museum of Natural History. These specimens represent the *in situ* decomposition-oxidation of the arsenide to the arsenate. Arseniosiderite has been noted in the literature from elsewhere as having originated by the low temperature decomposition of sulfarsenides or other arsenates (Kingsbury and Hartley, 1957; Moore and Ito, 1974). About 10 meters south of the garnet shear zone were found a series of seams containing clear needle-like brandtite crystals with reddish sarkinite (Sanford, 1976). They were deposited in voids in the red ore on a pink to tan carbonate filling. No kraisslite was present, and this is the only time the minerals sarkinite and brandtite were found together at the Sterling mine.

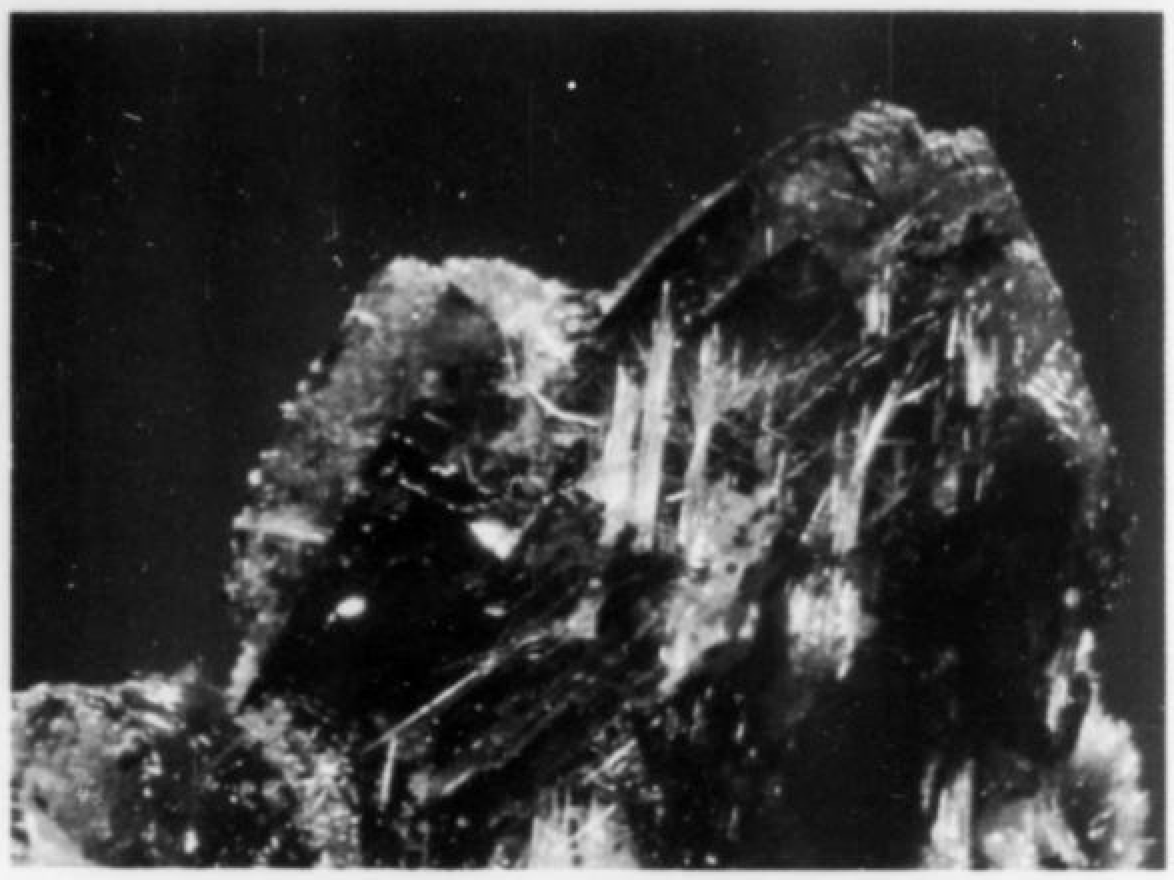

Figure 1. **Reddish allactite crystal with white chlorophoenicite crystals on red ore. Largest allactite is 5 mm. (All specimens: Fred Parker collection.)**

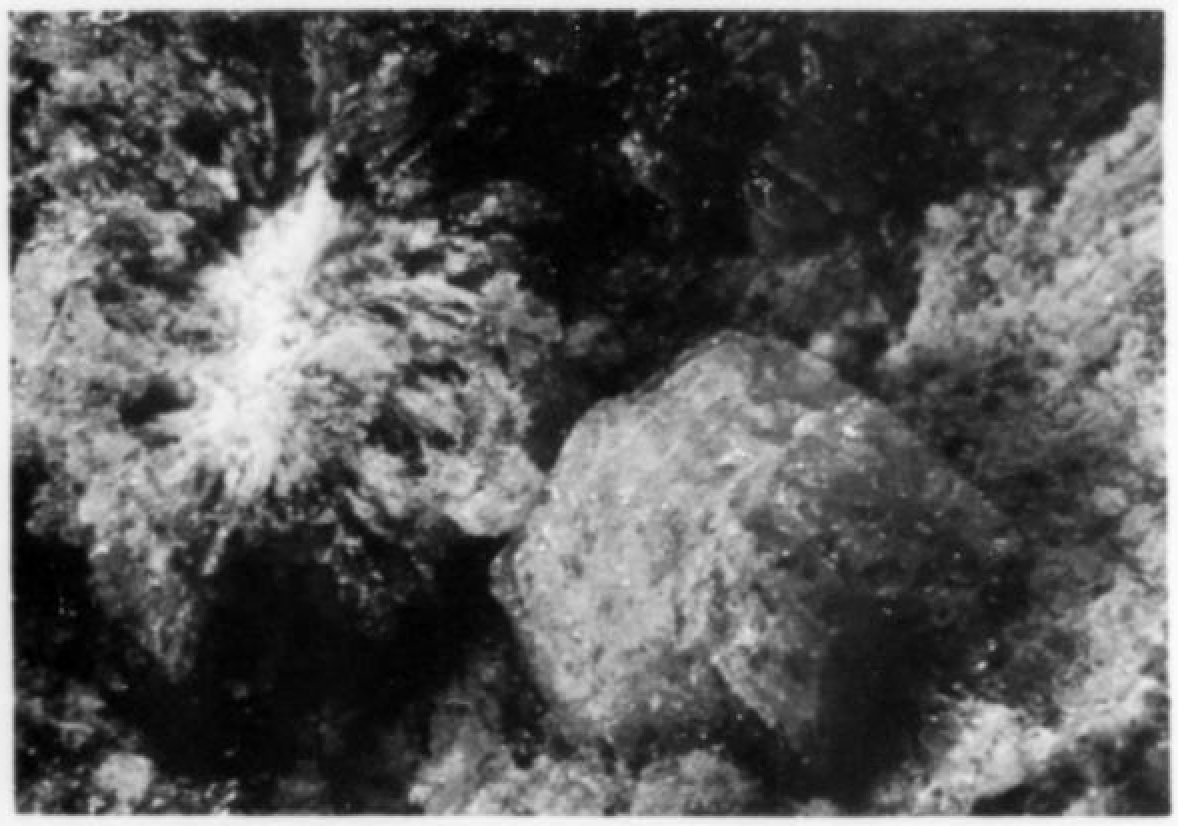

Figure 2. **Orange sarkinite rosette (3 mm in diameter) with brown bladed allactite and an unidentified copper alteration on red ore.**

The arsenate minerals guerinite ($Ca_5H_2AsO_4 \cdot 9H_2O$) and picropharmacolite ($H_2Ca_4Mg(AsO_4)_4 \cdot 12H_2O$) have been found as efflorescences on white marble but have not been found in either the red or black ores. They occur with arsenopyrite and represent the decomposition of the arsenopyrite with reprecipitation of the arsenic in the form of the hydrated arsenate species from low temperature solutions.

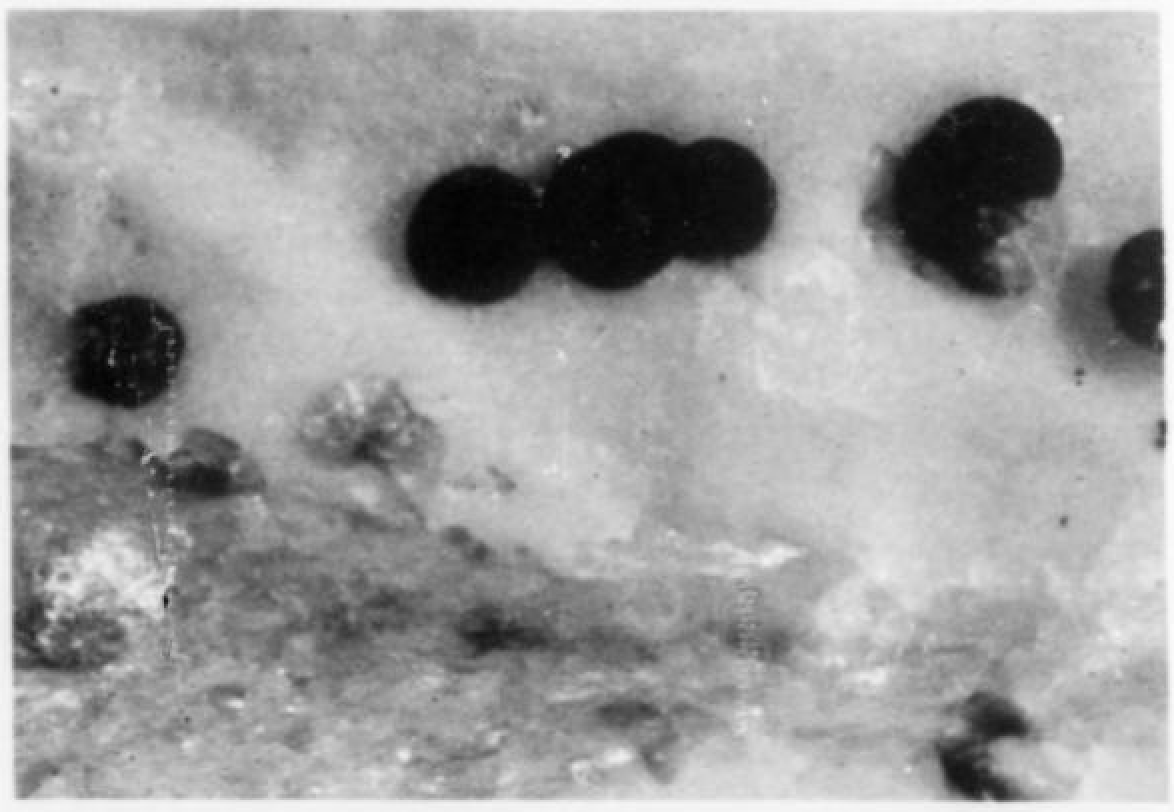

Figure 3. **Brown radiating hemispheres (0.25 mm diameter) of austinite on calcite with bronze-colored platy kraisslite, from red ore.**

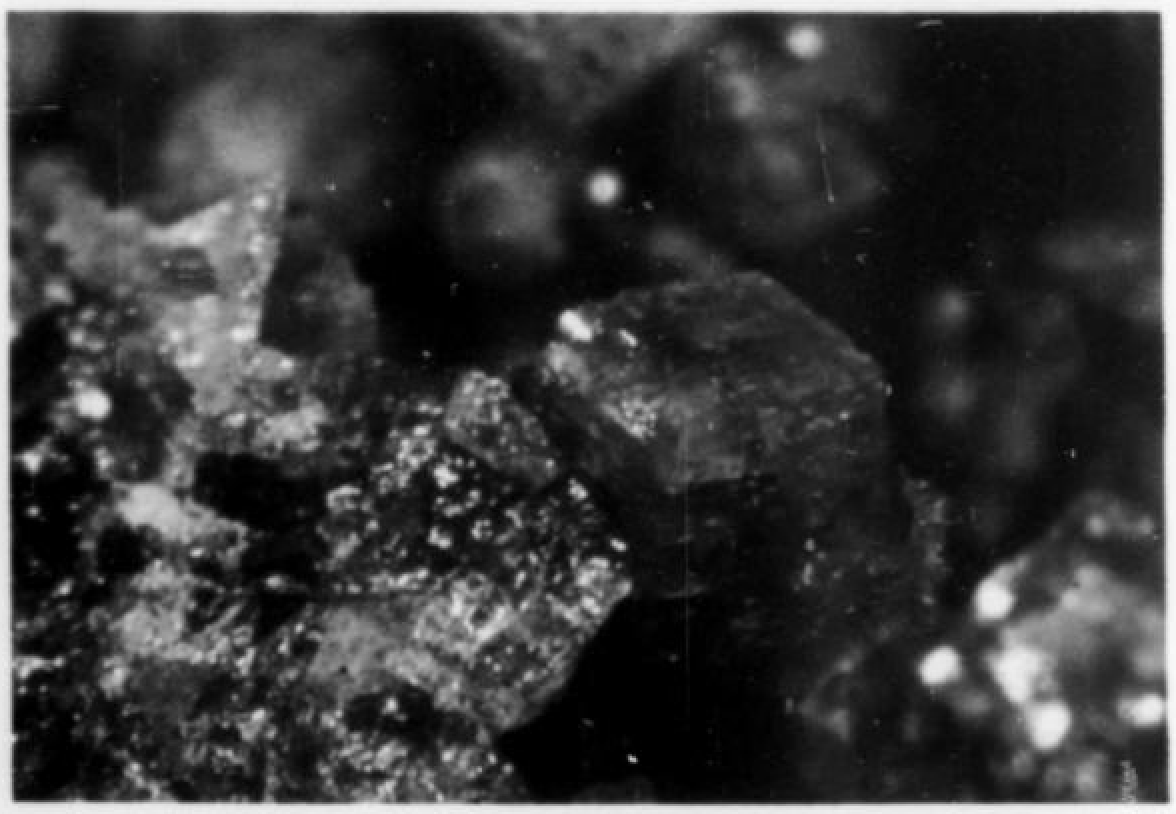

Figure 4. **Pharmacosiderite crystal (1 mm on edge) with willemite prisms and franklinite. Black ore.**

A recent find in the 1620 crosscut on the 1600-foot level revealed an exceptional series of brandtite specimens in the black ore. Clear blades of brandtite to 5 mm were found implanted on pink rhodocrosite. No other arsenate minerals were found. This is very similar to the original brandtite find from Sterling mine described by Gaines (1959). A tan to yellow sphalerite forms pods and veinlets in the ore. A nearby find of flattened brandtite rosettes was on a similar dark ore matrix and was observed to contain very minute, finely dispersed loellingite.

DISTRIBUTION of LOELLINGITE and ARSENOPYRITE

Loellingite ($FeAs_2$) and arsenopyrite (FeAsS) have been identified from Sterling Hill but never as coexisting species. Arsenopyrite

Table 1. **Black ore arsenate assemblages****

Ore	
franklinite	$(Zn,Mn,Fe)^{+2}(Fe,Mn)_2^{+3}O_4$
willemite	Zn_2SiO_4
Gangue	
calcite	CaCO
Accessory	
sphalerite	ZnS
loellingite	$FeAs_2$
roepperite	$(Fe,Mn,Zn)_2SiO_4$
Arsenates	
koettigite-symplesite	$(Zn,Fe)_3^{+2}(AsO_4)\cdot 8H_2O$
pharmacosiderite	$KFe_3^{+3}(AsO_4)_3(OH)_6\cdot 6H_2O$
legrandite	$Zn_2(AsO_4)(OH)\cdot H_2O$
scorodite	$Fe^{+3}(AsO_4)(OH)\cdot 2H_2O$
arseniosiderite (?)	$Ca_3Fe_4^{+2}(AsO_4)_4(OH)_6\cdot 3H_2O$
pharmacolite (?)	$CaH(AsO_4)\cdot 2H_2O$
adamite	$Zn_2(AsO_4)(OH)$
erythrite	$Co_3(AsO_4)_2\cdot 8H_2O$
metalodevite	$Zn(UO_2)_2(AsO_4)_2\cdot 10H_2O$
brandtite	$Ca_2(Mn,Mg)(AsO_4)F$

(*) denotes species found directly in association with kraisslite.

(**) The compilation of mineral names herein includes those described in the literature and species in public and private collections which, to the best of the author's knowledge, are authentic.

Table 2. **Red ore arsenate assemblages****

Ore	
franklinite	$(Zn,Mn,Fe)^{+2}(Fe,Mn)_2^{+3}O_4$
willemite	Zn_2SiO_4
zincite	ZnO
Gangue	
calcite	$CaCO_3$
manganoan calcite	$(Ca,Mn)CO_3$
Accessory	
gold	Au
copper	Cu
sphalerite	ZnS
tenorite	CuO
pyrochroite	$Mn(OH)_2$
barite	$BaSO_4$
fluorite	CaF_2
sussexite	$Mn(BO_2)(OH)$
rhodochrosite	Mr.CO_3
dypingite	$Mg_5(CO_3)_4(OH)_2\cdot 5H_2O$
pyroaurite	$Mg_6Fe_2(CO_3)(OH)_{16}\cdot 4H_2O$
aurichalcite	$(Zn,Cu)_5(CO_3)_2(OH)_6$
tephroite	Mn_2SiO_4
alleghanyite	$Mn_5(SiO_4)_2(OH)_2$
sonolite	$Mn_9(SiO_4)_4(OH,F)_2$
hodgkinsonite	$MnZn_2SiO_5\cdot H_2O$
hemimorphite	$Zn_4Si_2O_7(OH)_2$
Arsenates	
retzian	$Mn_2Y(AsO_4)(OH)_4$
magnussonite	$Mn_{18}^{+2}(As_6^{+6}Mn^{+1}O_{18})_2Cl_2$
tilasite	$CaMg(AsO_4)F$
brandtite	$Ca_2(Mn,Mg)(AsO_4)F$
kolicite	$Mn_7Zn_2(AsO_4)_2(SiO_4)_2(OH)_8$
akrochordite	$Mn_4Mg(AsO_4)_2(OH)_4\cdot 4H_2O$
synadelphite*	$(Mg,Mn,Ca,Pb)_4(AsO_4)(OH)_5$
holdenite*	$(Mn,Mg)_6Zn_3(OH)_8(AsO_4)_2(SiO_4)$
chlorophoenicite*	$(Mn,Zn)_5(AsO_4)(OH)$
austinite*	$CaZn(AsO_4)(OH)$
sarkinite*	$Mn_2(AsO_4)(OH)$
allactite*	$Mn_7(AsO_4)_2(OH)_8$
cuprian adamite*	$(Cu,Zn)_2(AsO_4)(OH)$
adelite*	$CaMg(AsO_4)(OH)$
manganese-hoernesite*	$(Mn,Mg)_3(AsO_4)_2\cdot 8H_2O$
yeatmanite	$(Mn_5Sb_2)(Mn_2Zn_8Si_4)O_{28}$
kraisslite*	$(Mn_{0.89}Mg_{0.08}Fe_{0.02})_{24}Zn_4(AsO_4)_4(SiO_4)_8(OH)_{12}$

is well known from the surrounding marble quarries and the Buckwheat open cuts in nearby Franklin (Palache, 1935). It is found at Sterling Hill in calcite with the corundum-anorthite-margarite assemblage, and crystals in pure calcite have been found sporadically in the past. More recently arsenopyrite has been found in the central core and on the 1680-foot level. In both cases sulfide minerals but no ore were in association. It is also reported from the 1300-foot level, and on the 1000-foot level in the footwall vein of black willemite.

Loellingite is more frequently encountered but almost exclusively in black ore. Some of the more recent occurrences were on the 340, 1000, 1100, 1200 and 1600-foot levels. In the black ore, loellingite is found as grains, blebs, crystals and masses, rarely to several kilograms. Loellingite appears to be much more common than arsenopyrite at the Sterling mine, but this may be biased by the fact that mining operations tend towards the ore and away from the arsenopyrite-bearing but ore-barren marble.

Figure 5. **White radiating spray of picropharmacolite on calcite. Spray is 3 mm in diameter.**

DISCUSSION

The intent of this paper has been to document information relating to the arsenate minerals at the Sterling mine and to draw from these observations some generalized conclusions relating to their origin. Certainly there was enough loellingite and arsenopyrite available to account for the source of the arsenic. The presence of the arsenated in the proximity of the ore only and not in the surrounding rock suggests the Ca, Mg, Zn, Mn, etc., are derived directly from the alteration and decomposition of locally available minerals. One notices in Tables 1 and 2 that nearly all the arsenates and accessory minerals contain manganese, iron, zinc and calcium with magnesium and copper to a lesser extent. The source of the manganese, iron, zinc and calcium can be explained by the breakdown of ore minerals and carbonates. Magnesium and copper could have originated from magnesium-bearing carbonates and copper-bearing sulfides or oxides, respectively. With the abundance and distribution of these minerals it seems unlikely an external source would be required for their origin, though hydrothermal solutions of an external origin could have aided in the mobilization of elements.

The most significant feature of the Sterling mine arsenates is the presence of three chemically different, mutually exclusive assemblages. The black ore assemblage contains iron and zinc-rich arsenate minerals such as köttigite, legrandite, scorodite and adamite. The principal arsenate minerals in the red ore are rich in manganese and magnesium, and include allactite, sarkinite, holdenite and chlorophoenicite. The abundance of kraisslite in the red ore (and its total absence in the black ore) is a prominent feature. The third assemblage consists of guerinite and picropharmacolite on marble which contains a small amount of arsenopyrite.

It is apparent that there is no singular means of origin for *all* the arsenate-bearing minerals at the Sterling mine but observations suggest two: (1) the direct oxidation and alteration of an arsenide or sulfarsenide precursor to the arsenate, *it situ;* and (2) the decomposition of an arsenide or sulfarsenite followed by dissolution and transport of the arsenic with eventual reprecipitation elsewhere as arsenate minerals.

The arsenate occurrences on the 340-level are probably low-temperature products. Species such as köttigite, legrandite and adamite are frequently found in low temperature, oxidized gossan environments, and the 340-level minerals may be the result of similar paragenetic conditions.

The origin of the arsenates in the red ore is a more complex problem. The intimate association of kraisslite with sussexite, hodgkinsonite and other species of possible hydrothermal origin suggest the kraisslite veins might also be hydrothermal. If this were the case, the other arsenate species found with the kraisslite (allactite, sarkinite, etc.) could be of (1) the same parentage, or (2) the result of later alteration of the kraisslite, or (3) of secondary origin from circulating solutions. It is important to note the limited distribution of the kraisslite outlined earlier. This, coupled with the fact that kraisslite has not been recognized from any other arsenate-bearing locality (including Franklin) to date may indicate a unique origin of at least part of the red ore assemblage.

The origin of the secondary minerals is undoubtedly the result of a rather complex series of chemical reactions and conditions. The types and concentrations of ions present, pH or the solutions and other chemical factors could play a role in determining the ultimate assemblage. The exact conditions remain to be deciphered. In the meantime, concentrated study by institutions and mineral scientists will continue to unravel more information about this remarkable mineral occurrence.

ACKNOWLEDGMENTS

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What's New in Minerals?

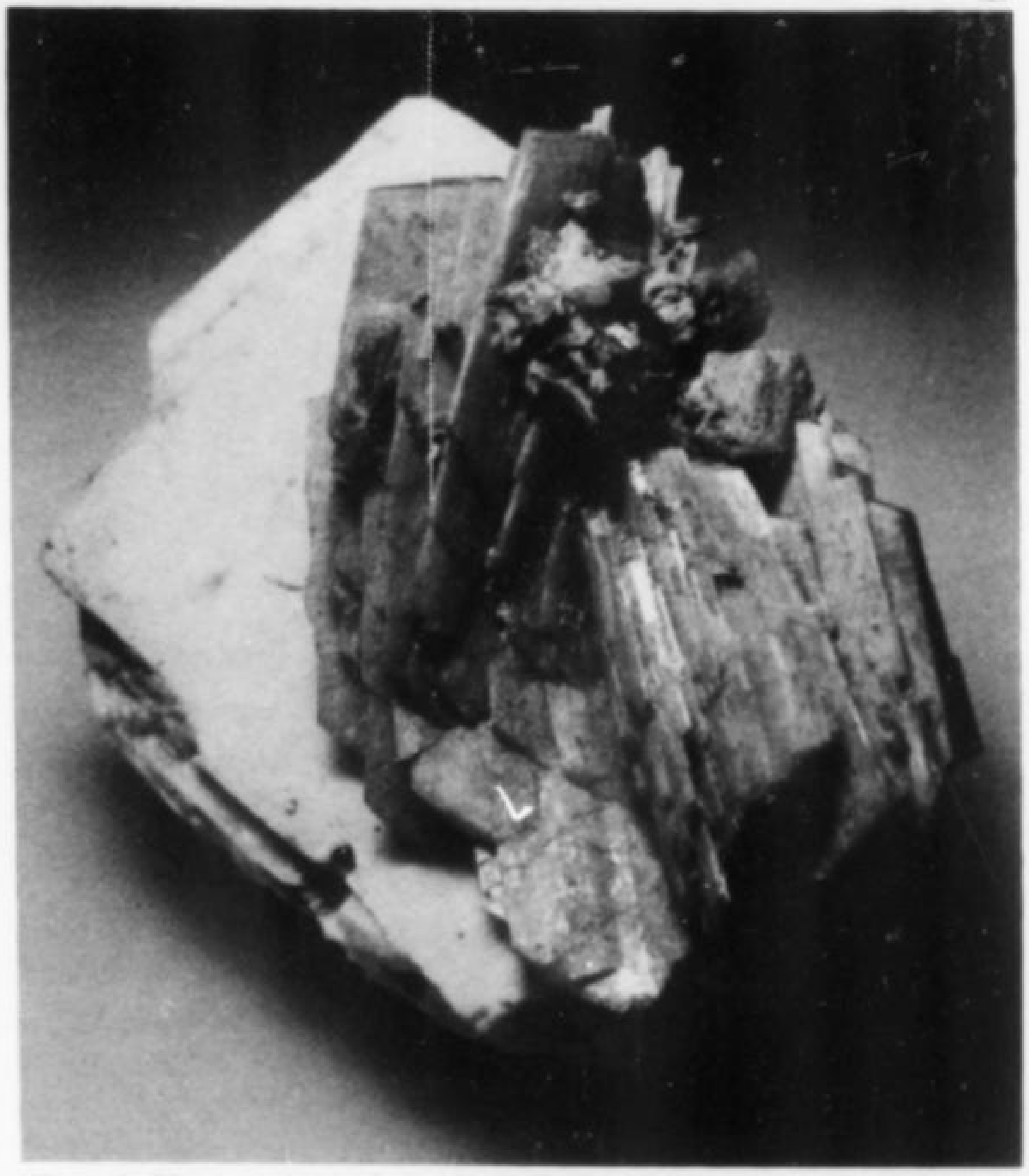

Figure 1. **Pale orange-pink serandite crystal group about 2 inches tall on a white microcline crystal, from Mont St. Hilaire, Quebec. Ernie Schlichter specimen.**

Every once in a while this column is privileged to contain news of some significant discovery in the world of minerals. But not often are several such finds reported at once, as is the case with ths installment. A remarkable serandite find, a third great locality for epidote, the world's finest sylvite, the world's finest vauxite, the world's finest adamite, and some exceptional pyrargyrite have all turned up recently. In fact, though the mineral market is somewhat depressed at present, we are passing through a time of numerous important discoveries. The last year or so has seen the emergence of the world's finest creedite, exceptional azurite, stibnite and cinnabar from China, continued production from the Toussit mine in Morocco including superb anglesite, fine pegmatite minerals from Afghanistan and Pakistan, abundant pyrite in superb quality from Peru, and many others both foreign and domestic. Though some (but not all) prices are high, the situation is much preferable to having no new discoveries at all. For those collectors who are still in the game, so to speak, the times are good. And for those who have sidelined themselves for one reason or another, perhaps the temptation to become active again will soon prove irresistible.

A MAJOR SERANDITE DISCOVERY

Ernie Schlichter (35 Silver Hill Road, Sudbury, MA 01776) and Larry Venezia were at the De Mix quarry in Mont St. Hilaire, Quebec, on the right day. They found a serandite-filled vug or pipe 15 feet long and several feet across from which they estimate they have removed a quarter of a million dollars in specimens.

The serandite is in the form of flattened, bladed crystals to 10 inches (in contrast to the rectangular, blocky crystals of earlier discoveries); the color is a pale pink-orange (in contrast to the intense orange of earlier discoveries). Hundreds of specimens, mostly groups, some to 12 inches across, were removed from the pocket, and about 200 fine pieces were available in Schlichter's motel room during the Detroit Show. The pocket was not only lined but actually *filled* with layers of crystals. If one can discount the lighter color, the best pieces are probably the world's finest serandite; they are more esthetically shaped and grouped than the earlier material, and the crystals are large, sharp and well formed.

Associations are not lacking; fine, milky analcime crystals commonly an inch or less in size but up to 4 by 6 inches; small (to ⅓ inch) rosettes of flattened rhodochrosite crystals; black acmite prisms to 4 inches; white, terminated natrolite prisms to nearly an inch; pearly white plates of polylithionite in sprays to an inch; and blocky white crystals of microcline to 4 inches. Though few if any specimens contain actual wall-rock matrix, nearly all specimens *seem* to be matrix pieces because of the association of large crystals of various different species perched and piled on one another. This is truly a remarkable find; and the prices, believe it or not, are reasonable.

ADAMITE, OJUELA MINE

Many collectors might yawn at the mention of more adamite from the famous Ojuela mine, Durango, Mexico. The locality has been a prolific though sporadic producer for decades. But now John Whitmire (a partner with Delma Perry in Artrox, 12496 Montana, El Paso, TX 79935) has personally dug out what are by far the finest adamite crystals ever found. Only a few pieces reached the Detroit Show, where they were displayed in a case; but Whitmire was even then still digging and it is probable that more will surface. Pale yellow crystals, translucent and milky, to more than 3 inches, on matrix, were found. In addition, other smaller crystals (to an inch or two) were found in a brilliant royal purple color. One specimen in their case has purple tips and pale green bottoms, with the crystals rather thick and stubby in a pleasing group 2 or 3 inches long. Other yellow crystals are large and blocky rather than prismatic, some well over an inch on an edge. According to Delma, there were no second rate specimens in the pockets . . . *only* large, top quality crystals!

NEVADA EPIDOTE

A discovery of epidote which may rank with the Price of Wales Island, Alaska, and the Knappenwand, Austria, material has been made in Mineral County, near Hawthorne, Nevada, by Dick Jones (*Dick Jones Mineral Company,* 117 W. 10th Street, Casa Grande, Arizona 85222), and his associates, Mike Madsen (*Mike Madson Minerals,* Grand Junction, Colorado) and Mike Smith (a local Nevada resident.)

The first batch of specimens, some of which were available at the Detroit Show, consisted of four magnificent cabinet pieces and several hundred thumbnails and miniatures. The crystals are very lustrous and well formed, of a moderately prismatic habit (though not quite as attenuated as the Knappenwand habit) and without matrix in almost all cases. Crystal groups are common, especially in the larger sizes where individual crystals reach 6 inches in length. The groups are typically somewhat divergent and make very attractive specimens valued in the several-thousand-dollar range for the best cabinet pieces.

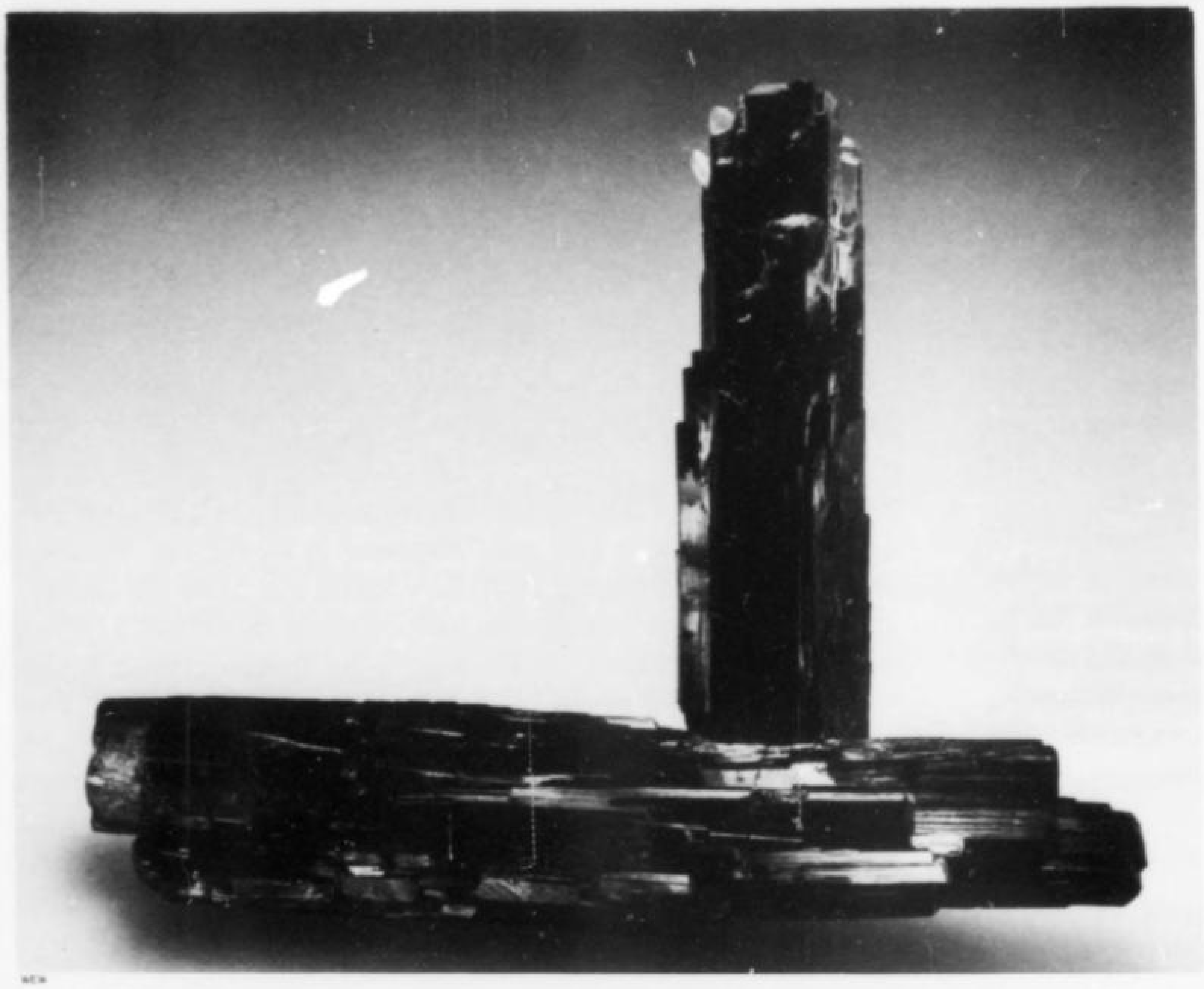

Figure 2. **A semi-parallel group of dark green epidote crystals 5¾ inches long, from near Hawthorne, Mineral County, Nevada. Dick Jones Specimen.**

Figure 3. **Two large, dark green epidote crystals joined at 90° to each other; the lower crystal is 6 inches long. From near Hawthorne, Mineral County, Nevada. Dick Jones specimen, now in the Tom McKee collection.**

The crystals were found in the surface outcrop of a large skarn zone. Digging in the skarn revealed collapsed pockets which had been lined with clear quartz crystals and epidote crystals. Other associated minerals include lustrous black, octahedral spinel crystals to ⅛ inch, brownish garnet crystals highly fractured, and cubic "limonite" pseudomorphs after pyrite. The epidote crystals commonly show new multiple terminations grown as a second generation on the base; these crystals had been broken from matrix by natural movement in the pocket, and the new growth has resulted in doubly terminated crystals and floaters. The largest pocket opened thus far measured 1 by 2½ feet by 10 to 15 inches tall.

The quality of the epidote crystals is not immediately apparent in freshly collected specimens because they are usually encrusted with heavy caliche which must be soaked off in acid. However, the resulting specimens are extremely fine, showing dark green internal reflections and lustrous faces even on the termination in many examples. This ranks as a major discovery, and there is every indication that more specimens can be collected from the area.

Collectors are strictly forbidden from entering the claim, and Jones has made a standing offer of $1000 for information leading to the conviction of anyone who has collected specimens there without authorization. In addition, there is another miner living within sight of the claim and serving as a guard.

Dick Jones, incidentally, is a veteran (one of the few) of Prince of Wales Island, where he collected epidote in 1970. He says there is a striking similarity between the ocurrences, and plans a thorough search for Japan-law quartz twins at the new locality (since these were part of the assemblage at Prince of Wales Island).

PYRARGYRITE FROM PERU, ETC.

Gary Nagin (Route 2, Box 1077, Ragweed Valley Road, Royal, AR 71968) brought some remarkable pyrargyrite crystals back from Peru. They are large and blocky to prismatic, with a dark red color and good transparency when held up to the light. The largest crystal is around 1½ inches in size, though smaller crystals in the lot are of very high quality as well. About three flats of specimens, all from the San Jenaro mine, Huancavelica, Peru, were available in Gary's room during the Detroit Show.

Caroline Ewing and Jane Girard (River Hill Gems and Minerals, 26 River Hill Road, Louisville, KY 40207) brought to the motel show a lot of 12 vivianite specimens from the Clear Springs mine, Barstow, Florida. The mine is a phosphate quarry, and col-

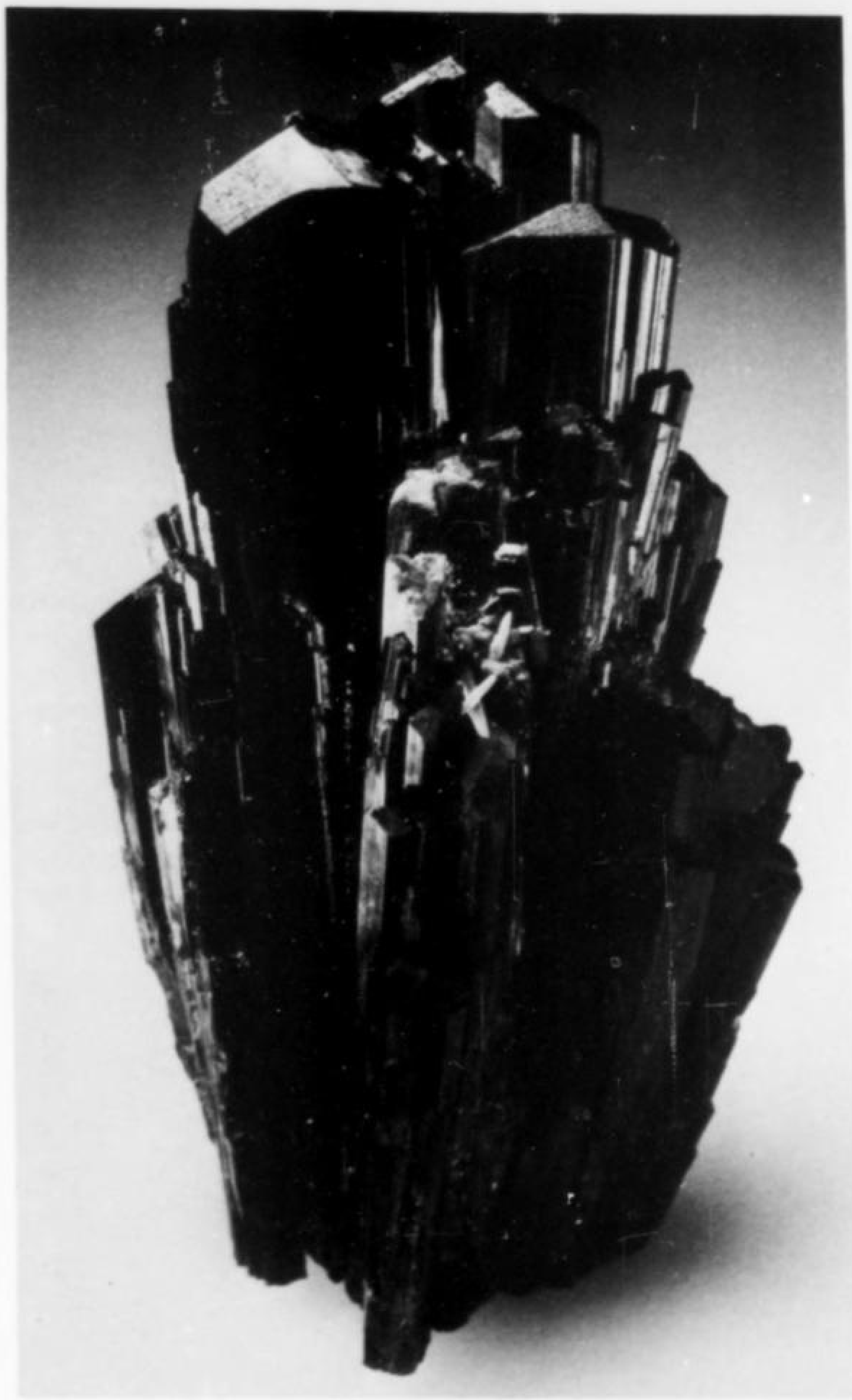
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Figure 4. **Divergent group of dark green epidote crystals 4 inches tall; the lower end has been reterminated by second-generation crystal growth. From near Hawthorne, Mineral County, Nevada. Dick Jones specimen.**


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Figure 5. **Dark, gemmy red pyrargyrite crystal group 1¾ inches across, from the San Jenaro mine, Huancavelica, Peru. Gary Nagin specimen.**

lecting is possible only when the water is low. During the last year, some exceptional crystals of a thick blocky habit, up to ⅓ by ⅓ by 1¼ inches in size, were collected on a matrix of white phosphatic chalk and limonite. These crystals are equal in quality, though not in maximum size, to the crystals from the Santa Eulalia district in Chihuahua, Mexico, and might actually be mistaken for that locality were it not for the matrix. Also in their motel room was the finest selection of deeply colored amber-red calcite from the Elmwood mine seen in a very long time. Most of the specimens were not recently collected.

Shams and Aisha Rind (Gems and Minerals International, P.O. Box 660644 Miami Springs, FL 33166), in the wholesale show area at the motel, were offering some fine Afghanistan pegmatite minerals including aquamarine crystals on matrix and beautiful yellow beryl crystals without matrix. Bags of crystals were available, and a diligent but highly pleasurable search produced many excellent crystals, 1 to 2½ inches long, of collector quality. They are essentially flawless, prismatic, interestingly terminated, and glassy faced. The Rinds are involved in the common but frustratingly difficult problem of trying to explain to the Afghan miners that unscratched, unchipped crystals are worth more, and crystals on matrix (worthless rock!?) are worth *much* more. But crystals are coming out in good quantity despite the Russian occupation. Behind their table the Rinds had a very heavy bag filled with spodumene crystals, some of collector quality too. WEW.

BLUE VAUXITE

The following note is from Mitch Abel (M. P. Abel Minerals, Aurora, Colorado):

The mineral vauxite, an iron-aluminum phosphate, has previously been found sparingly in several sections of the Contacto vein of the Siglo XX mine, Llallagua, Bolivia, and also in the nearby San Jose, Serrano and Bismark veins of that mine. Specimens were collected by Sam Gordon and described as a new mineral in 1922. These are generally pale blue, rarely a darker blue, and form small, spherical crystal aggregates seldom exceeding ¼ inch in size.

Now a new locality has been found for vauxite: the Miraflores mine, Huanuni, Bolivia. Two pockets have been collected; the first, found in mid-1980, contained small specimens of dark blue crystal aggregates. The second, found in early 1981, contained crystals of an exceptional, intense, royal-blue color in association with marcasite, crystallized wavellite and clays. These are by far the largest and finest ever found for the species. The largest plate of crystals measures about 8 inches across and is now in the Smithsonian collection.

Several hundred fine specimens were recovered from these two pockets, along with a fair amount of study-grade material. It has

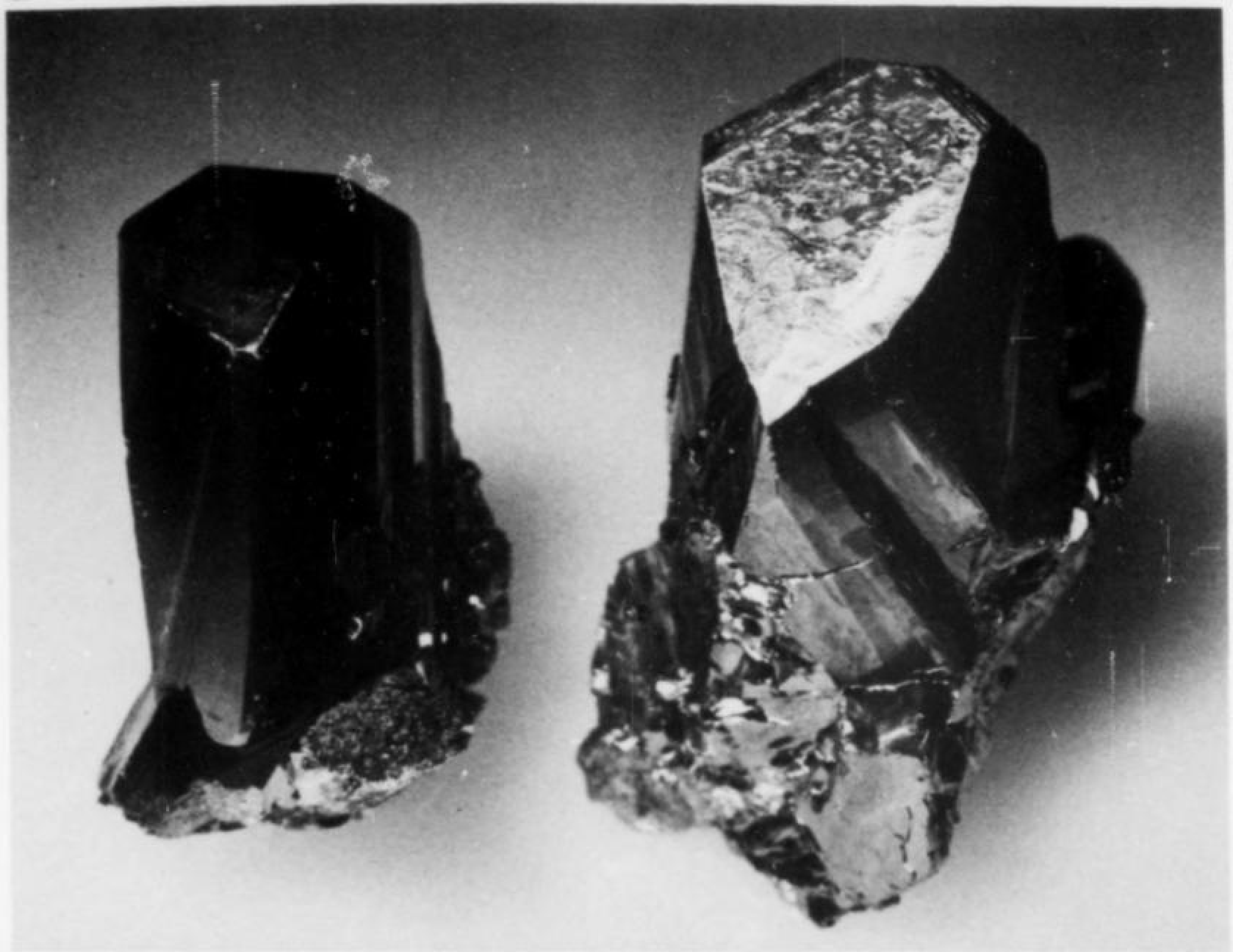


Figure 6. **Dark, gemmy red pyrargyrite crystals, the right one measuring 1½ inches tall, from the San Jenaro mine, Huancavelica, Peru. Gary Nagin specimen.**

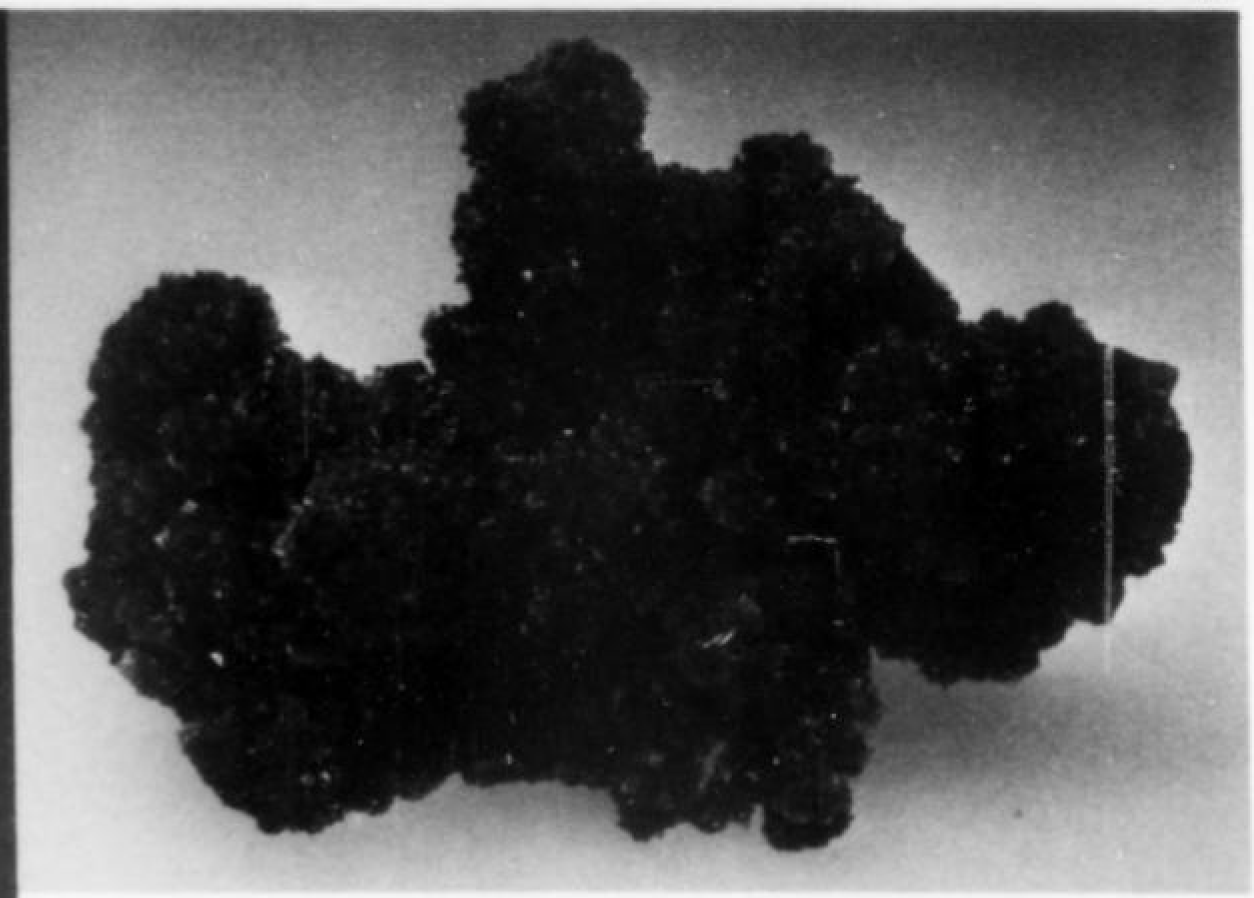


Figure 7. **Dark electric-blue vauxite crystal crust 1½ inches across, from the Miraflores mine, Huanuni, Bolivia. Mitch Abel specimen.**

Figure 8. **Colorless, octahedral crystals of sylvite to 1 inch on an edge, on orange cubic halite, from near the Salton Sea, Imperial County, California. Mark Rogers specimen.**

been about a year since the last find, suggesting that the pockets were isolated occurrences.

OCTAHEDRAL SYLVITE

The following note is from Mark Rogers (P.O. Box 1093, Yucaipa, California 92399).

In May of 1981 John Seibel (Tehachapi, California) found and removed a subsurface pocket of sylvite and halite crystals near the Salton Sea in Imperial County, California.

The sylvite crystals are undoubtedly the world's finest, far exceeding in quality the crystals from Germany, Poland, and Carlsbad, New Mexico. Lemon-yellow to white in color, and with a bright luster, the sylvite crystals were collected as pure clusters and also in association with cubic halite crystals. Most crystals show only the octahedron faces, but a few have very small cube faces truncating the octahedron points. In a few cases a sylvite octahedron is epitaxially surrounded by a halite cube, with only the octahedron points protruding above the surface of the cube. The sylvite crystals are commonly around ¾ to 1 inch in size, but a few giants to 3 inches were collected.

The associated halite is also attractive; it occurs as orange, transparent, lustrous cubes 1½ to 2 inches in size, with some exceptional crystals reaching 4 inches. It fluoresces a brilliant yellow-orange under longwave ultraviolet light (unlike the sylvite, which does not fluoresce).

Also associated are small, ¼-inch crystals of gypsum, and bladed masses to 6 inches of what has been tentatively identified as rinneite ($K_3NaFeCl_6$).

The pocket was located by thumping the ground with a heavy bar and listening for a hollow sound. A promising spot was found about ¼ mile from the sea shore, and the overlying crust was blasted to expose the pocket about 18 inches below the surface. The cavity was elongated, water-filled, and 1½ by 20 feet in size. About 4000 pounds of material was removed, 35% sylvite and 65% halite. Due to the quantity found in this one pocket, the material is very reasonably priced, and is being marketed by Seibel, ourselves, and a number of other dealers. ◆

At the Tsumeb smelter

At an Indian Zeolite Quarry

Microminerals

by Violet Anderson

There's a circular aspect to column writing which tends to appear willy-nilly. In writing about Zaire uranium minerals way back in year one, I said that if ever I should really see guilleminite or derriksite rather than merely look at patches, respectively, of yellow and dark green, I would make it known. Across the Atlantic from here, Wouter Van Tichelen wrote to say he had some specimens he thought might meet the requirements, and from his collection risked all the various postal services to let me see them. These included not only the rare uranium selenite, guilleminite, in relatively long blades, but some excellent becquerelite. Both minerals are orthorhombic, both are yellow, the guilleminite more lemon-yellow, the becquerelite more orange-yellow. The specimens are now safely home in Europe and thanks to Wouter Van Tichelen I know what these look like. On a specimen most recently acquired, I show an example of smaller crystals of guilleminite (Fig. 1), crystals you are more likely to find than the extraordinary longer blades. It appears with derriksite in a dark green botryoidal form and with a lighter green malachite – a common association.

From Brussels, a gesture similar to Wouter Van Tichelen's was made by Joseph Derriks. He lent me a specimen of derriksite (his namesake), and this also is one of the rare uranium selenites, with crystals so seldom clearly visible. In this specimen I saw the truly orthorhombic, dark bottle-green crystals, albeit very small. A photograph was made with my scope set at 70X, and that is at the limit the optics can handle for photomicrography. Sharon Cisneros often has material from Musonoi, Shaba, Zaire, and I suggest that those interested in Zaire minerals watch her listings.

And then there is Harry Foy, with his marvelous Irish zeolites, once more to my delight appearing on the scene. Although some of the quarries of Northern Ireland (including Magheramorne quarry) are closed due to economic problems, Harry keeps on finding zeolites: beautiful and intricate gmelinite crystals, unusual chabazite, thomsonite, mesolite *and* gismondine. Even natrolite, with which we are all so familiar, comes in a pale yellow, and in cross-section unequivocally square.

The most interesting gmelinite crystals, Magheramorne quarry having "been dead for months," seem to be coming from Glenarm. They are not too unlike those I described once before, in the *Mineralogical Record* (Vol. 10, No. 3), from Magheramorne, but even stranger. A phantom crystal (a core), pink and opaque, is clearly seen through a small band of transparent colorless bipyramidal faces. On the outer rim of these clear faces is an edging, still forming part of the bipyramidal area, which looks like a frill but could, perhaps, be called serrated. The pinacoid faces coating the main body of the pink phantom are colorless but richly textured, as if stippled. Harry Foy believes that only the pink core is gmelinite, and that the overall clear coating, stippled or frilled, may be chabazite. Other specimens, gmelinite or not, show the platy crystals packing together in parallel arrangement to form aggregates. They look like dishes which have got stuck together. Could be chabazite.

There are chabazite-like crystals from the Island Magee, County Antrim. These are bulky, and transparent throughout, although still hexagonal plates with the strange frill-like or pleated or serrated edging. There is a possibility that these are really herschelite crystals. (When anything may be something else, we're not exactly on firm ground. Mont St. Hilaire collectors like myself are not unaware of the feeling.)

A new aspect of thomsonite (*faroelite* variety) appears in the blockiness of its crystals. These come from Moneymore quarry, County Londonderry. They form in a mass together which Harry calls a "crystal ball."

There is stilbite to be found in the Slieve Donard quarry, Mourne Mountains, County Down. Here the stilbite is interesting as much for its associates as for itself. It is found on pegmatite minerals such as orthoclase, smoky quartz, albite, and occasionally with crystals of topaz or beryl (aquamarine). The stilbite crystals are clear and flat in shape, or are brown with various elongated shapes. Unusual.

Finally, gismondine, monoclinic by the book, juts forth in small vugs as minute pyramidal points. Reason: pseudotetragonal bipyramidal. These occur on top of a botryoidal mineral, possibly phillipsite. Locality: Dunsevenick, County Antrim.

Harry Foy has minerals available. From his letters I would guess that he works rather strenuously to produce his supply. We can be thankful to him.

A sparkling zeolite, as brilliant as herkimer diamonds, is coming out of Jacupiranga mine, Sao Paulo, Brazil. This is edingtonite, crystal clear (very different from the Ice River, Britich Columbia), glittering in tiny orthorhombic shapes, cube-like or brick-like, occasionally with rhombic prisms appearing as minute bevels, all crystals perched on long needles of natrolite or scolecite.

Third on my circuit is Mont St. Hilaire. It goes round and round. Or more accurately, St. Hilaire minerals whirl around in the heads of all dedicated St. Hilaire collectors. The minerals of one species seem far too easily to slip into the habits and trappings of another. Each year, more "unknowns" are shut up in small boxes, waiting for identification. A geologist might well go round the bend trying to understand the ingredients and processes that produced this witches' brew. Our latest described mineral (at least, at the time of writing) is petarasite, named after Peter Tarassoff, a Montreal man who has found many a new mineral at St. Hilaire. Photographs of specimens in his collection have appeared in this column before. Petarasite is a yellow monoclinic mineral, often with a number of faces appearing in the same zone as the *a* and *b* faces. The shade of yellow varies, sometimes resembling a yellowish eudialyte (much of what was believed yellowish eudialyte will probably turn out to be petarasite), sometimes so pale it can be confused with the remnants of huge pale yellow catapleiite crystals. The number of yellow minerals at St. Hilaire rivals the number of yellow uranium minerals in Zaire.

Mont St. Hilaire quarries are at the moment closed. A reorganization is taking place, and I believe the crusher is to be moved, making available ground at a lower level for quarrying. But the book on Mont St. Hilaire minerals is moving ahead apace now, with about a dozen knowledgeable people contributing to it, and Joe Mandarino captaining the ship. Have faith.

Leaving this circularity now, I want to speak about a quarry in Massachusetts which you should find interesting if you are in the area in collecting weather. Pete Dunn discussed this mine, the Loudville mine, in the *Mineralogical Record* (Vol. 6, No. 6). The

Figure 1. **Guilleminite from Zaire; the center clump measures 0.3 mm.**

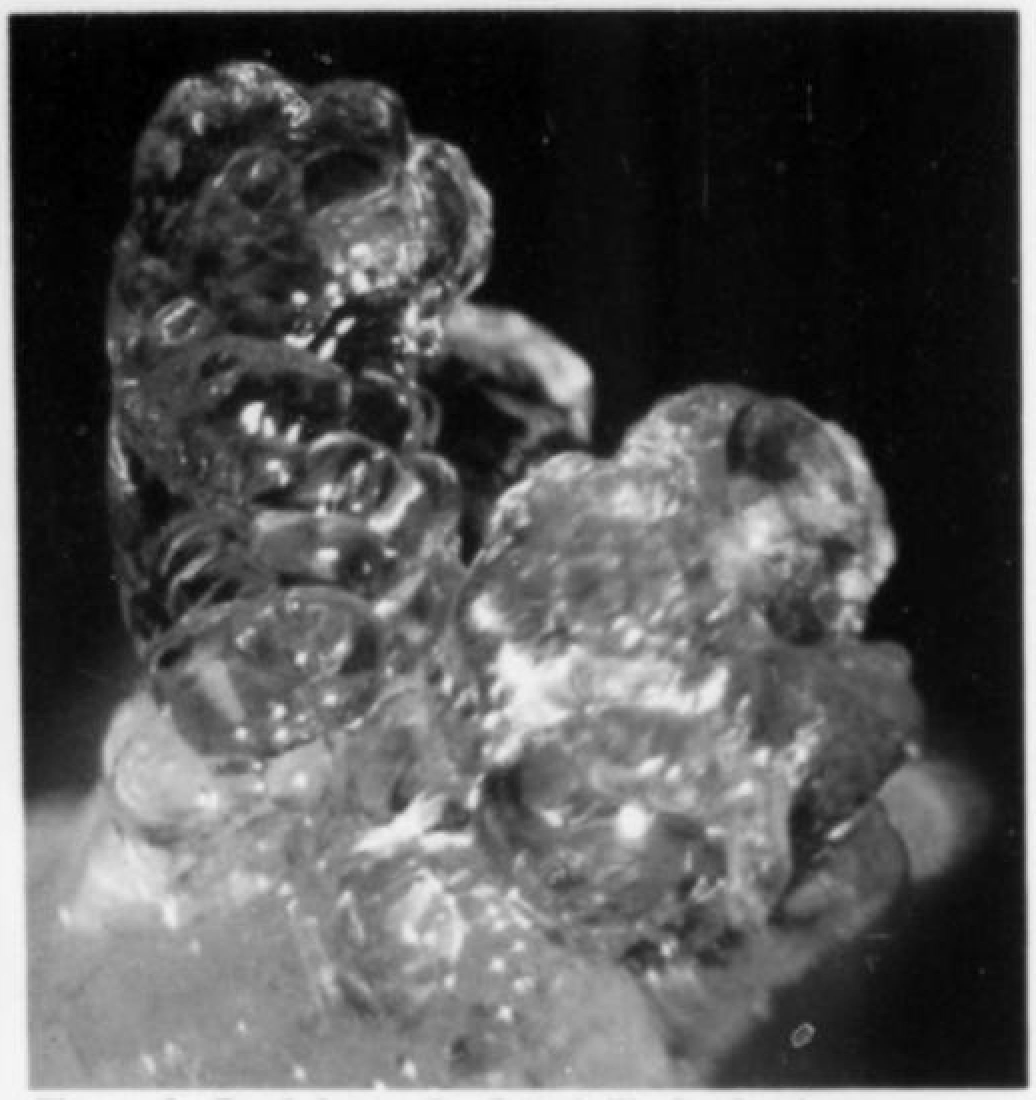


Figure 2. **Opal from the Loudville lead mine; the blue mass is 1.8 mm tall.**

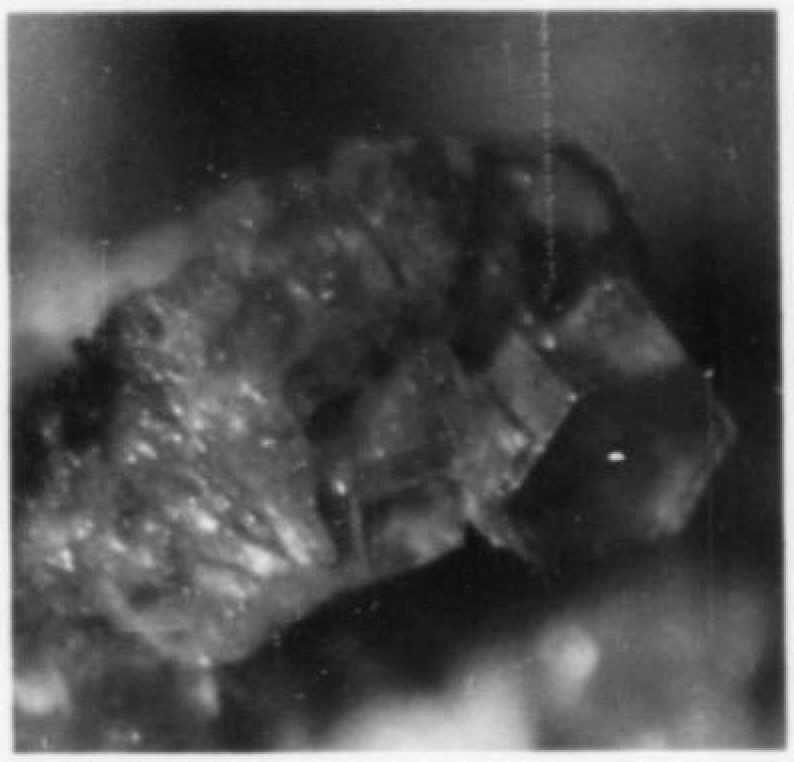


Figure 3. **Blue wroewolfeite with leadhillite from the Loudville lead mine; area shown is about 1 mm wide.**

Photographs copyright Violet Anderson.

Figure 4. **Barite from the Loudville lead mine; the crystal is about 3 mm tall.**

Figure 5. **Wulfenite from the Loudville lead mine; the largest crystal measures about 0.75 mm.**

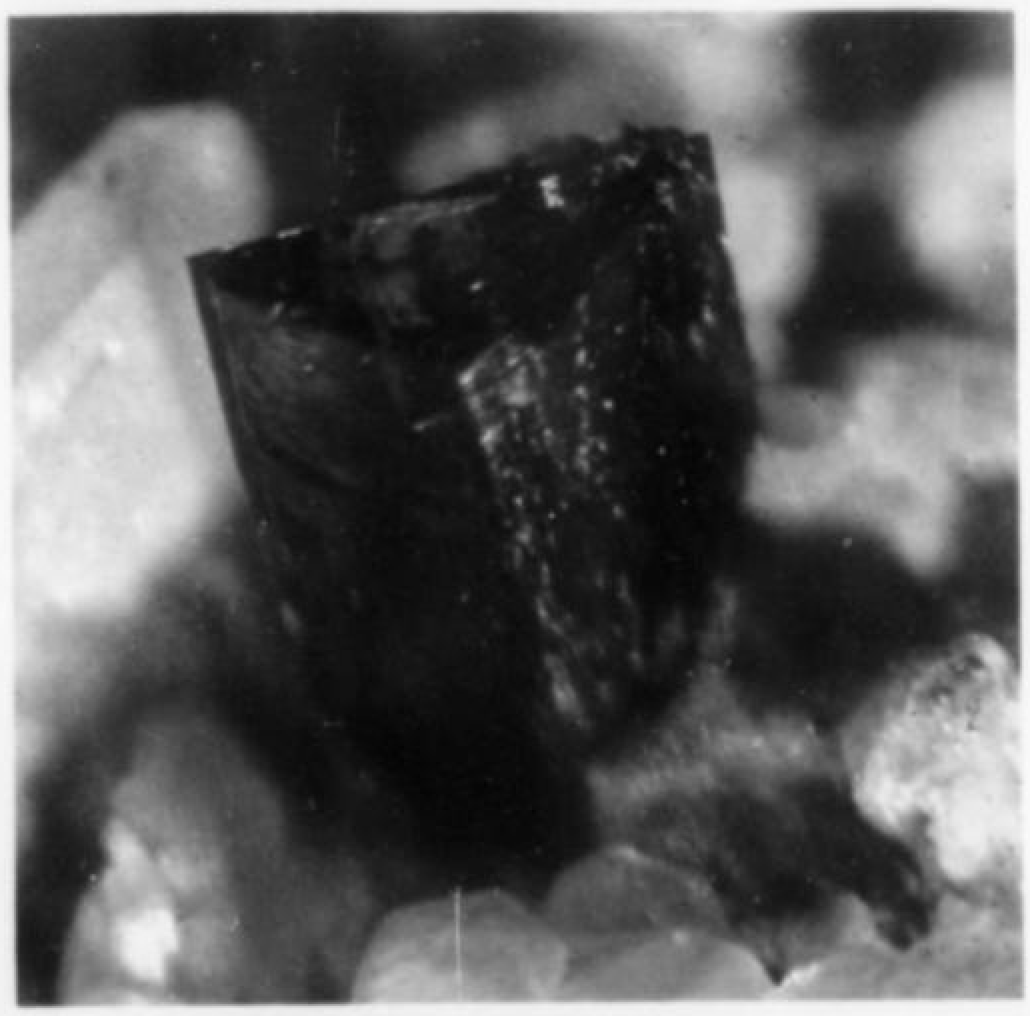


Figure 6. **Malachite from the Loudville lead mine; the crystal is about 0.6 mm tall.**

directions to the mine as given by Dunn read: "From Route 10, just south of Easthampton center, take Glendale Street for 3.2 miles. Take a dirt road to the left and park. Follow downhill trails to the river [the Manhan River] where collecting areas are obvious. If you cross the river on Glendale Street, you have overshot the dirt road." Pete lists the species found there (around the 35 mark). Stephen and Janet Cares introduced me to this collecting area by lending me their complete suite of Loudville mine minerals, thinking that photographs might enliven the reality of the minerals for micromounters. This is near to being wishful thinking, since many of the species form such small crystals at Loudville that only by the grace of the gods can I occasionally pull it off. All the Loudville mine minerals photographed belong to the Cares.

Following an order, with deviation, based as much on photogenic attributes as anything else, there are first anglesite and cerussite, both lead minerals and both not too scarce. The anglesite shows up clearly as orthorhombic (Fig. 7). In the cerussite there are many varieties of habit. I have chosen one which is basically reticulated, but displaying feathering along the main crystals (Fig. 8).

The mine was originally a source of lead-silver ore and it is the minerals which were then considered useless to the operation which are sought on the dumps today. Most of these are sulfates or carbonates; it cannot but be a collector's treat to find so many sulfates in one spot. One significant exception to these is the mineral wulfenite, richly versatile in its habits.

Most of the beautiful blue minerals, no doubt influenced in their color by the presence of copper (covellite, linarite, aurichalcite, and others to be mentioned) are unfortunately almost too small for photography. (One of these days we shall be using SEM pictures with color fed into the final result – and where will a photomicrographer be then, poor thing?) The sulfide, covellite, is difficult enough to find in good crystals anytime; it is just a little unborn thing in my group. This is not to say that you cannot find lovely little specimens among the blue minerals for micromounts. Two eyes, through a stereomicroscope, can find value in the most unlikely rocky specimens. Caledonite, for instance, should quite readily be picked up at the Loudville mine and enjoyed in its little clusters of short blue prismatic crystals. Linarite, in scatterings of thin translucent crystals, delicate and attractive and blue, is said to be most plentiful.

Opal, possibly the hyalite variety with some degree of orderly internal structure, appears in the mine to resemble a congealed molten glass. But blue. Why collectors who are not often pink-and-blue persons should fall in love with pink and blue minerals is an interesting though not difficult question. The opal is lovely (Fig. 2).

My attempt to get the minuscule blue wroewolfeite into a photograph is far from earth-shaking, although Janet Cares suspects that it is the only wroewolfeite photograph in existence (Fig. 3). Wroewolfeite, a rare monoclinic copper sulfate for which the Loudville lead mine is the type locality, is dimorphous with langite. Langite, too, is found in this mine in tiny blue but well-formed orthorhombic crystals, not as exciting as that which occurs at Monte Cristo, Snohomish County, Washington, but one of the species you go after. In the photograph of wroewolfeite, the clear crystal is leadhillite, a monoclinic chemically complex mineral, pseudohexagonal in habit.

The pyromorphite, again very small, shows clusters of crystals winging upwards from its matrix.

Barite, on the other hand, is sufficiently large, but of a strange appearance, orthorhombic truly enough, but in parallel growth, making for a little mass of crystals: greenish, opaque, but showing a glossy surface (Fig. 4).

The wulfenite is the most readily accessible to the camera and quite protean in its habits: platy, thick or thin; bipyramidal, low or high (Figs. 5); various modifications on these general shapes.

Finally, smithsonite, malachite, brochantite, chalcanthite, and hemimorphite should be mentioned. Of this group, no one can dispute the quality of the clear, transparent, orthorhombic crystals of hemimorphite (I cannot continue any longer saying "tiny"; take it as read). Chalcanthite in the Cares' specimen is fibrously fanciful; with a sense of humor you'd enjoy it. Smithsonite and brochantite are too difficult this time to photograph. Not so the malachite. One single crystal shows the characteristic wedge shape of a good malachite crystal (Fig. 6). Other malachite habits include thin transparent blades, or thick, tightly packed, near-botryoidal growth.

Figure 7. **Colorless anglesite from the Loudville lead mine; the crystal is about 0.8 mm across.**

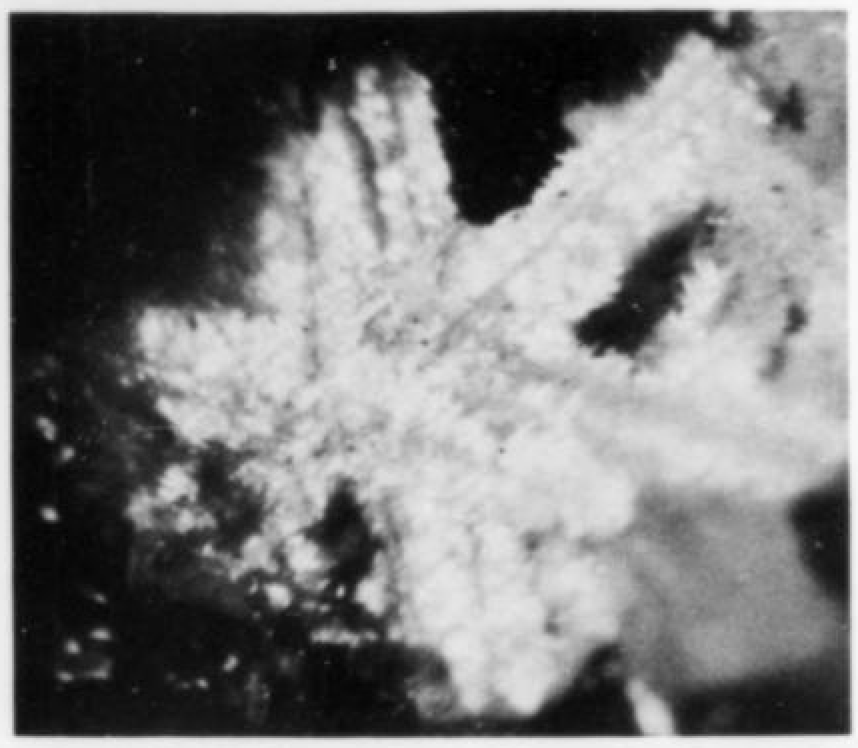


Figure 8. **White cerussite from the Loudville lead mine; the view is about 7 mm across.**

That is a goodly number of colorful and often enough rare minerals. To them can now be added plumbogummite, which was the subject of some discussion at the Rochester Symposium April, 1981. It is only a yellowish sort of crust, I believe, but hard to come by.

I want to end on a silver note. Rod Tyson and John Gorham (8507 – 111 Street, Edmonston, Alberta, Canada T6G 1H6) are selling silver collected from the El Bonanza mine near Port Radium in the Northwest Territories. It is some of the most beautiful micro silver I have ever seen, making artistic patterns from every angle. The habit is generally fern-like. It is sold in small fixed lots, and on some pieces, by request, you may have included minute pink crystals of pryosmalite – if still available.

A silver fern for a silver pick. Fair enough.

Violet Anderson
137 Buckingham Ave.
Toronto, Ontario, Canada
M4N 1R5

Additions and Corrections To The *Glossary of Mineral Species, 1980*

II. Oct. 1, 1980 to Oct. 1, 1981.

by **Michael Fleischer**
Mineral Sciences Department
Smithsonian Insitution
Washington, D.C. 20560

The past year has been one of continued activity in mineralogical research, as shown by the new results summarized here, including the description or revalidation of 67 mineral species (here designated by ☐). Keeping up with the flood of new data has become a difficult task and is possible only because of the help I get from many friends, too many to list here, but to whom I am deeply grateful.

Page

2 **Ajoite** change formula to $(K,Na)Cu_7AlSi_9O_{24}(OH)_6 \cdot 3H_2O$; change mon. to tric., add **66,** 201–203 (1981)
☐ 3 **Aldermanite,** $Mg_5Al_{12}(PO_4)_8(OH)_{22} \cdot 32H_2O$, orth., Min. Mag. **44,** 59–62 (1981)
4 Almbosite, $Fe^{+2}{}_5Fe^{+3}{}_4V^{+5}{}_4Si_3O_{27}$, **66,** 878 (1981)
4 **Alstonite,** change to trimorph. with **Barytocalcite** and **Paralstonite**
☐ 4 **Alumopharmacosiderite,** $KAl_4(AsO_4)_3(OH)_4 \cdot 6\frac{1}{2}H_2O$, cub., compare **Pharmacosiderite**
☐ 5 **Alumotantite,** $AlTaO_4$, orth.
5 **Alumotungstite,** $(W,Al)(O,OH)_3$(?), cub. or ps. cub., Mineral. Record **12,** 82–85 (1981)
7 **Anthoinite,** $(W,Al)(O,OH)_3$(?), tric., Mineral. Rec. **12,** 82 (1981)
8 **Apophyllite,** add "and **Natroapophyllite**"
☐ 9 **Arsenhauchecornite,** Ni_9BiAsS_8, tet., **Hauchecornite** group, **66,** 436 (1981)
10 **Ashanite,** add **66,** 217 (1981)
☐ 12 **Balyakinite,** $CuTeO_3$, orth., blue-green, **66,** 436 (1981)
☐ 13 **Bartelkeite,** $PbFe^{+2}Ge_3O_8$, mon.
13 **Bartonite,** add "tet., blackish-brown, **66,** 369–384 (1981)"
13 **Barytocalcite,** change to "trimorph. with **Alstonite** and **Paralstonite**"
14 **Bayldonite,** change formula to $PbCu_3(AsO_4)_2(OH)_2 \cdot H_2O$ (?), **66,** 148–153 (1981)
☐ 15 **Bentorite,** $Ca_6(Cr,Al)_2(SO_4)_3(OH)_{12} \cdot 26\ H_2O$, hex., bright violet, compare **Ettringite, 66,** 637 (1981)
15 **Bergenite,** change to "$(Ba,Ca)_2(UO_2)_3(PO_4)_2(OH)_4 \cdot 5\frac{1}{2}H_2O$, mon., yellow"
16 **Bessmertnovite,** add **66,** 878 (1981)
☐ 18 **Bismutohaucheocornite,** $(Ni,Co)_9Bi_2S_8$, tet., **Hauchecornite** group, **66,** 436, (1981)
19 **Boltwoodite,** add **66,** 610–625 (1981)
20 **Brabantite,** add **66,** 878–879 (1981)
24 **Calciborite,** change mon. to orth.
27 Cathophorite = **Brabantite, 66,** 878–879 (1981)
☐ 28 **Cestibtantite,** (Cs, Na, Sb) $Ta_2(O,OH)_7$, cub., **Pyrochlore** group
31 **Chlorophoenicite,** change formula to $(Mn,Mg)_3Zn_2(AsO_4)(OH,O)_6$, Can. Mineral. **19,** 333–336 (1981)
☐ 31 **Choloalite,** $PbCu(TeO_3)_2 \cdot H_2O$, cub., green, Min. Mag. **44,** 55–57 (1981)
32 **Clinobisvanite,** change to "trimorph. with **Dreyerite** and **Pucherite**"
32 **Clinochalcomenite,** add **66,** 217 (1981)
☐ 33 **Clinophosinaite,** $Na_3CaPSiO_7$, mon., compare **Phosinaite**
☐ 34 **Cobaltkoritnigite,** $(Co,Zn)(As^{+5}O_3)(OH) \cdot H_2O$, tric., deep purple, compare **Koritnigite.**
☐ 35 **Colquiriite,** $CaLiAlF_6$, trig., **66,** 879 (1981)
38 **Cuprosklodowskite,** change formula to $Cu(UO_2)_2Si_2O_6(OH)_2 \cdot 6H_2O$
43 **Dorfmanite,** add **66,** 217–218 (1981)
☐ 43 **Dreyerite,** $BiVO_4$, tet., orange-yellow to brownish-yellow, trimorph. with **Clinobisvanite** and **Pucherite.**
☐ 44 **Duhamelite,** $Pb_2Cu_4Bi(VO_4)_4(OH)_3 \cdot 8H_2O$, orth., yellow- green, Mineralog. Mag. **44,** 151–152 (1981)
45 **Eifelite,** add **66,** 218 (1981)
☐ 45 **Ekaterinite,** $Ca_2B_4O_7(Cl,OH)_2 \cdot 2H_2O$, hex., **66,** 437 (1981)
47 **Ettringite,** add "compare **Bentorite**"
☐ 48 **Eugsterite,** $Na_4Ca(SO_4)_3 \cdot 2H_2O$, mon., **66,** 632–636 (1981)
☐ 50 **Ferrarisite,** $Ca_5H_2(AsO_4)_4 \cdot 9H_2O$, tric., dimorph with **Guerinite, 66,** 637 (1981)
51 **Ferritungstite,** formula perhaps $(W,Fe^{+3})(O,OH)_3$, Mineralog. Record **12,** 82–85 (1981)
54 **Fillowite,** change formula to $Na_2Ca(Mn,Fe^{+2})_7(PO_4)_6$, add "compare **Johnsomervilleite, 66,** 827–842 (1981)"
☐ 54 **Florencite-(La),** $(La,Ce)Al_3(PO_4)_2(OH)_6$, trig., **Crandallite** group, Can. Mineral. **18,** 301–311 (1980)
54 Fluocerite–(La) Delete the entire entry
54 **Fluorapophyllite,** add "compare **Natroapophyllite**"
57 **Gaitite,** change formula to $Ca_2Zn(AsO_4)_2 \cdot 2H_2O$
☐ 58 **Geerite,** Cu_8S_5, ps. cub., Can. Mineral. **18,** 519–523 (1980)
59 **Giniite,** change orth. to mon., add **65,** 1066 (1980)
☐ 59 **Giuseppettite,** $(Na,K,Ca)_{7-8}(Si,Al)_{12}O_{24}(SO_4,Cl)_{1-2}$, hex., **Cancrinite** group
☐ 60 **Glushinskite,** $Mg(C_2O_4) \cdot 2H_2O$ (an oxalate), mon., **66,** 439 (1981)
☐ 61 **Goosecreekite,** $CaAl_2Si_6O_{16} \cdot 5H_2O$, mon., **Zeolite group,** Can. Min. **18,** 323–330 (1980)
61 **Gorceixite,** change trig., to mon., ps. trig.
62 Gregoryite, $(Na_2,K_2,Ca)CO_3$, **66,** 879 (1981)
63 **Guerinite,** add "dimoph with **Ferrarisite**"
65 **Hauchecornite,** change to "Ni_9BiSbS_8,tet., **Hauchecornite** group, **66,** 436–437 (1981)"
70 **Howieite,** add "compare **Taneyamalite**"
71 **Hydrocalumite,** change formula to $Ca_2Al(OH)_6Cl_{1-x}(OH)_x \cdot H_2O_{2+x}$
72 **Hydroxyapophyllite,** add "compare Natroapophyllite"
73 **Hydroxyellestadite,** change hex. to mon., ps. hex.
76 **Ixiolite,** change orth. to mon.
76 **Jagoite,** change trig. to hex.
☐ 76 **Jamesite,** $Pb_2Zn_2Fe^{+3}{}_5(AsO_4)_5O_4$, tric., reddish-brown
77 **Jeremejevite,** change formula to $Al_6B_5O_{15}(F,OH)_3$
77 **Joesmithite,** the reference should be **54,** 577
☐ 78 **Johnbaumite,** $Ca_5(AsO_4)_3(OH)$, hex., **Apatite** group, **65,** 1143–1145 (1980)
☐ 78 **Johnsomervilleite,** $Na_{10}Ca_6Mg_{18}(Fe,Mn)_{25}(PO_4)_{36}$, trig., brown, compare **Fillowite, 66,** 437 (1981)
78 **Jungite,** change the color to "yellow to greenish-yellow"
79 **Kainosite,** change the formula to $Ca_2(Y,Ce)_2Si_4O_{12}(CO_3) \cdot H_2O$.

☐ 79 **Kalborsite,** $K_6BAl_4Si_6O_{20}(OH)_4Cl$, tet., **66,** 879 (1981)
☐ 80 **Karlite,** $Mg_7(BO_3)_3(OH,Cl)_5$, orth., white to light green, **66,** 872–877 (1981)
80 **Kazakovite,** change formula to $Na_6MnTiSi_6O_{18}$
☐ 82 **Khademite,** change to "$Al(SO_4)F\cdot 5H_2O$, orth."
84 **Kolymite,** add **66,** 218 (1981)
84 **Koritnigite,** add "compare **Cobaltkoritnigite**"
☐ 84 **Kovdorskite,** $Mg_5(PO_4)_2(CO_3)(OH)_2\cdot 4\frac{1}{2}H_2O$, mon., pale rose, **66,** 437 (1981)
85 **Kraisslite,** change formula to $(Mn,Mg)_{24}Zn_3Fe^{+3}(AsO_3)_2(AsO_4)_3(SiO_4)_6(OH)_{18}$. Add **65,** 957–960 (1980)
85 **Kulkeite,** add **66,** 218 (1981)
☐ 86 **Kuznetsovite,** $Hg_6As_2Cl_2O_9$, cub., yellow to brown
☐ 87 **Lammerite,** $Cu_3(AsO_4)_2$, mon., dark green
☐ 87 **Lanthanite – (Nd),** $(Nd,La)_2(CO_3)_3\cdot 8H_2O$, orth., **66,** 637–638 (1981)
88 **Lawsonite,** add "dimorph. with **Partheite**"
91 Lingaitukuang = **Brabantite** (?), **66,** 878–879 (1981)
☐ 94 **Macquartite,** $Pb_3Cu(CrO_4)(SiO_3)(OH)_4\cdot 2H_2O$, mon., orange, **66,** 638 (1981)
96 **Magnesium-chlorophoenicite,** change formula to $(Mg,Mn)_3Zn_2(AsO_4)(OH,O)_6$, Can. Mineral. **19,** 333–336 (1981)
☐ 100 **Mcguinessite,** $(Mg,Cu)_2(CO_3)(OH)_2$, mon. or tric., greenish-blue, compare **Rosasite, Kolwezite**
☐ 105 **Miharaite,** $PbCu_4FeBiS_6$, orth., **65,** 784–788 (1980)
108 **Morozevicite,** add **66,** 437–438 (1981)
109 **Mpororoite,** probably tric., perhaps $(W,Al,Fe^{+3})(O,OH)_3\cdot H_2O$, Mineral. Record, **12,** 83 (1981)
109 **Nacaphite,** add **66,** 218 (1981)
☐ 109 **Nagashimalite,** $Ba_4(V^{+3},Ti)_4Si_8B_2O_{27}Cl(O,OH)_2$, orth., greenish-black, compare **Taramellite, 66,** 638 (1981)
☐ 110 **Natroapophyllite,** $NaCa_4Si_8O_{20}F\cdot 8H_2O$, orth., compare **Fluorapophyllite, Hydroxyapophyllite, 66,** 410–423 (1981)
110 **Natrophosphate,** change formula to $Na_7(PO_4)_2F\cdot 19H_2O$, add **66,** 879 (1981)
☐ 111 **Natrotantite,** $NaTa_3O_8$, mon.
111 **Neptunite, Mangan-neptunite** is misspelled
113 **Nontronite,** Formula should be $Na_{0.33}Fe^{+3}_2(Si,Al)_4O_{10}(OH)_2\cdot nH_2O$
☐ 114 **Nullaginite,** $Ni_2(CO_3)(OH)_2$, mon., bright green, Can. Mineral. **19,** 315–324 (1981)
114 **Oboyerite,** add **66,** 220 (1981)
114 **O'Danielite,** add **66,** 218–219 (1981)
☐ 114 **Okanoganite,** $(Na,Ca)_3(Y,Ce)_{12}Si_6B_2O_{27}F_{14}$, trig., **65,** 1138–1142 (1980)
114 **Olgite,** add **66,** 438 (1981)
☐ 115 **Glympite,** Na_3PO_4, orth., **66,** 438 (1981)
116 **Orthopinakiolite,** change to "trimorph. with **Pinakiolite** and **Takeuchite**"
☐ 117 **Otjisumeite,** $PbGe_4O_9$, tric., ps. hex.
117 Paigeite, change to "Paigeite = **Hulsite**"
119 **Paralstonite,** add **64,** 1332 (1979), **66,** 219 (1981)
☐ 119 **Pararealgar,** AsS, mon., yellow to orange-yellow, dimorph. with **Realgar,** Can. Mineral. **18,** 525–527 (1980)
☐ 120 **Parascholzite,** $CaZn_2(PO_4)_2\cdot 2H_2O$, mon., dimorph. with **Scholzite, 66,** 843–851 (1981)
120 **Partheite,** add "dimorph with **Lawsonite, 65,** 1068 (1980)"
121 **Paulingite,** formula $(K,Na)_2CaSi_{13}Al_4O_{34}\cdot 13H_2O$ (?)
☐ 121 **Pehrmanite,** $(Be,Zn,Mg)Fe^{+2}Al_4O_8$, trig., green, Can. Mineral. **19,** 311–314 (1981)
☐ 122 **Peretaite,** $CaSb_4O_4(SO_4)_2(OH)_2\cdot 2H_2O$, mon., **65,** 936–946 (1980)
☐ 123 **Petarasite,** $Na_5Zr_2Si_6O_{18}(Cl,OH)\cdot 2H_2O$, mon., **Lovozerite** group, Can. Mineral. **18,** 497–509 (1980)
123 **Pharmacosiderite,** add "compare **Alumopharmacosiderite**"
123 **Phosinaite,** add "**compare Clinophosinaite**"
124 **Pinakiolite,** change to "trimorph. with **Orthopinakiolite** and **Takeuchiite**"
126 **Polkovicite,** add **66,** 437–438 (1981)
☐ 127 **Preiswerkite,** $NaMg_2AlAl_2Si_2O_{10}(OH)_2$, mon., **Mica Group, 65,** 1134–1137 (1980)
127 **Prosperite,** change formula to $CaZn_2(AsO_4)_2\cdot H_2O$
128 **Pucherite,** change to "trimorph. with **Clinobisvanite** and **Dreyerite**"
☐ 128 **Putoranite,** $Cu_{16-18}(Fe,Ni)_{18-19}S_{32}$, cub., **66,** 638–639 (1981)
129 **Pyrophyllite,** change mon. to "mon. and tric."
131 **Realgar,** add "dimorph. with **Pararealgar**"
☐ 132 **Revdite,** $Na_2Si_2O_5\cdot H_2O$, tric.
☐ 133 **Roaldite,** Fe_4N, cub.
134 **Rokuhnite,** add **66,** 219 (1981)
☐ 136 **Sacrofanite,** $(Na,Ca,K)_9(Si,Al)_{12}O_{24}[(OH)_2,(SO_4),Cl_2,(CO_3)]_4\cdot nH_2O$, hex., **Cancrinite Group**
137 **Saleeite,** change tet. to mon., ps. tet.
☐ 138 **Saneroite,** $Na_2(Mn^{+2},Mn^{+3})_{10}Si_{11}VO_{34}(OH)_4$, tric., deep orange
☐ 138 **Santaclaraite,** $CaMn_4Si_5O_{14}(OH)_2\cdot H_2O$, tric., **66,** 154–168 (1981)
140 **Schieffelinite,** add **66,** 219 (1981)
140 **Scholzite,** add "dimorph. with **Parascholzite**"
☐ 143 **Shabynite,** $Mg_5(BO_3)(Cl,OH)_2(OH)_5\cdot 4H_2O$, mon. (?)
☐ 143 **Shahovite,** $Hg_8Sb_2O_{13}$, tric., lettuce-green to olive green
145 **Sklodowskite,** change formula to $Mg(H_3O)_2(UO_2)_2(SiO_4)_2\cdot 4H_2O$, **66,** 610–625 (1981)
146 **Soddyite,** change formula to $(UO_2)_2SiO_4\cdot 2H_2O$, add **66,** 610–625 (1981)
☐ 146 **Sodium phlogopite,** $NaMg_3Si_3AlO_{10}(OH)_2$, **Mica Group, 66,** 219, 639 (1981)
☐ 147 **Spertiniite,** $Cu(OH)_2$, orth., blue to blue-green, Can. Mineral. **19,** 337–340 (1981)
☐ 147 **Spionkopite,** $Cu_{39}S_{28}$, hex., Can. Mineral. **18,** 511–518 (1980)
☐ 149 **Sterlinghillite,** $Mn_3(AsO_4)_2\cdot 4H_2O$, **66,** 182–184 (1981)
☐ 149 **Stibivanite,** $Sb_2^{+3}V^{+4}O_4$, mon., yellow-green, Can. Mineral. **18,** 329–338 (1980)
151 **Strunzite,** change mon. to tric., ps. mon.
☐ 151 **Suessite,** $(Fe,Ni)_3Si$, cub.
152 **Sundiusite,** add **65,** 506–508 (1980)
152 **Surinamite,** change formula to $(Mg,Fe^{+2})_3Al_4BeSi_3O_{16}$
152 Svetlozarite = **Dachiardite**
153 **Takeuchiite,** $(Mg,Mn^{+2})_2(Mn^{+3},Fe^{+3})BO_5$, orth., black, trimorph. with **Orthopinakiolite** and **Pinakiolite, 65,** 1130–1133 (1980)
154 **Taramellite,** change formula to $Ba_4(Fe^{+3},Ti,Fe^{+2},Mg)_4Si_6B_2O_{29}Cl$, add "compare **Nagashimalite**"
☐ 155 **Tellurohauchecornite,** Ni_9BiTeS_8, tet., **Hauchecornite Group, 66,** 436 (1981)
156 **Thalfenisite,** add **66,** 219 (1981)
☐ 158 **Tiragalloite,** $Mn_4As^{+5}Si_3O_{12}(OH)$, mon., **65,** 947–952 (1980)
158 **Tisinalite,** add **66,** 219–220 (1981)
158 **Tivanite,** $V^{+3}TiO_3(OH)$, mon., black, **66,** 866–871 (1981)
☐ 161 **Tugarinovite,** MoO_2, mon., dark lilac-brown, **66,** 438–439 (1981)

(continued on page 52)

BOB SULLIVAN'S

LETTER from EUROPE

It's been a long time since the spring of any year has failed to produce a really outstanding mineral find; in this respect the spring of 1981 has been almost a bust, but not quite. Harking back the last few years you will recall some really exciting finds such as (in 1977) those very large, magenta-colored kämmererite crystals from Turkey and the brilliant, deep green pyromorphite specimens from France. In '78 it was the incredible pocket of "cranberry tourmaline" from the Jonas mine, Itatiaia, Minas Gerais, Brazil. People are still talking about that one, and an occasional super specimen is still popping out of the woodwork in Governador Valadares. (One such example was shown recently on the cover of the March-April issue of the *Record*.) For the spring of '79 it was that very unusual gold-coated native copper from Coquimbo, Chile, plus a few others that left a fine taste in the mouths of mineral lovers. And for 1980 it was the superbly crystallized aquamarine crystals from Kunar, Afghanistan, that raised a lot of blood pressures.

Certainly this year's Tucson show produced an extraordinary number of new finds, perhaps the greatest ever, and since most of these subsequently showed up at the spring and early summer European bourses, it provided more than enough to satisfy our overseas friends.

Most collectors don't think much of muscovite as a mineral specimen but occasionally some really fine examples do appear. One such case was a recent find from a new mine at Camp de Timoteo, Cidade Jaguaraçu, in Minas Gerais, Brazil. The 1/16 to 1/8-inch-thick, bright, silvery, hexagonal crystals range from ½ to 1½ inches in diameter and are piled up in very attractive groupings resembling stacks of interlocked checkers. Most of the crystals have a dark edging which adds to their attractiveness. The groups average about fist-size. The bulk of the specimens appeared at early Swiss and German bourses but I did see a few of the early arrivals in one of the hotel rooms at Tucson. Since the mine is reportedly a prolific one, more of these fine specimens should be coming our way.

For quite a few months now a fairly impressive quantity of green tourmaline marked simply "Conselheiro Pena, M.G., Brazil" has been seen on both the European and American markets. While the color (a sort of dark brownish green) is not all that exciting, the esthetics of some of the tourmaline crystals in association with albite and clear quartz is outstanding. The number of combinations has seemed almost limitless, as all three minerals have crystallized more or less simultaneously in a wide range of crystal sizes and configurations. Some of the quartz crystals formed in a flat, double axe-head shape with tiny, gemmy green tourmaline crystals included in the quartz as well as deposited on the surface. The tourmaline crystals range to nearly an inch in diameter but most of the larger ones are partially hollow and show signs of moderate to severe deterioration. Only recently did I learn that these specimens actually come from the Jonas mine, which produced the famous "cranberry tourmaline" back in 1978. There is, then, some hope for more rubellite, as the mine is producing a sufficient quantity of gem green tourmaline to pay the high lease costs. Since the new lessee of the mine has presumably not renamed it, a question arises as to how the full labeling of these specimens should read. When pressed, some of the Brazilians who are on top of the situation down there merely shrug their shoulders and say "ex-Jonas mine," but at least it seems the locality "Itatiaia" belongs in there, and *near* Conselheiro Pena would be more correct.

Norway is in the news again, this time with some very fine, large examples of crystallized zircon from Seiland Island in the Alta Fjord area of extreme northern Norway. Zircon from this area has been known for some time and is usually referred to as being from Finnmark, a huge area in Norway even further north than the northern tip of Sweden. If you check your map you will find that Seiland Island is at a latitude of more than 70° and is a pretty cold spot even in the summertime, which is when two German amateurs worked the area successfully for a small but outstanding collection of mostly matrix specimens. The sharply formed crystals vary from 1/16 inch to nearly 2 inches, really huge by any standard and some are quite gemmy. The color is a rich, dark, orange-brown. The crystals are almost textbook examples of the tetragonal system, and sit nicely on a matrix of whitish feldspar and blackish biotite. Most of these specimens have appeared in Europe but two of the largest crystal examples have ended up in the Smithsonian collection. Incidentally, Norway has another zircon-producing area much further south in Tvedalen, Larvik. The crystals from Tvedalen run much smaller, to about an inch, are not at all gemmy, but are beautiful light brown matrix examples of the zircon crystal form.

France's famous St. Marie aux Mines bourse in early July was very well attended this year and, as usual, business was conducted anywhere and everywhere at the typical fast and furious French pace. An unusually large number of German dealers showed up, to buy, not to sell, and a few Americans also attended. "They must be pretty desperate to come to France," clucked one of the French dealers about the visiting Germans, but the pickings were pretty slim at St. Marie. A small but excellent collection of beautiful, semi-gemmy pink apatite from Morro Velho, Brazil, was offered by one French dealer. The material has been periodically available from Morro Velho but the crystals on these recent specimens range up to 1½ inches and are on an attractive matrix of white calcite and quartz!

There were a few outstanding pyromorphite specimens from the famous Mine des Farges in Corréze, France, but although the dark green color is excellent, the crystals are in the 1/16 to 1/8 inch range only. A newly arrived small collection of azurite, anglesite and cerrusite from the Toussite mine, Morocco, caused quite a stir, as did some fine blue fluorite from southern France. There were lots of very fine minerals available, including many collector-pleasers from the U.S.A. and Mexico, and business was quite brisk.

Thanks to Giancarlo Fioravani of Rome, Italy, I have received a complete list of 30 Italian mineral bourses and shows which were scheduled for 1981 (last year). A partial listing follows and for the most part they are repeated each year on the same weekends.

February 28 to March 1, **Genoa;** March 14–15, **Bologna,** 21–22, **Torino;** April 25–26, **Florence;** May 9–10, **Verona** (?); July 11–12, **Riccione,** 18–19, **Aosta,** 26, **Massa Marittima;** September 5–6, **Livorno,** 19–20, **Milan;** October 9–11, **Torino;** November 7–8, **Verona** (?), 14–15, **Rome,** 28–29, **Milan;** December 12–13, **Grosseto.** In addition there are 15 others listed, of which 6 are exchange-only shows. The major shows are Bologna, Florence, Milan, Rome and, the biggest of them all, Torino. Further details are available from the Federazione Nazionale, Gruppi Mineralogici and Paleontologici Italiani, Viale Maroncelli 7, Riccione, Italy.

Back in the U.S.A. our "National Show" at Salt Lake City was an early June success in terms of attendance and some really fine lapidary, jewelry and mineral exhibit cases were to be seen. Strangely, very few mineral dealers participated in this event. But there were enough specimens available, including even a surprise or two from the heavily outnumbered mineral collectors (some of whom yanked their kids out of school early in order to be able to attend or compete).

Mexican minerals have been generally scarce for quite some time now, but some really fine examples are still available, particularly from the prolific mines in the Naica area of Chihuahua. I recently acquired for my collection an excellent, hand-sized, brilliant deep black group of *marmatite* (ferroan sphalerite) crystals from Naica that rival in color and brilliance the best of the Trepça, Yugoslavia, specimens. Until now I have had only Trepça specimens, because virtually all the Naica specimens I have seen have been more of a blackish brown color. The Trepça sphalerite crystals do run considerably larger, however, and when adorned with pink rhodochrosite can be truly spectacular.

Naica has long been famous for very fine examples of octahedral and dodecahedral crystals of pale green fluorite, but some of the recent specimens have been especially outstanding. The fluorite is remarkably clear, much of it facetable, and a vibrant emerald-green in color. The large blocky crystals are up to hand-size, some with attached black sphalerite groupings, and show mostly stepped parallel growth, much like a staircase in form. Beautiful, very finely crystallized golden barite on a white quartz matrix was also available from Naica at the Salt Lake City show and, like most Mexican minerals, was moderately priced. Crystals are on the smallish size, none more than ½ inch, but they are gem-clear and beautifully formed window-shaped examples much like the old Kapnik, Romania, specimens (which, however, could exceed several inches in length). From Zacatecas there were also some very unusual barite groups with heavy, blocky, interlocking crystals that looked more like rhombs of dolomite than barite, and with a strange randomly zoned black and white coloration. They were appropriately called "black and white barites." Crystals vary from ½ to 2 inches and are very opaque but sharply defined. They reminded me of a clown's suit in which the legs and arms are alternately black and white, because they did have a somewhat comical appearance – if you can believe that a mineral specimen can have a comical appearance!?

Let us end it there with a special thanks to Helmut Brückner of Germany for his on-the-scene comments from St. Marie. Until next time . . .

Cheers,

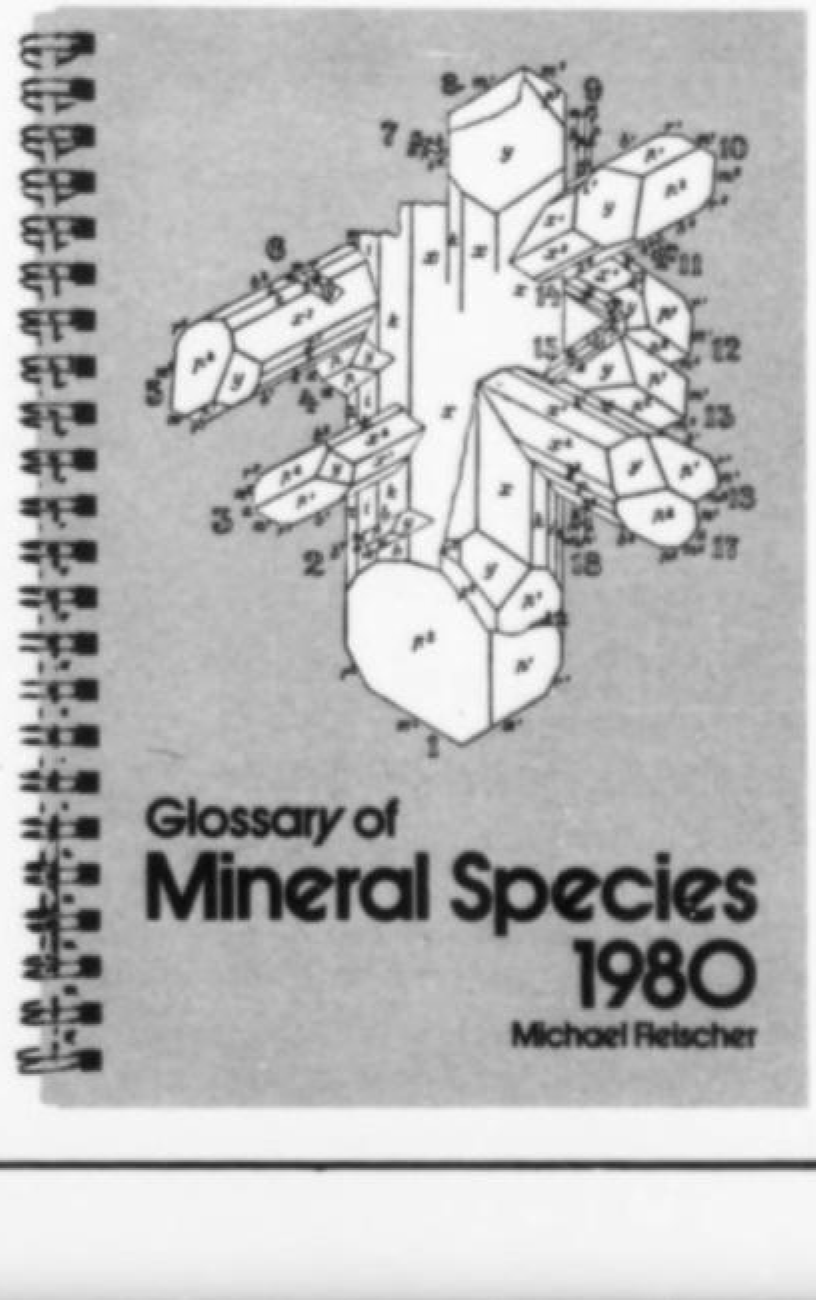
Bob Sullivan

Kubler Weiherhof 21
8604 Volketswil (Zurich)
Switzerland

3202 Saguaro West Trail
Tucson, Arizona 85705
U.S.A.

(continued from page 50)

162 **Tunisite,** change formula to $NaCa_2Al_4(CO_3)_4(OH)_8Cl$
164 **Uranophane,** change formula to $Ca(H_3O)_2(UO_2)_2$
$Si_2O_8 \cdot 2H_2O$, add **66,** 610–625 (1981)
164 **Uranophane-beta,** change formula to $Ca(UO_2)_2$
$Si_2O_7(OH)_2 \cdot 4H_2O$, add **66,** 610–625 (1981)
168 **Voglite,** change "tric. to mon."
☐ 173 **Wonesite,** $(Na,K)(Mg,Fe,Al)_6(Si,Al)_8O_{20}(OH,F)_4$, mon.,
66, 100–105 (1981)
☐ 174 **Yarrowite,** Cu_9S_8, hex., Can. Mineral. **18,** 511–518 (1980)
☐ 176 **Zhonghuacerite,** $Ba_2Ce(CO_3)_3F$, trig., pale yellow
☐ 176 **Ziesite,** $Cu_2V_2O_7$, mon., black, **65,** 1146–1149 (1980)
179 **Apatite Group,** add **Johnbaumite**
181 **Cancrinite Group,** add **Giuseppettite** and
Sacrofanite
183 add **Hauchecornite Group,** tetragonal sulfides, formula
AB_2S_8,
A = Ni,Co; B = As, Bi, Sb, Te
Arsenohauchecornite **Tellurohauchecornite**
Bismutohauchecornite **Tucekite**
Hauchecornite
185 **Lovozerite Group,** add **Petarasite**
186 **Mica Group,** add **Preiswerkite** and **Sodium phlogopite**
187 **Osumilite Group,** add **Eifelite**
188 **Pyrochlore Group,** add **Cestibtantite.**
191 **Zeolite Group,** add Goosecreekite



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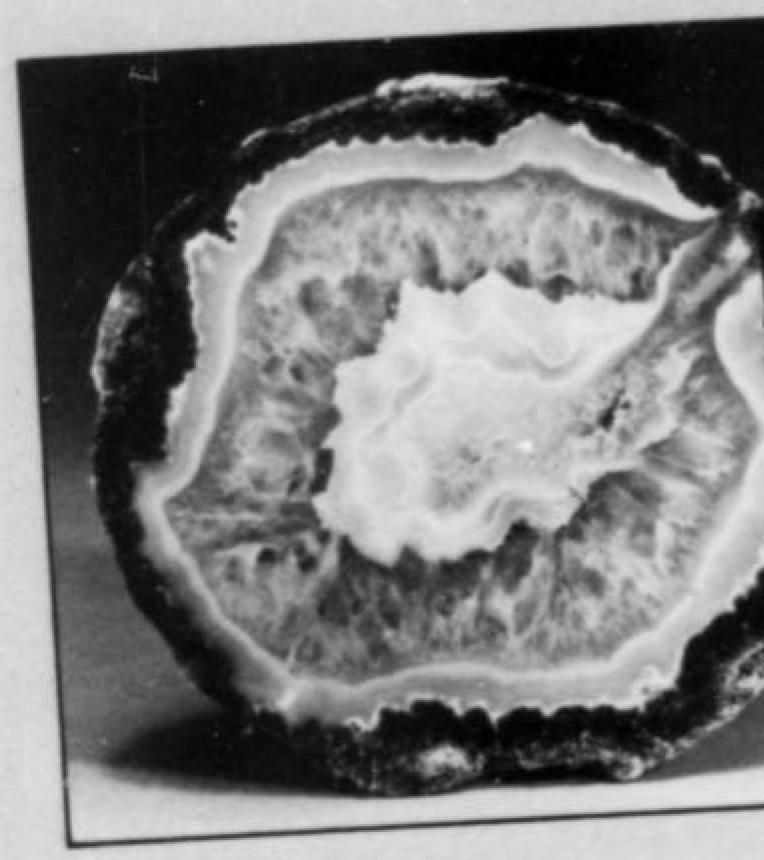

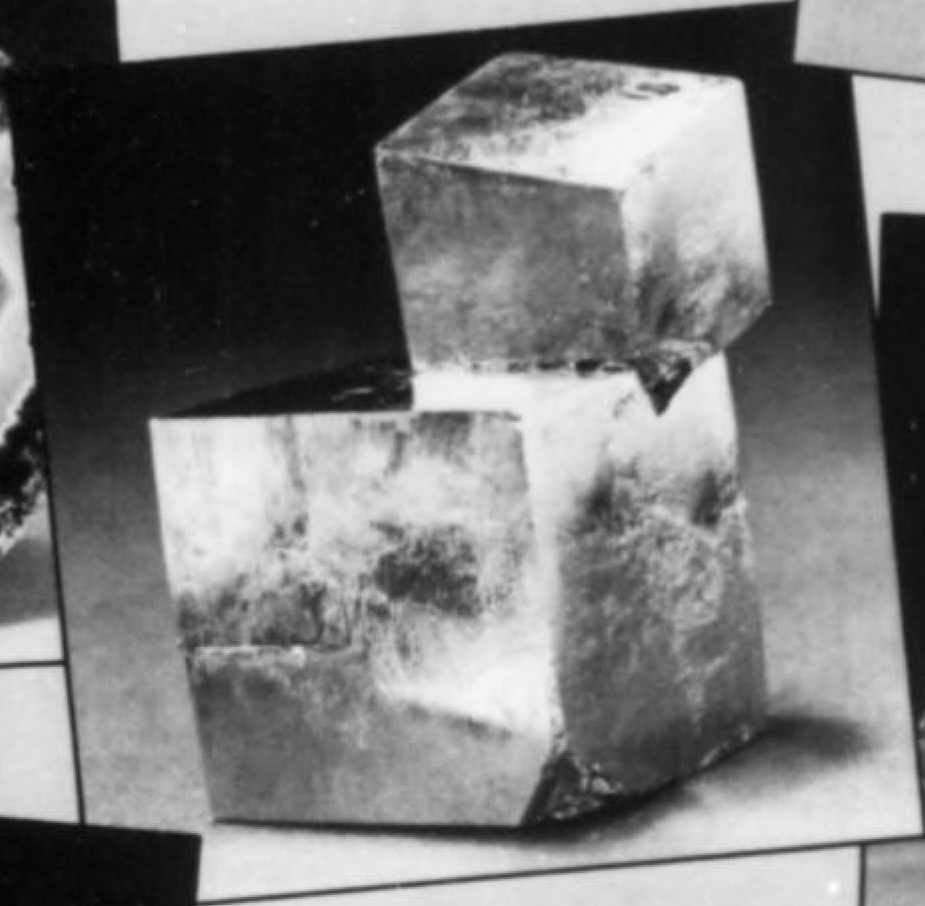

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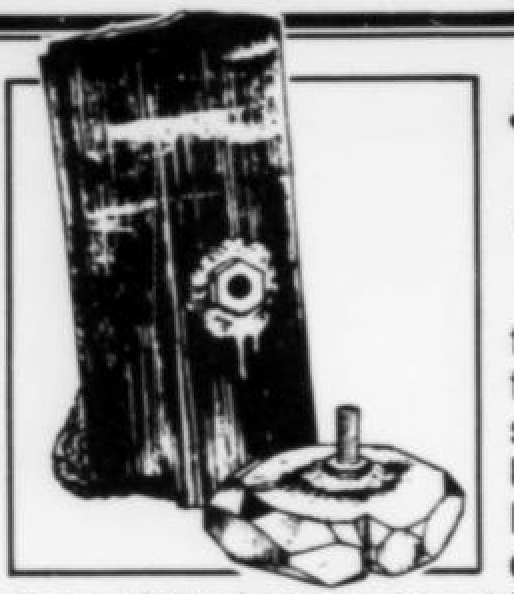

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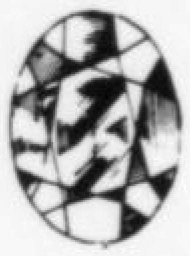

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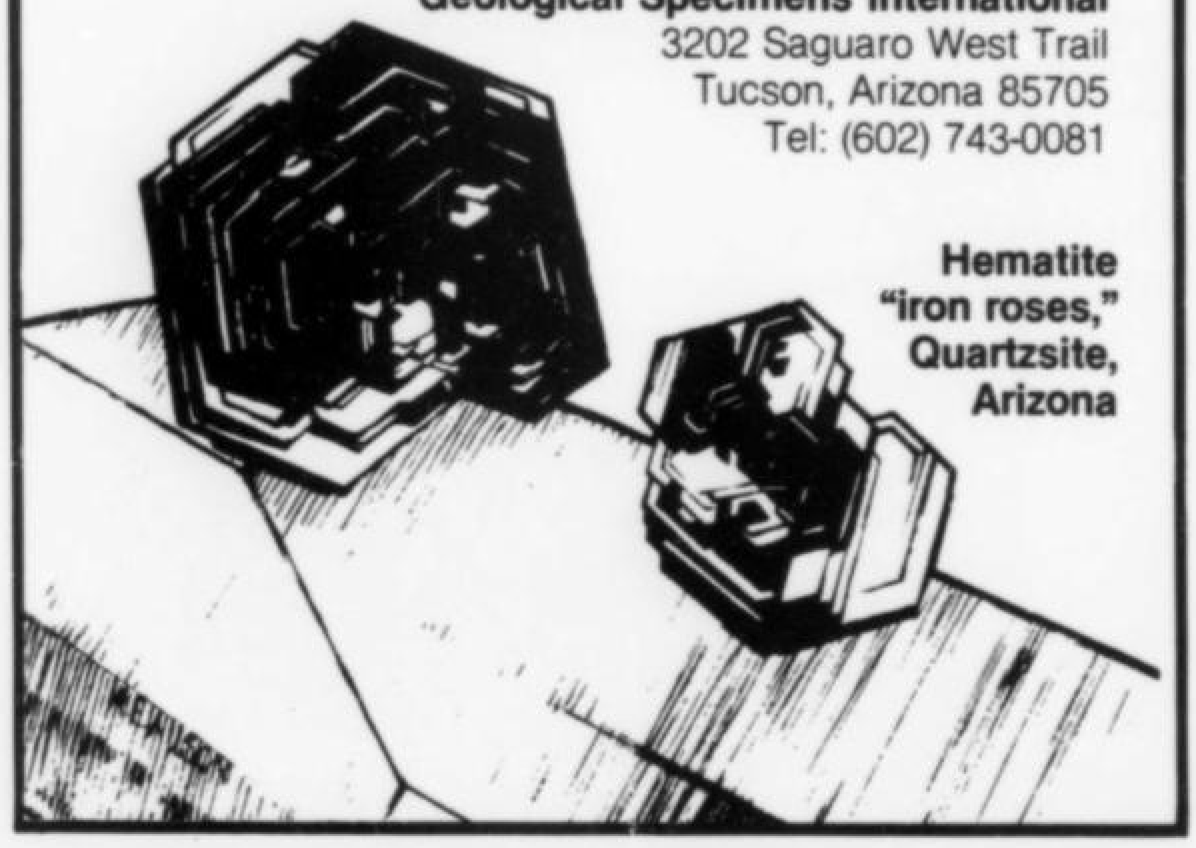

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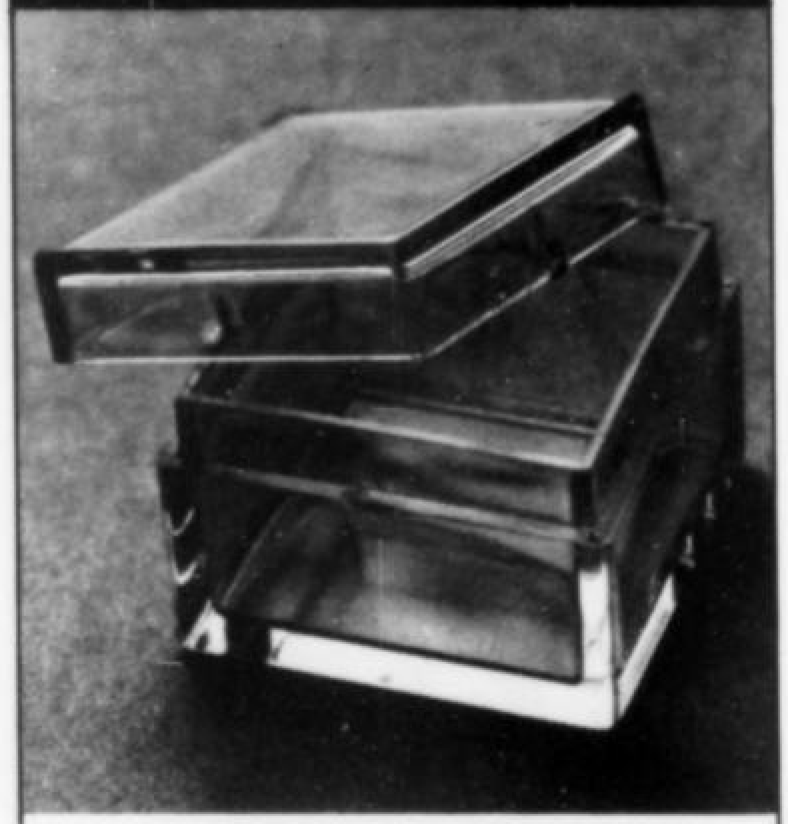

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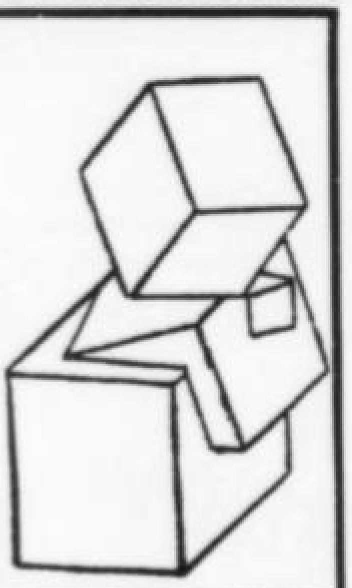

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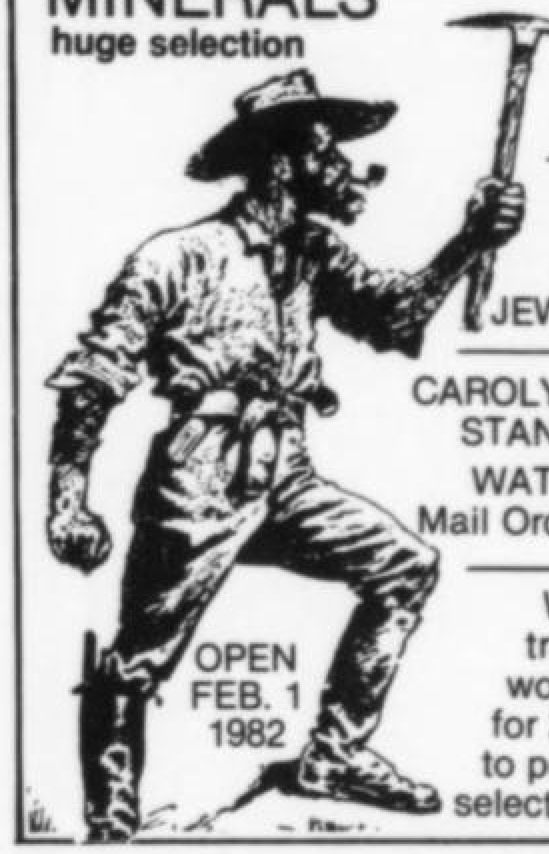

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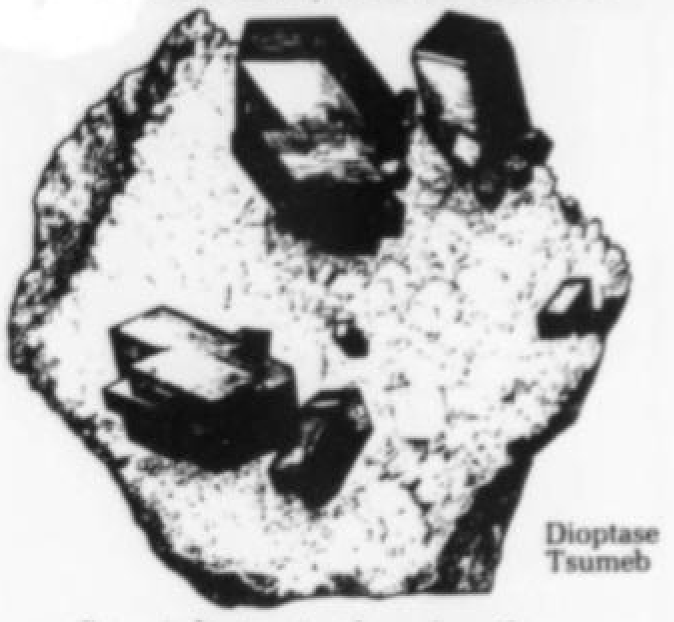
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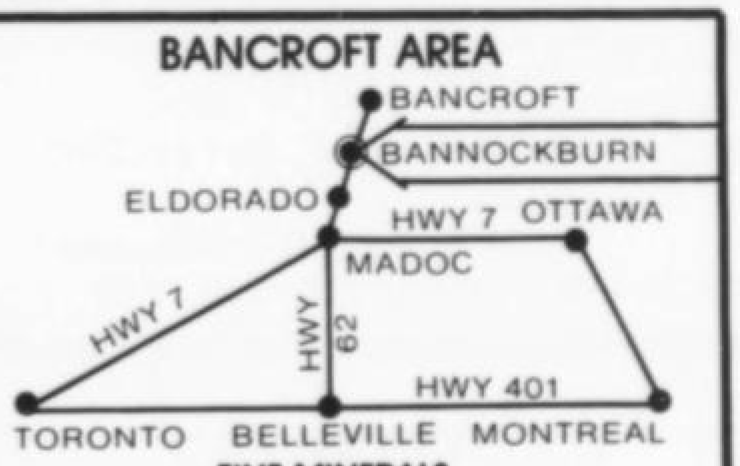

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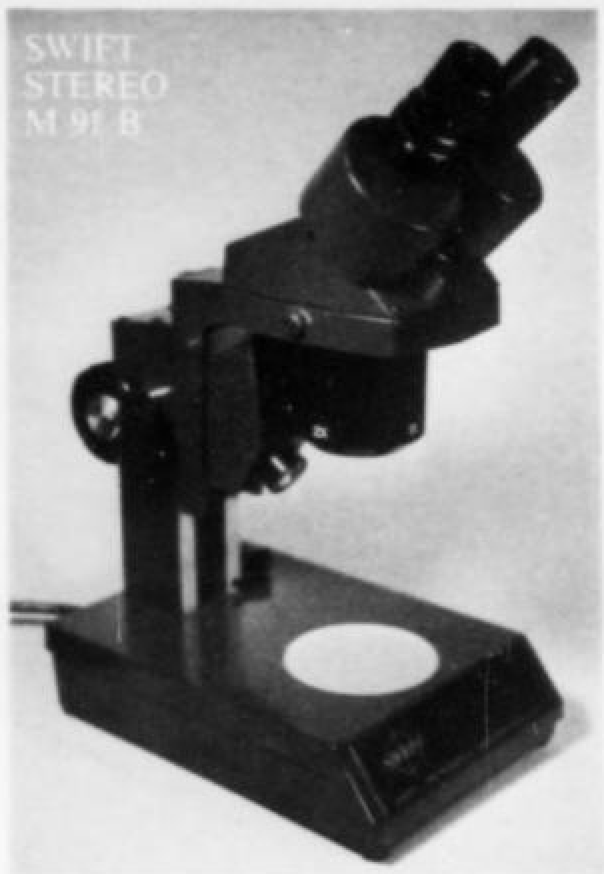

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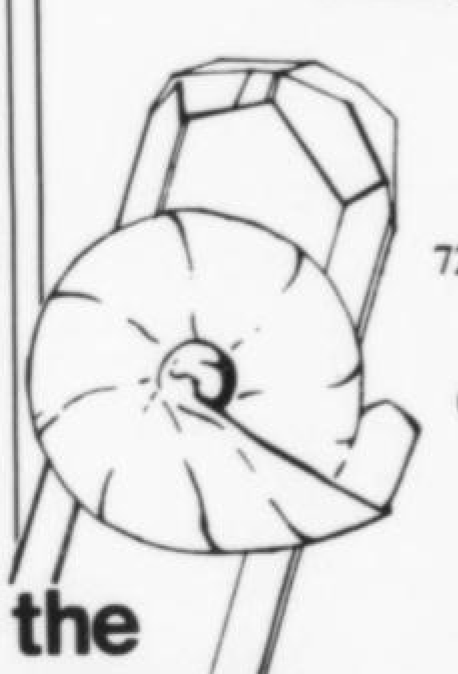

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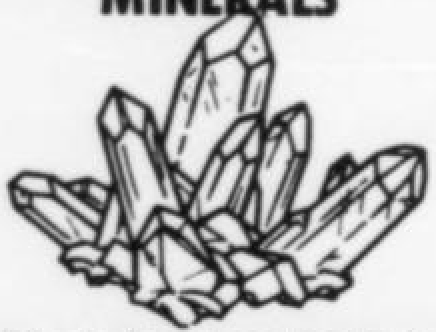

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