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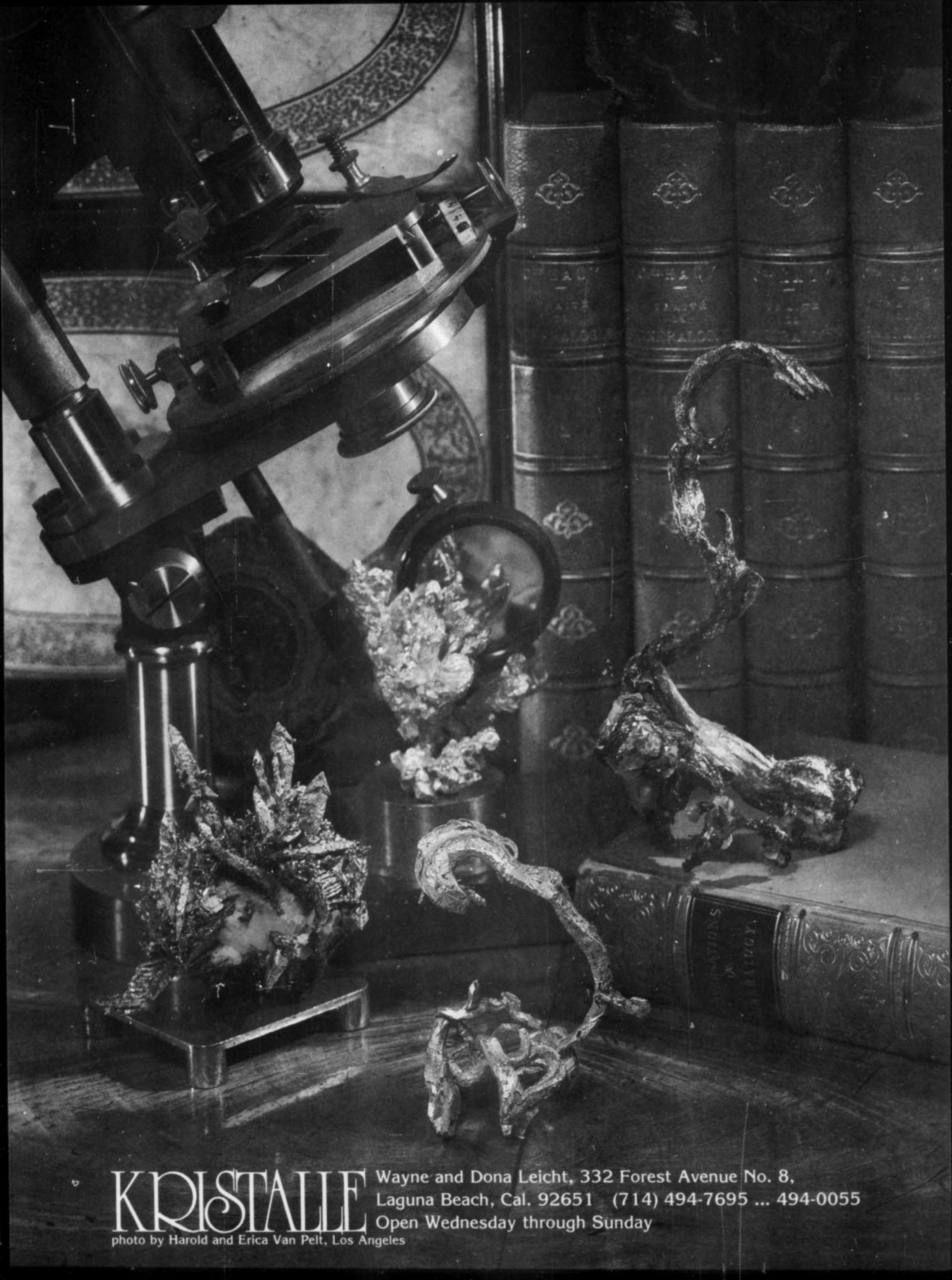

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COVER: ELBAITE on albite, from the Jonas mine, Minas Gerais, Brazil. Keith Proctor specimen; photo by Harold and Erica Van Pelt, Los Angeles.

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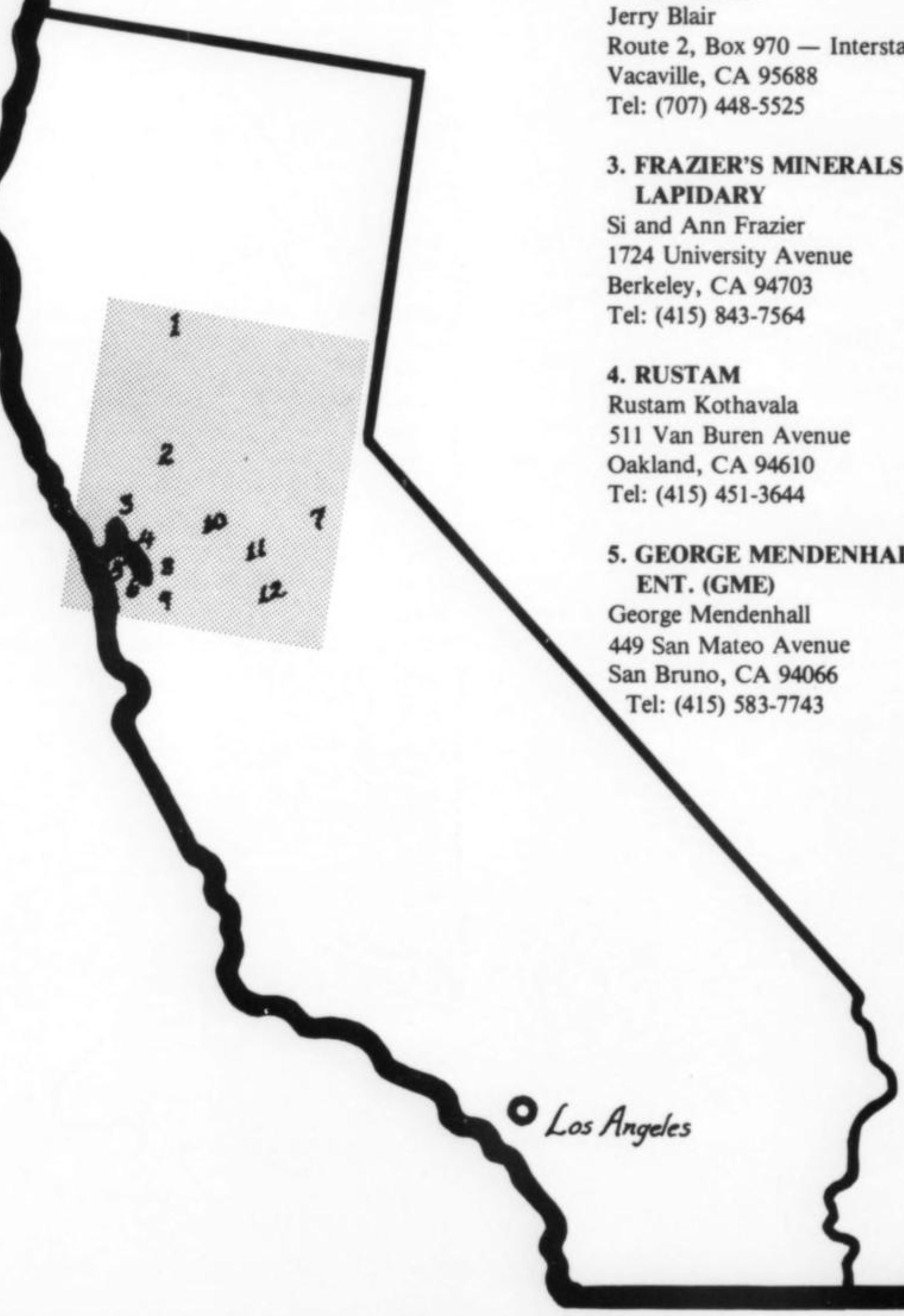

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Minerals of the Lavra do Énio Pegmatite

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INTRODUCTION

Recently, a small pegmatite body in Minas Gerais has produced magnificent ludlamite and vivianite crystals (J. and J. Cassedanne, 1978). This pegmatite contains an abundance of many minerals, mainly phosphates, which are new to Brazil and very good specimens are still recoverable from the dumps or in the mine workings.

LOCATION, ACCESS AND REGIONAL SETTING

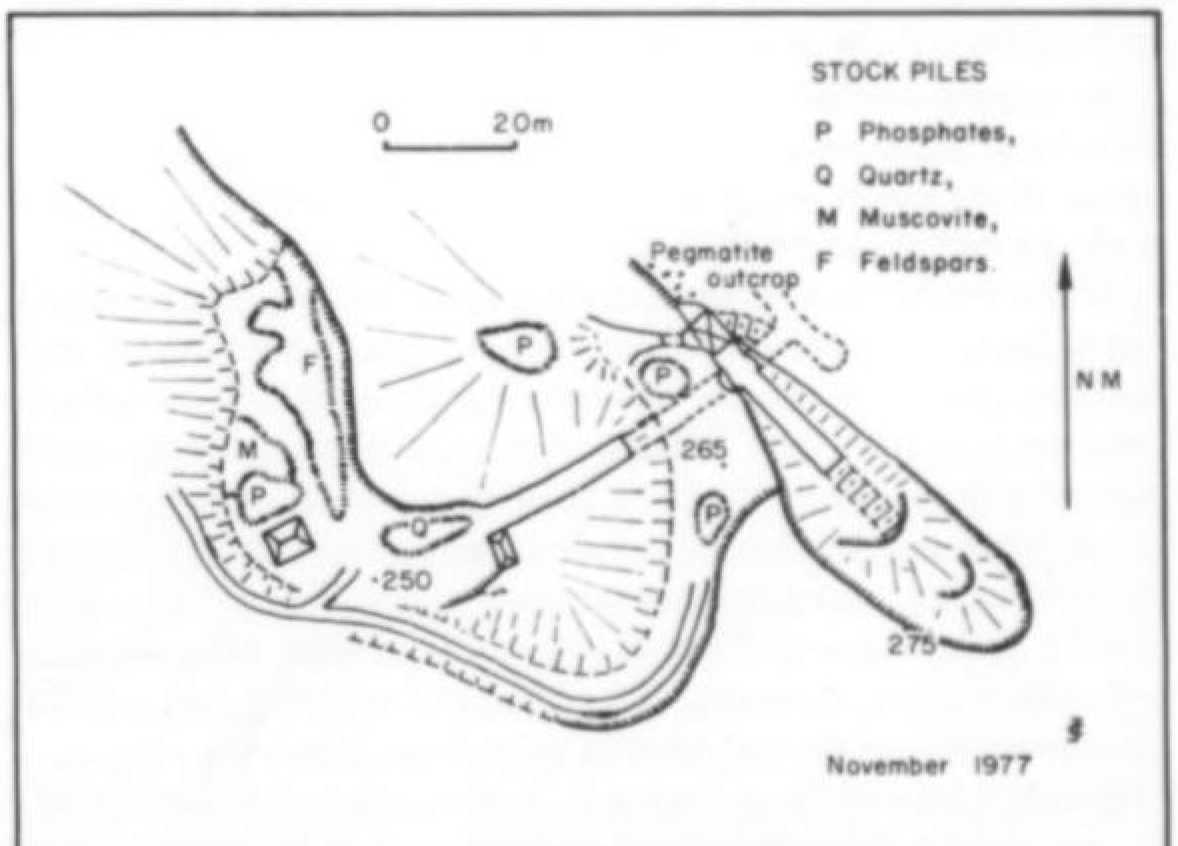
The occurrence is known as Lavra do Énio (from the name of its owner, Énio Deniculi), and also as Fazenda Boa Vista, Boa Vista and, more rarely, Fazenda Laranjeiras. It is located to the northeast of Galiléia to which township it belongs, and east-southeast from Governador Valadares, near the Rio Doce Valley and to the west of the famous Urucum pegmatite.

Access from Governador is made using the good but unpaved road toward Mantena until São Vitor (32.5 km), where a road towards Conselheiro Pena forks to the right. Proceeding on this road for 28.5 km, that is to say, 1.5 km before the town of Galiléia, a good small road to the left runs to Baixio by way of Laranjeiras. At 10.5 km (elevation 160 m), near this latter village, a jeep road forks to the right and leads first to the houses of the Fazenda Laranjeiras and, after a short slope, reaches the mine at the elevation of 250 m.

LOCATION MAP

The Baixio road runs upstream along the Côrrego (Creek) Laranjeiras Valley, carved into gently undulating hills dominated by granitic inselbergs. Vegetation is mainly thick, high grass with scarcely any forest. Deep weathering and thick vegetation make outcrops rare. Little villages are scattered about; the population lives by farming and small-scale mining.

The adjacent area is mainly gneissic with mica schists and belongs to the Paraiba group (São Tomé formation of Barbosa *et al.*, 1966), Lower Precambrian in age (about 1,980 million years). Tectonically it is located in a Transamazonic belt which was remobilized during the Brazilian cycle (1,000–500 m.y.) and has been migmatized and intruded by granites and pegmatites (de Almeida *et al.*, 1976). Age dating in granitic rocks near Galiléia ranges from 550 to 600 m.y.



MAP OF THE ÉNIO PEGMATITE

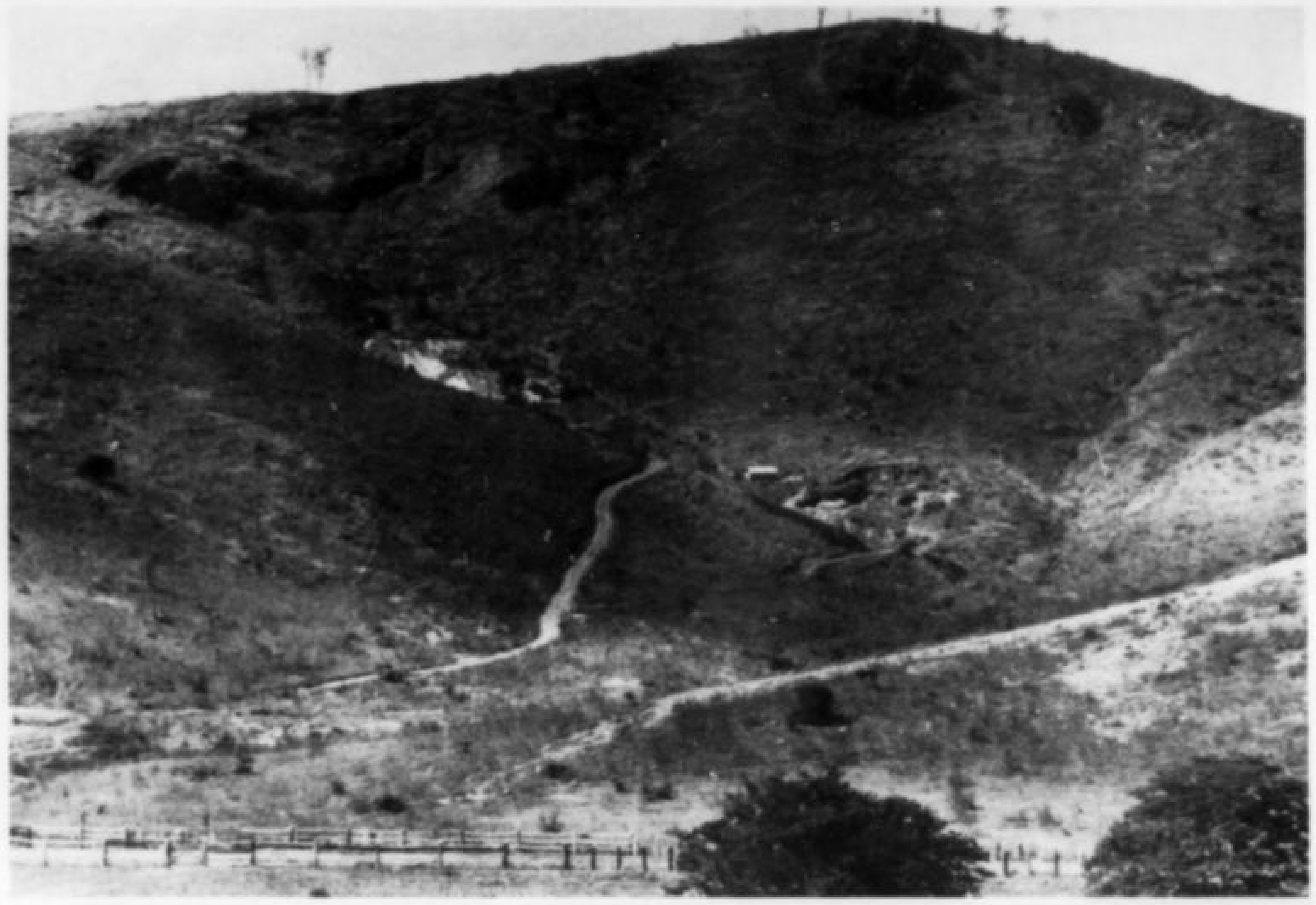


Figure 1. **The Boa Vista property. Mine dumps are white in the thalweg below the cliff. In the foreground, the access track. View taken from the Fazenda Laranjeiras house.**

DESCRIPTION OF THE PROSPECT

The lavra consists of a lenticular, granitic, albitized heterogenous pegmatite that strikes N40W and dips 65°NE, about 80 m in length. The thickness of the pegmatite, asymmetric, is about 10 m as it may be seen in a crosscut at an elevation of 250 m where the quartz core, 5 m in width, is near the north wall. The pegmatite is interbedded in a quarzitic mica schist with biotite and tourmaline, that dips 80°NE.

The following section was exposed in the southeastern mining face, from west to east, in July of 1977:

—Wallrock,

—Coarse bed of centimetric muscovite crystals, a few centimeters thick,

—Feldspar zone entirely crossed by large dendritic graftonite crystals, with large platy muscovite sheets in which black tourmaline is thinly tabular. Width about 2.5 meters,

—Feldspar zone with triphylite (and other phosphates) nodules and metric opaque beryls. Amblygonite is abundant in places. Vugs with fine crystallized minerals are scattered along and near the contact with the quartz core. Width about 2.5 meters,

—Quartz core with some large beryls in the outside part.

The mining is by open pit, with pneumatic drilling. Sorting, loading and haulage are manual.

At an elevation of 250 m, a crosscut in the south wall serves the present mining level, where workings are concentrated in the southeast portion of the pegmatite between the core and the wallrock, because good beryl concentration occurs there. The depth is about 30 m from the surface to the present mining level. Irregular inclines up to 10 m below this level, dug in search of amblygonite, are presently caved and backfilled.

Above the 265-m level, the pegmatite has been thoroughly mined out as far as the outcrops. Today only the quarry open in this level remains. About 10 tons of heterosite (with exsolution of sarcopside) are stockpiled near the end of the access track. At the north corner of the same quarry floor are 1 or 2 tons of triphylite stock containing many secondary phosphates and about 200 kg of metallic ore minerals, mainly arsenopyrite and other sulfides. They represent the sorted minerals from above the 265-m level and await sale.

On the slope to the east are several tons of triphylite rich in thick sarcopside exsolution and patches of wolfeite and arrojadite.

Finally, at the crosscut level near the hut where mica is trimmed, is a stockpile of more than 15 tons of phosphates rich in triphylite, vivianite, graftonite and siderite. Along the cut leading to the adit a large pile of milky quartz is without mineralogical interest but a stockpile of more than 100 tons of feldspar (November, 1977) to the north of the hut contains good graftonite, a few apatite, roscherite and childrenite crystals and, always associated with beryl, large patches of beryllonite.

Figure 2. **Mining in January, 1977, view looking southeast. On the right hand the mica schist wall rock, on the left the quartz core with some feldspar. Drilling in the upper part is in a beryl crystal concentration in albite.**

On the south side of the quartz core, presently unworked and near the actual mining face, phosphate nodules are well exposed. They reach more than 1 m in diameter, several hundred kg in weight, and are surrounded by vivianite and siderite.

The mine started with feldspar production. Then mica was mined with amblygonite to which a little triphylite was added for sale.

Today beryl is the bulk of the production, the feldspar (albite) being stockpiled and mica being a byproduct. Mineral specimens are not especially sought and are poorly sorted.

Figure 3. **Phosphate masses, mainly triphylite and vivianite (gray), in feldspar near the quartz core (January, 1976).**

MINERALS

1 — ORE MINERALS

They are scattered near or in the phosphate nodules, in isolated grains or compact masses reaching up several kg. For a more detailed study of these minerals and their matrixes, see J. and J. Cassedanne (1980). Only a few of them are attractive for collectors, most being identifiable only by using a reflected light microscope.

Arsenopyrite is the main metallic mineral. Many vugs lined with good crystals, which rarely reach 1 cm, are present in the massive blocks. A partial resorption phenomenon produced threadlike, curved or skeletal crystals very suitable for micromounting. Small aggregates of nice arsenopyrite crystals may also be easily recovered from the soft secondary phosphate matrix, mainly in vivianite.

Löllingite is rare, in fine dendrites in albite.

Pyrite belongs to 3 stages of crystallization. The first, porous after pyrrhotite, and the second, massive, are not attractive. The third furnishes good micromounts as small bright octahedrons and pyritohedrons perched on cleavelandite in small vugs.

Sphalerite crystals are rare, isolated or in vugs in a phosphate matrix, or sometimes in milky quartz. They are brownish black marmatite (FeO = 10.02 percent and MnO = 6.71 percent). Nice chalcopyrite intergrowths may frequently be seen without a lens.

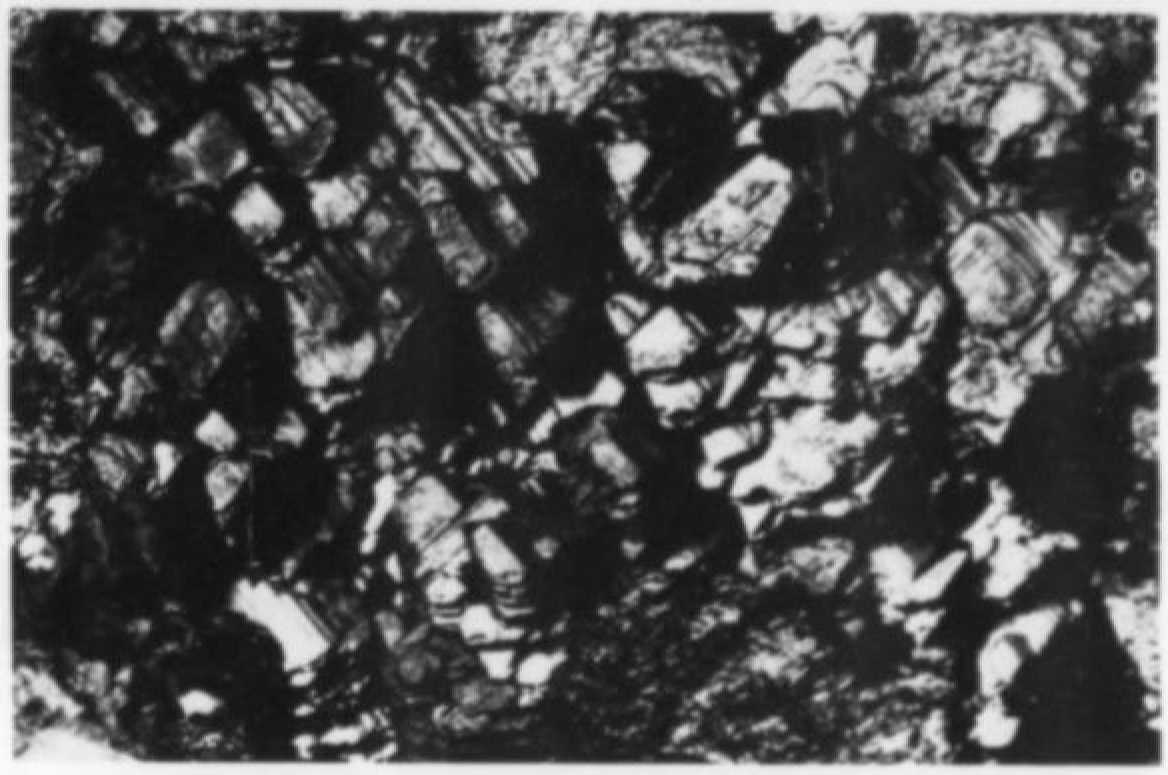


Figure 4. **A druse of crystallized arsenopyrite. The sample is 4.7 cm in length.**

Chalcopyrite is found in irregular patches in arsenopyrite with other sulfides and phosphates.

Pyrrhotite, cubanite, bornite, covellite and tennantite in small patches are only determinable by microscopic investigation of polished sections.

Bismuth, rare, is in skeletal threads reaching 4 mm in the matrix and/or in metallic ores.

Galena, very rare, occurs in fine millimetric octahedrons, bright steel-gray, perched on cleavelandite in the vugs. It is highly suitable for micromounting.

Goethite, claudetite and sulfur, alteration minerals are not frequent, as thin coating.

Wolframite (FeO/MnO = 16.24/6.29 percent), scattered, is relatively rare as centimetric blades, generally fractured (J. and J. Cassedanne, 1979).

Columbite (FeO/MnO = 13.16/6.49 percent) occurs in bladed, bright crystals, longitudinally striated, reaching 4 cm, sometimes easily separable from the white feldspar matrix (d = 5.90 ± 0.05), or in fractured, irregular lenses (d = 5.77 ± 0.05).

Uraninite is abundant in rose-colored potassium feldspar as multicentimetric nodules or dendritic aggregates of small grains (d = 9.05 ±0.05); curved octahedrons are very rare. Uraninite is frequently found surrounded by some pyrite.

2 — PHOSPHATES

The large variety and good crystallization of some phosphates, and the many rare species occuring there qualify the Lavra do Ênio pegmatite as a classic mineralogical locality. Accurate identification of all phosphates is in process, mainly by way of complete chemical analysis. Preliminary determinations were carried out by means of X-ray diffraction and partial or qualitative chemical analysis in order to place the phosphates in the group to which they belong, for instance in a complete series between Fe and Mn end-members.

Descriptions will begin with the older ("primary" in part) phosphates, frequently massive. Theoretical compositions are, for the most part, from Fleischer (1980).

Triphylite $Li(Fe^{2+},Mn)PO_4$

Triphylite occurs in very large, lustrous gray masses with good cleavages but not attractive, in which the ratio FeO/MnO is 33.06/7.50 percent. Many other minerals are included.

Sarcopside $(Fe^{2+},MnMg)_3(PO_4)_2$

Sarcopside always occurs as exsolution in triphylite and heterosite. Salmon-pink to light buff or orange, its blades sometimes exceed 3 mm thick in triphylite. They are much thinner in heterosite. Good samples may be easily collected in the stockpiles. Calcium is practically lacking but magnesium is present. The ratio of FeO to MnO is 40.78/6.70 percent.

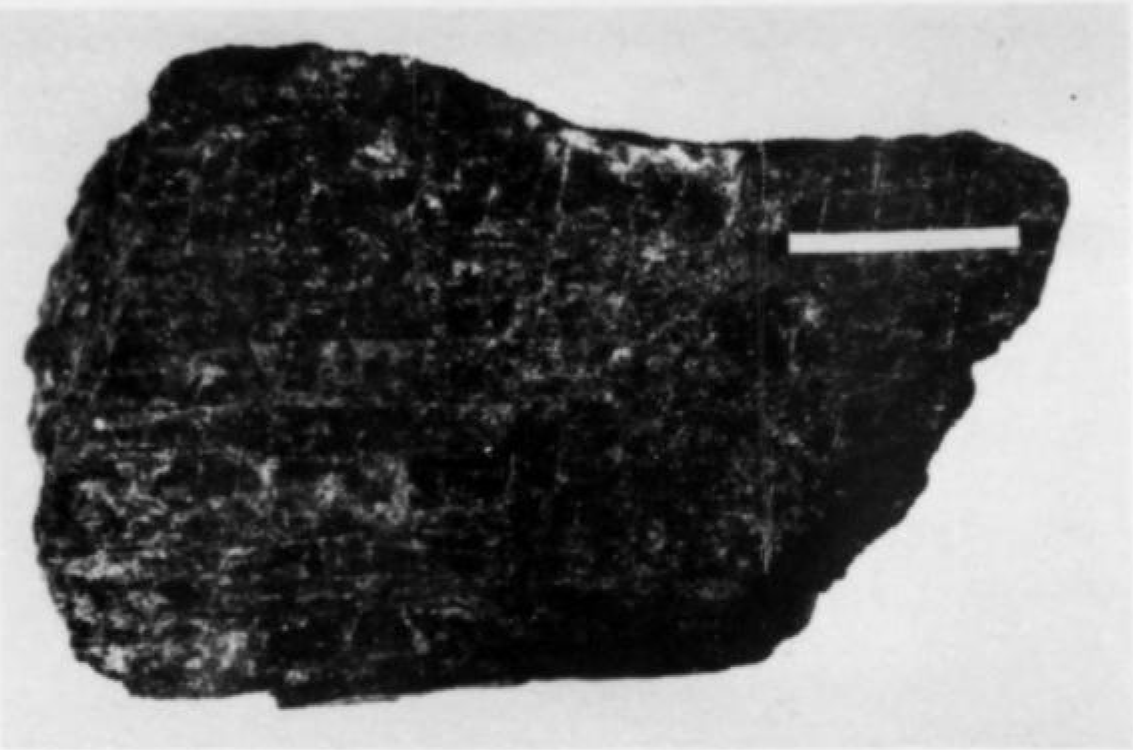


Figure 5. **Sarcopside exsolution blades in triphylite. The scale is 3 cm in length.**

Heterosite $(Fe^{3+},Mn^{3+})PO_4$

Heterosite forms large purple to red-brown masses with good cleavage and a black weathered crust. The ratio FeO/MnO is 37.92/12.00 percent. Massive heterosite may be easily carved and polished, the sarcopside exsolution giving a delicate network on the surfaces.

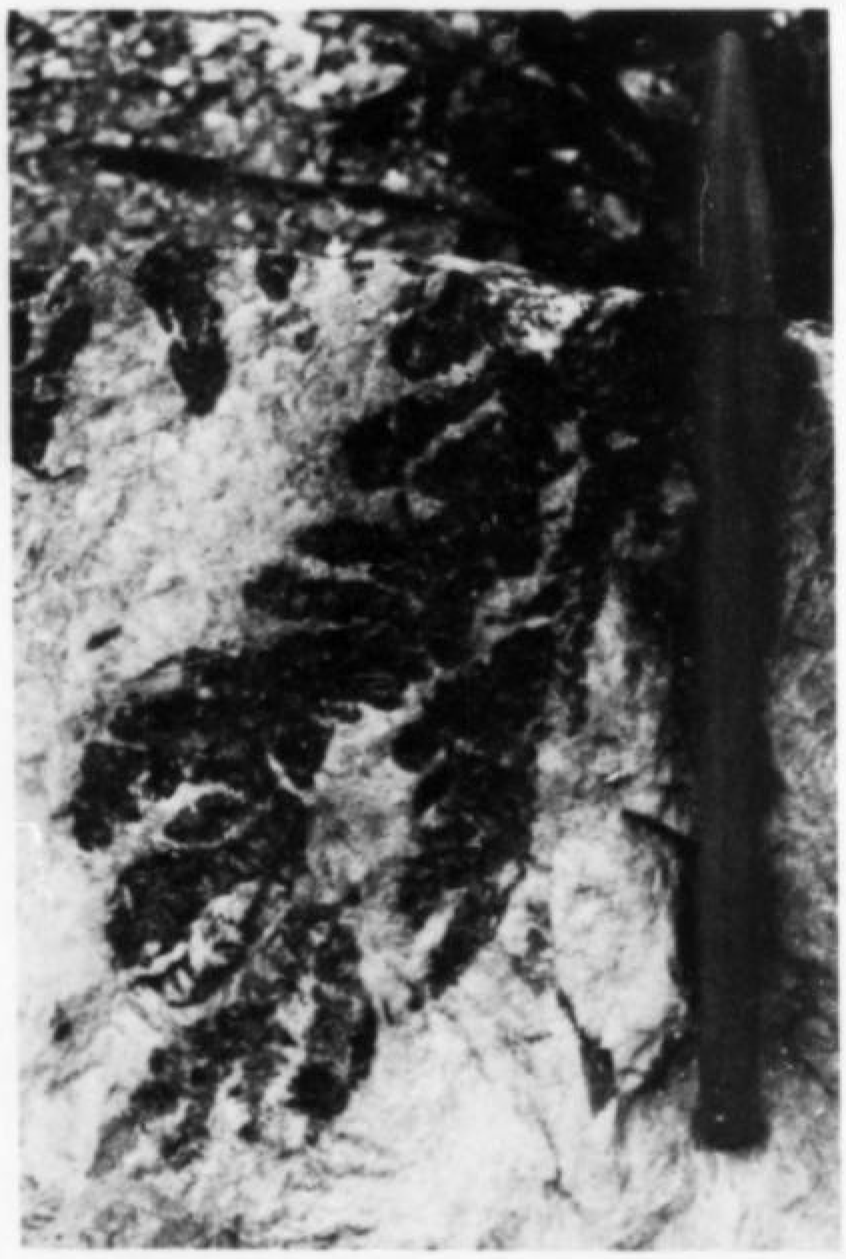


Figure 6. **A dendritic group of graftonite crystals in albite. Sample collected in the dumps. The ball-point pen is 14.7 cm in length.**

Graftonite $(Fe^{2+},Mn,Ca,Mg)_3(PO_4)_2$

Graftonite occurs as prismatic, rounded crystals intergrown with feldspar or in elongated multidecimetric groups. It is pink-beige to orange-yellow in color. The ratio FeO/MnO is 30.52/13.70 percent.

Wolfeite $(Fe^{2+},Mn)_2(OH)(PO_4)$

Wolfeite occurs in multicentrimetric orange-red to currant-red translucent nodules, looking like garnet but softer, scattered in triphylite. Chemical analysis shows 4.41 percent MgO and a ratio FeO/MnO of 34.46/7.98 percent.

Arrojadite $(K,Ba)(Na,Ca)_5(Fe^{2+},Mn,Mg)_{14}Al(PO_4)_{12}(OH,F)$

Rather common, arrojadite occurs in irregular or rounded patches reaching 10 cm in length in feldspar and triphylite. It is bottle-green with a shade of yellow, translucent, very cracked and with a conchoidal fracture. The ratio FeO/MnO is 28.15/13.74 percent.

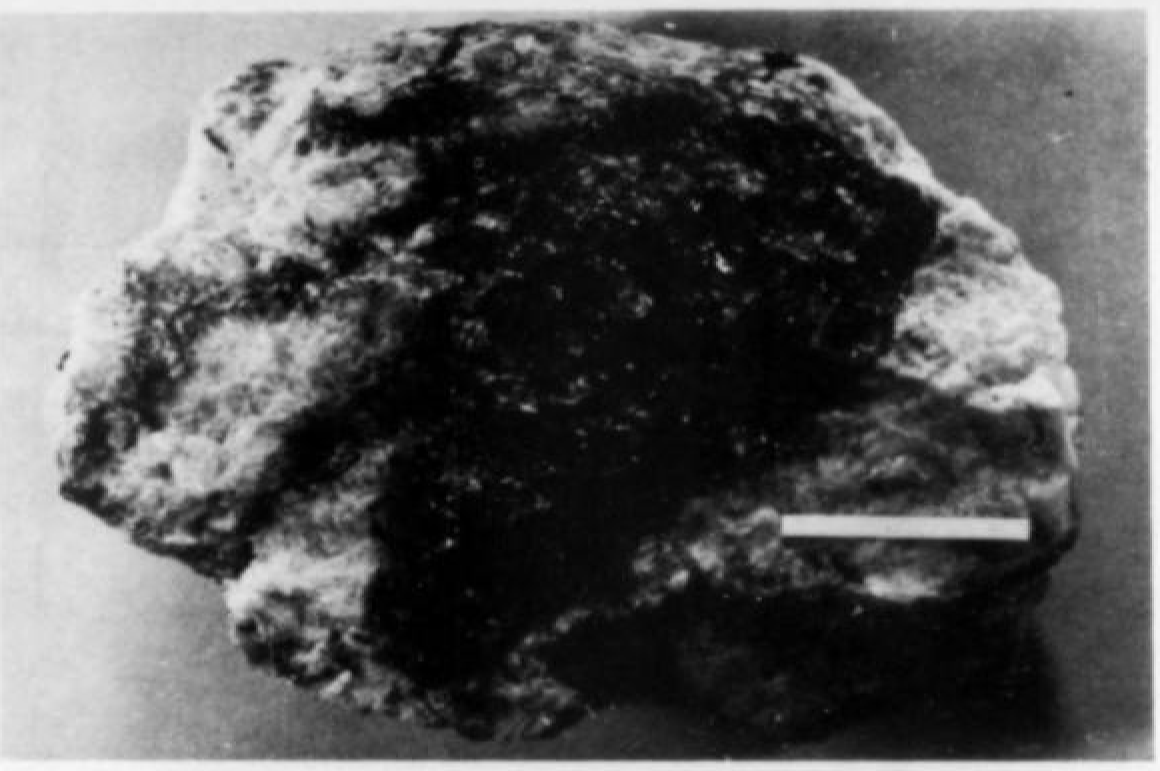


Figure 7. **A large arrojadite patch in feldspar. Scale is 3 cm in length.**

Beryllonite $NaBePO_4$

Beryllonite occurs as a white, porous multicentimetric microcrystalline wrapping around large, elongated, translucent beryl crystals. It is presently rather common in the mining face at the 250-m level and is sometimes associated with roscherite in greenish gray patches.

Alluaudite $(Na,Ca)_4Fe_4^{2+}(Mn,Fe^{2+},Fe^{3+},Mg)_8(PO_4)_{12}$

Rare, it occurs in dark green crystallized patches in triphylite. Its ratio Fe_2O_3/MnO is 24.67/23.73 percent.

Apatite group

Apatite belongs to two stages of crystallization. The first occurs as small centimetric, automorphic, blue prisms in massive and drusy albite. The second is spherulitic, beige, coating druses in albite and with small whiteite crystals scattered over its surface.

Amblygonite $(Li,Na)Al(PO_4)(F,OH)$

Amblygonite is white and saccharoidal in large masses in albite; or it occurs as well-formed crystals, lemon-yellow with a shade of green, translucent, rarely transparent. Reaching 6 cm in length, they are pyramid-like with stepped faces. The best samples are found, sometimes lightly coated by small pyrite crystals, in druses of albite near the quartz core. Amblygonite crystals are harder than common phosphates.

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

Vivianite is the most common alteration product and occurs crystallized around triphylite nodules and as blue stains in the adjacent minerals such as feldspar, quartz and triphylite.

The crystals, in alteration vugs of primary phosphates and druses, are multicentimetric, light bottle-green, transparent, and have contributed (with the ludlamite) to the recent fame of the Lavra do Énio. Mostly, after a light alteration, vivianite turns dark ultramarine-blue with prominent development of the cleavage which gives it a mica-like appearance. Good, multicentimetric, flat-shaped samples were easily collected in the dumps in recent years.

Finally, some magnificent, transparent, blue, small crystals may be seen in vugs. They are associated with childrenite, rockbridgeite, siderite and ludlamite and are very suitable for micromounting.

Ludlamite $(Fe^{2+},Mg,Mn)_3(PO_4)_2\cdot 4H_2O$

In well developed crsytals, it was the ludlamite that first called collectors' attention to the Lavra do Énio. Unaltered samples are apple-green, translucent to transparent, turning dull green after long exposure to air, with a truncated lozenge-shaped section, a good (001) cleavage and in length up to 1 cm. They occur in parallel aggregates or irregularly scattered around triphylite nodules. Frequently ludlamite crystals are coated by clusters of childrenite,

Figure 8. **A vivianite crystal, 4 cm in length, grown in a feldspar vug. Clusters above the crystal are childrenite.**

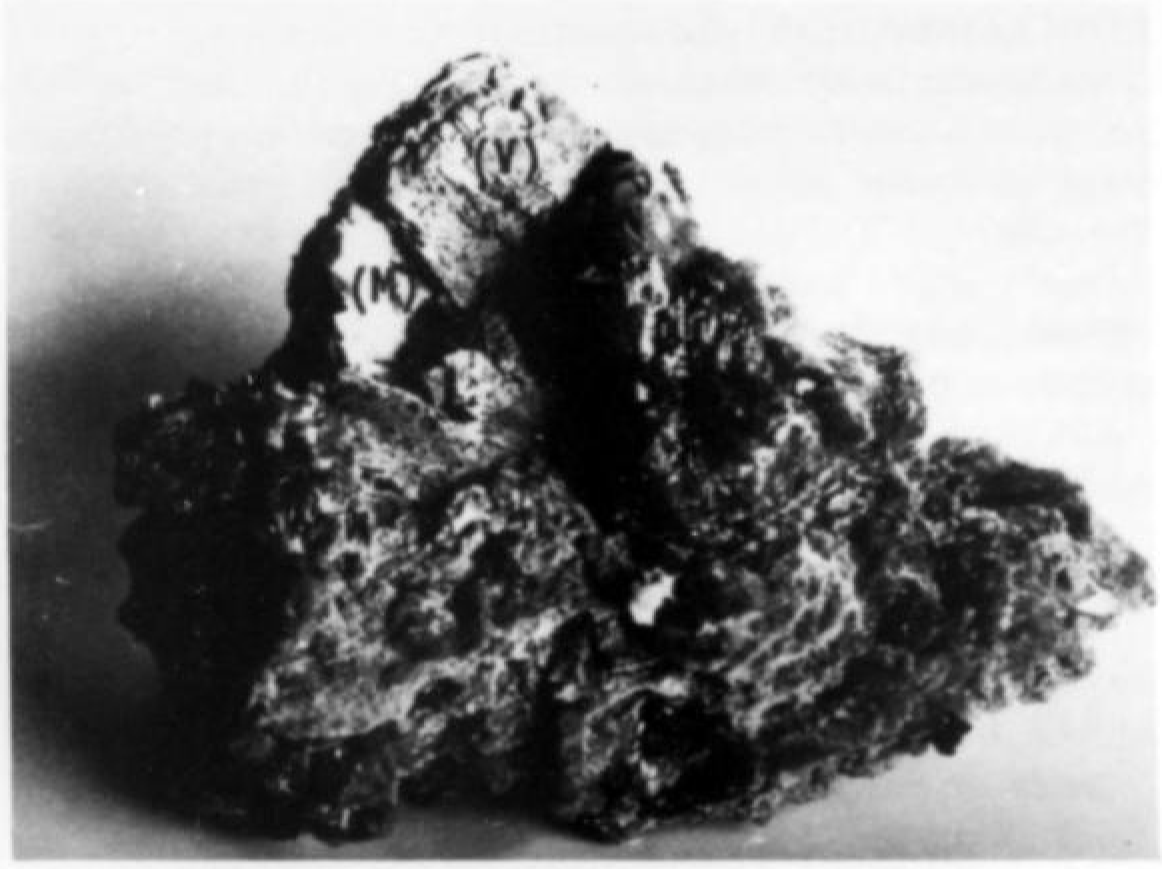


Figure 9. **A large group of small ludlamite crystals with vivianite blades (V), messelite (M) and veinlets of siderite. The sample is 10.5 cm in length.**

siderite needles, messelite crusts or completely covered by large vivianite crystals. Ludlamite makes very fine micromounts, thumbnail and cabinet specimens of high quality. It contains 50.73 percent FeO and traces of Mg, Ca and Mn.

Rockbridgeite $(\mathrm{Fe}^{2+},\mathrm{Mn})\mathrm{Fe}_4^{3+}(\mathrm{PO}_4)_3(\mathrm{OH})_5$

Rockbridgeite forms multimillimetric botryoidal coatings and globules with a radiating structure or exceptionally in needles in vugs mainly in feldspar, triphylite and siderite. Dark green, turning brown superficially, it gives excellent specimens from micromount to cabinet size. Its FeO/MnO ratio is 46.25/4.62 percent.

Childrenite $\mathrm{Fe}^{2+}\mathrm{Al}(\mathrm{PO}_4)(\mathrm{OH})\cdot\mathrm{H}_2\mathrm{O}$

It is in multimillimetric, radiating, waxy yellow globules in the outer alteration crust of triphylite blocks, or in needles. These, light orange in color and transparent, irregularly coat many cavities mainly in albite and arsenopyrite. Frequently growing upon roscherite or light blue tourmaline in cleavelandite vugs, childrenite gives excellent micromounts and thumbnail specimens. Its FeO/MnO ratio is 13.88/10.12 percent.

Phosphoferrite. $(\mathrm{Fe}^{2+},\mathrm{Mn})_3(\mathrm{PO}_4)_2\cdot 3\mathrm{H}_2\mathrm{O}$

Some dark green, very cracked crystals occur scattered in the outer alteration crust of triphylite. Its FeO/MnO ratio is 33.06/17.64 percent with traces of Ca and Mg.

Phosphosiderite $\mathrm{Fe}^{3+}\mathrm{PO}_4\cdot 2\mathrm{H}_2\mathrm{O}$

Phosphosiderite appears as small sky-blue to lavender patches in the outer alteration crust of triphylite with graftonite masses, always associated with other secondary products. Chemical analysis gives FeO/MnO = 37.67/0.79 percent.

Roscherite $\mathrm{Ca}(\mathrm{Al},\mathrm{Fe}^{2+},\mathrm{Mn})_3\mathrm{Be}_2(\mathrm{PO}_4)_3(\mathrm{OH})_3\cdot 2\mathrm{H}_2\mathrm{O}$ (?)

Beige to light green in color, roscherite is relatively abundant in millimetric botryoidal crusts and radiating clusters in the cleavelandite vugs, associated with sharp mica sheets and pale tourmaline. Frequently childrenite needles are perched on it. Roscherite gives excellent micromounts and cabinet specimens.

Figure 10. **A very large wrapping of white beryllonite, with a little massive roscherite, around a light, water-green, translucent, cracked beryl crystal. Matrix is albite with muscovite and some vivianite with limonitic veinlets. The sample is 27.5 cm in length.**

Herderite $\mathrm{CaBe}(\mathrm{PO}_4)\mathrm{F}$

Rare, it is in gray lustrous, sometimes translucent, porous, unattractive aggregates associated with beryllonite.

Saleeite $\mathrm{Mg}(\mathrm{UO}_2)_2(\mathrm{PO}_4)_2\cdot 10\mathrm{H}_2\mathrm{O}$

Relatively common, but in isolated, small, gold-yellow, translucent or waxy crystals, it is found mainly on rockbridgeite coatings. Some good micromounts may be recovered. Chemical analysis shows that calcium is lacking.

Phosphuranylite $\mathrm{Ca}(\mathrm{UO}_2)_3(\mathrm{PO}_4)_2(\mathrm{OH})_2\cdot 6\mathrm{H}_2\mathrm{O}$

It occurs as thin, cryptocrystalline, gold-yellow coatings on potassium feldspar and in its cavities. In some cases it has replaced uraninite.

Laueite $\mathrm{Mn}^{2+}\mathrm{Fe}_2^{3+}(\mathrm{PO}_4)_2(\mathrm{OH})_2\cdot 8\mathrm{H}_2\mathrm{O}$

Laueite forms small, yellow-orange, millimetric crystals rich in forms in vugs in limonite or partially altered rockbridgeite. Good micromounts may be recovered.

Cyrilovite $NaFe_3^{3+}(PO_4)_2(OH)_4 \cdot 2H_2O$

Rare, it occurs in small clusters and isolated orange crystals with dark terminations in vugs in altered rockbridgeite.

Messelite $Ca_2(Fe^{2+},Mn)(PO_4)_2 \cdot 2H_2O$

Messelite appears as a pearly, snow-white, microcrystalline crust on ludlamite, vivianite and/or siderite crystals or fills some vugs. Its FeO/MnO ratio is 11.79/1.94 percent with 35.25 percent CaO.

Tavorite $LiFe^{3+}(PO_4)(OH)$

Very rare, it occurs in small patches in altered triphylite, yellow with a shade of green.

Whiteite $Ca(Fe^{2+},Mn^{2+})Mg_2Al_2(PO_4)_4(OH)_2 \cdot 8H_2O$

Very rare, it occurs as beige 3 or 4 mm lozenge-shaped crystals perched on buff apatite in drusy albite.

Vashegyite (?) $Al_4(PO_4)_3(OH)_3 \cdot 13H_2O$ (?)

One very small sample of light to dark green minuscule needles upon rockbridgeite, in vugs, was doubtfully reported as this mineral.

3 — OTHER MINERALS

Quartz, very abundant, belongs to several stages of crystallization. The quartz core is milky, sometimes rose, massive, often releasing H_2S when broken. Quartz of the last stages is automorphic, sometimes twinned, clear, transparent and frequent in cleavelandite and arsenopyrite druses. Very good micromounts and thumbnail specimens may be recovered.

Feldspar. Potassium feldspar occurs in large flesh-pink masses without interest as does white albite which constitute the bulk of the pegmatite lens. Macroscopic polysynthetic twins are common. The best samples (micromounts and thumbnail size) come from druses reaching 10 cm in length scattered along the quartz core. They are coated by stepped or columnar, transparent to translucent, multicentimetric cleavelandite crystals associated with transparent, sometimes flattened, doubly terminated quartz crystals.

In these vugs in diminutive crystals, also occur: elongated muscovite crystals, clusters of roscherite, childrenite needles, blue opaque tourmaline prisms, light yellow amblygonite crystals, pyrite and galena in small well-developed crystals, all excellent for micromounting.

Muscovite. Industrial mica in large irregular books, without good crystallographic faces is not attractive. Sometimes it encloses flat black tourmaline crystals. Little, light yellow, translucent, elongated crystals are scattered on cleavelandite druses.

Beryl. Opaque, in large crystals for industrial uses, it varies from colorless to light blue with grey, buff and greenish colors. Some crystals reach 1.3 meters in length. They are always cone-shaped and surrounded by a fine grained mixture of albite and muscovite; they also occur coated by a thin film of beryllonite. Crystals are zoned, in some cases with the core more translucent, and longitudinally striated.

Gemmy blue aquamarine fragments are rare.

Tourmaline is black (ferriferous dravite) in unattractive, small crystals and veinlets scattered in the pegmatite, with the exception of some flattened, sometimes doubly terminated samples occurring between mica sheets. It is also found as translucent, light blue, cracked prisms coated by roscherite and/or childrenite in albite druses. Some needles of dark green tourmaline are enclosed in milky quartz.

Siderite is very abundant around triphylite masses and belongs to two stages of crystallization. The first is in multicentimetric masses with rhombohedral cleavage, beige in the inner part and brown surficially, with many hydrothermal vugs.

Siderite from the second stage occurs in needles and very sharp scalenohedrons in the vugs of the first stage. Yellow-orange, transparent to translucent, it gives excellent micromounts. It is sometimes associated with transparent quartz crystals, vivianite, childrenite and well-formed arsenopyrite crystals.

Illite, montmorillonite and kaolinite, alteration clay-minerals, are common as veinlets or in vugs of various minerals.

***Figure 11.* A zoned beryl on matrix (polysynthetic twinned albite, triphylite, siderite and vivianite). The beryl is 9.7 cm in length.**

CONCLUSION

Preliminary mineralogical study shows that the Lavra do Énio pegmatite is very rich in phosphate minerals and may provide very good specimens. It will probably become famous in future literature.

Note: The authors have no material to exchange or sell. All the specimens and photos from J. P. Cassedanne.

ACKNOWLEDGMENTS

Many thanks to our colleague R. V. Gaines who kindly revised the English manuscript.

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the Urubu Pegmatite

and vicinity

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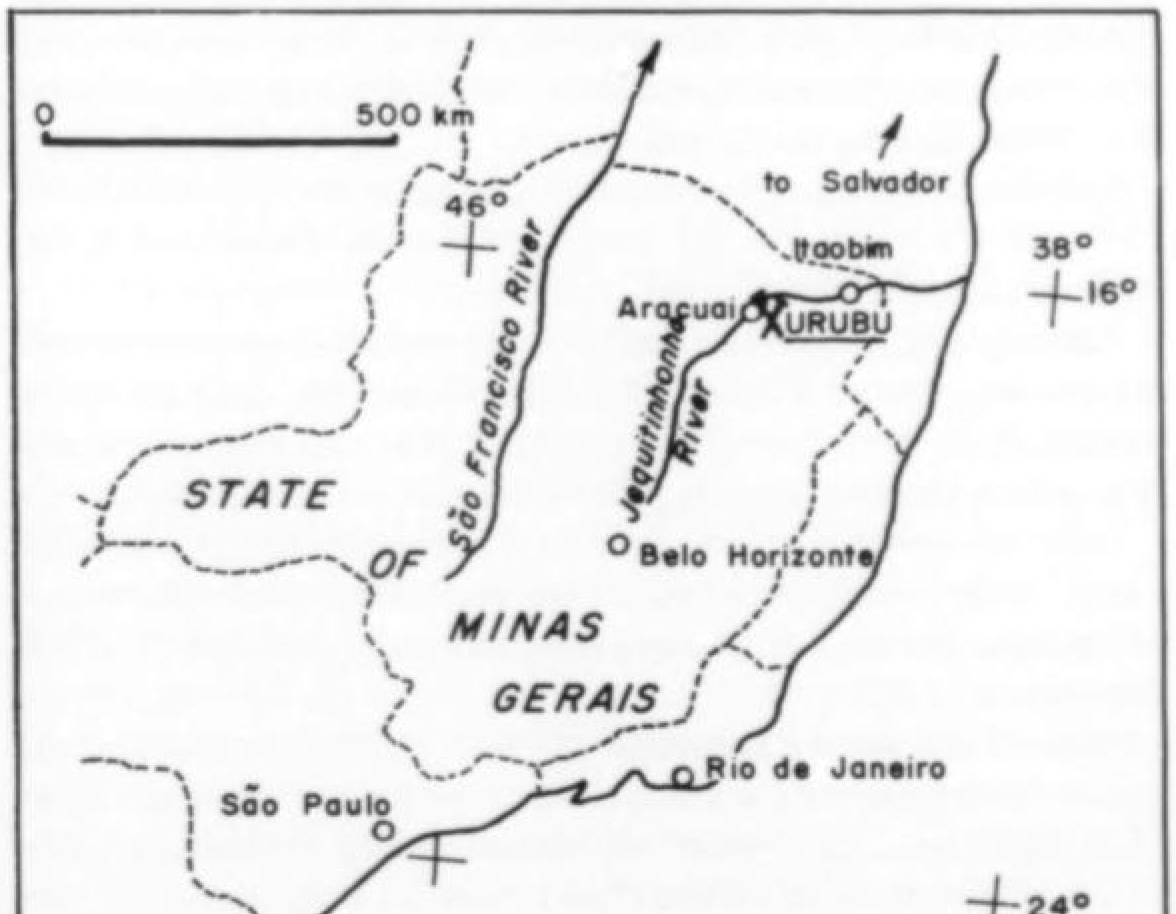
INTRODUCTION

Near the town of Araçuai, in the northern part of Minas Gerais, Brazil, exists a group of lithium pegmatite bodies that cross the Rio Piauí. It is economically well known as the principal Brazilian producer of petalite, spodumene, amblygonite and lepidolite for domestic consumption and exportation. From the mineralogical point of view it is also world famous, particularly because of crystallized phosphates and rose quartz from the Lavra da Ilha pegmatite (J. and J. Cassedanne, 1973) and other good mineral specimens, the exact origin of which is often unspecified, but which are well crystallized, such as amblygonite from Riacho Genipapo and gemmy petalite from several quarries. Finally it must be emphasized that, nearby to the west, there exists the satellite group of Virgem da Lapa pegmatites from which magnificent blue topaz and light purple herderite, among others, are world famous (J. and J. Cassedanne, 1976).

Among all these pegmatites, the one called Urubu ("carrion vulture") has produced for over 10 years lepidolite associated with other industrial minerals. Well crystallized pink and green elbaite in matrix, which may be easily collected here, has made this mine a classic locality for mineralogical and geological field trips. Thoreaulite was found here for the first time in Brazil.



LOCATION MAP

LOCATION AND ACCESS

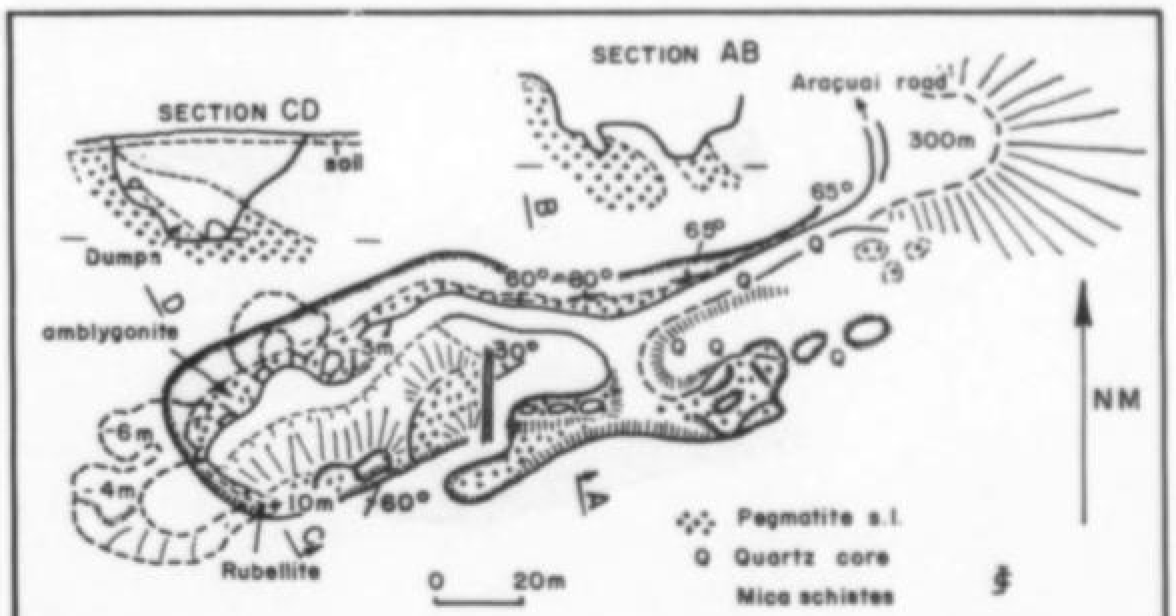
The Urubu pegmatite is located near the junction of the Piauí (a north-south tributary) and the Jequitinhonha Rivers, in the northern part of Minas Gerais state, east-southeast of Brasilia and north-northwest of Rio de Janeiro. Situated in Itinga township, it is in the neighborhood of Taquaral village, well known on account of the phosphates and crystallized rose quartz mined in a nearby pegmatite body.

Access is easy by way of Itaobim (kilometer 846.5, elevation 260 m) on the paved highway that joins Rio de Janeiro to Salvador. From Itaobim a good dirt road goes towards Diamantina by way of Araçuai, passing Itinga (30 km from the highway) and Taquaral (47 km from the same, elevation 270 m). At 3 km after Taquaral a good mining road belonging to Cia Arqueana de Mineração, owner of the property, forks to the left and serves several pegmatite quarries. The Urubu mine is the first of them, about 500 meters from the entry.

REGIONAL SETTING

The pegmatite zone is gently undulated with a low bush vegetation, dry several months of the year *(caatinga),* alternating with poor cultivated lands and scanty pastures. Some granite inselbergs dominate the country, which is semi-arid in spite of the fact that it is crossed by the perennial Jequitinhonha River. The scarcity of water explains why the population is concentrated in the valleys and near some small reservoirs.

Geologically the hills belong to the metamorphic basement and are covered in the south, disconformably, by reddish sandstone of Cenozoic age.



MAP OF THE URUBU PEGMATITE

Figure 1. **The Urubu pegmatite, view looking west-southwest. The rubellite concentration is concealed, in the photograph, by white dumps on the left. Gently dipping north contact between pegmatite and wallrock is visible above the entry slopes.**

The basement is essentially mica schists and gneiss, with quartzitic intercalations and mafic dikes. It is intruded by granitic cupolas from a main batholith, outcropping as rounded, steep elevations and "sugar-loafs," and by many pegmatites arranged in groups. The Urubu mine is located with several others known as the Rio Piauí group.

The wall rock of the pegmatites, 900–620 million years in age according to the Geological Map of Brazil (scale of 1/5,000,000), belongs to the São Francisco supergroup, and the Macaubas group (Pflug *et al.,* 1973). They were deposited as clastic sediments more than 2,000 m thick, in a geosyncline along the border of the Espinhaço Mountain range, after its consolidation about 1.000 m.y. ago. Subsequently 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).

De Almeida *et al.* (1976) proposed the name of Araçuai for the folded belt bordering the São Francisco craton to the southeast. It extends for more than 500 km and belongs to the Brazilian tectonic cycle (1,000–500 m.y. in age).

Many pegmatites occur in the Rio Piauí Valley and vicinity on the other side of the Jequitinhonha River. Geochemically they are characterized by a high lithium content.

In order to give a comparative idea of the importance of the pegmatite field, it must be noted that the Cia Arqueana de Mineração alone, owner of the Urubu pegmatite and chief mining company of the region, controls more than 200 pegmatite bodies. The company requires 5,000,000 tons of crude lithium ore from the often relatively small deposits, of which the principal one yields no more than 500,000 tons.

Several good roads and tracks serve the Rio Piauí properties. The main deposits are Maxixe, Manuel Teixeira, Chapadinha, Barreiro, Lavra da Cachoeira and Urubu. On the other side of the Jequitinhonha River another pegmatite field is known as Riacho Genipapo group (Lavra Velha, Mulundu, Genipapo . . .) near the Lavra da Ilha, previously described in the *Mineralogical Record.*

The more important minerals from these pegmatites are briefly noted below.

Lepidolite occurs fine grained or in large crystals in many pegmatites. Very good, well formed specimens, pseudohexagonal in form, dark pink in color and several kilograms in weight, are common from one pegmatite near to the Rio Piauí bridge (José da Silva prospect). Some cleavage fragments several centimeters thick, almost pure, show a rich carmine color when viewed in transmitted light.

Petalite is common in the Rio Piauí area and on the west side of the Jequitinhonha River. The Maxixe pegmatite is the most important, containing almost pure coarse grained masses of several hundred tons. The Lavra Velha in the Riacho Genipapo area is also as notable a producer as the upper Rio Piauí Valley.

The Lavra Velha pegmatite runs east-west and dips vertically. It is lens shaped, 50 x 15 meters, and mined about 20 m in depth for amblygonite and petalite. Located 1 km from the side of the Jequitinhonha River, it is a short distance upstream from the famous Lavra da Ilha deposit.

Pure, flawless, transparent fragments are scattered in the milky petalite and are actively sought by lapidaries. They reach up to 10 cm in length and several square centimeters in section. Many good specimens may be easily collected, mainly in the Maxixe and Lavra Velha pegmatites.

Spodumene is very abundant locally in some pegmatites, and also occurs disseminated through whole deposits. Milky to grayish green, it occurs frequently altered, in cracked, up to 1-meter crystals (Urubu, Lavra Velha, Chapadinha). Only massive specimens may be collected, sometimes translucent (Lavra da Cachoeira, Maxixe), very rarely transparent.

Sulfides. A little arsenopyrite and sphalerite are associated in the Lavra da Cachoeira on the border of the Rio Piauí, and in the Mulundu pegmatite.

Amblygonite occurs as milky saccharoidal, partially altered masses or, more rarely, in crystals. These are grayish white, elongated, to more than 20 cm in length (Lavra Velha) or translucent with a greenish gray to yellowish color (Lavra da Ilha).

Other phosphates are uncommon and scarcely appear as in the Lavra Velha (triphylite and vivianite). The rich phosphate paragenesis of Lavra da Ilha has been previously reported (J. and J. Cassedanne, 1973).

Mica. Very good specimens of light yellow to translucent, lithium-poor muscovite are abundant in the Riacho Genipapo area. They form large aggregates of lozenge-shaped crystals or platy groups of five-twinned blades ("star mica").

Quartz. Some transparent, terminated quartz crystals occur scattered on samples that vary from micromount to large cabinet size. Their base is always feldspar.

Pollucite. Recently discovered here (José *et al.,* 1976), it occurs in an east-west, vertically dipping pegmatite, 4–5 meters thick, that was mined to 25 m in length and 10 in depth. Irregular fine grained, creamy, multidecimetric lenses of pollucite are scattered in quartz and feldspar. Some amblygonite and light-colored kunzite was also recovered. The mine, known as Lavra do Zé Mario (or Mauro), 3 km north of the Igrejinha village near an elevation of 500 m, is abandoned but good massive specimens are easily collected.

DESCRIPTION OF THE URUBU PEGMATITE

With a general strike east-northeast and a gentle north-northwest dip, the Urubu pegmatite is granitic, heterogenous and albitized. It is divided into two lenses in its eastern part by a mica schist intercalation. Its thickness seems to be about 10–15 m. Wallrock is a dark gray biotite schist with quartz beds. The contact between the two rocks, very undulating, is always sharp and dips more at the south than at the north contact, where offsets are frequent. Everywhere the contact zone is visible, it is marked by an increase of small black tourmaline needles which locally transform the schist into tourmalinite (south of the quarry entry).

The unsystematic workings, made by quarrying with a mechanized *garimpo* method, do not permit mapping the mineralogical zones in any detail due to large areas covered by waste. A recent partial stripping operation has temporarily masked part of the pegmatite. The floor of the present quarry is at an elevation of about 300 m.

We will roughly delimit below the mineralogical zones as they sporadically appeared during former visits to the deposit. A description of the main obtainable minerals follows in the next section.

Near the quarry entry, light apple-green elbaite crystals (diameter 1-3 cm, length 10–20 cm), singly terminated, were common in both borders of the quartz core in which they partially penetrated. Below the core to the south, a large, fine grained pink lepidolite concentration, almost pure, was mined out leaving a small irregular pit. Some translucent pink elbaite prisms were scattered in the lepidolite with small quartz crystals and a few cleavelandite blades.

Beyond a waste-covered zone small winzes were sunk below the mica schist intercalation, to mine amblygonite associated with quartz and feldspar. Mica in large books is common near the contact with the schist roof. A north-south fault limits this zone to the west where thick dumps were deposited.

Farther to the west, a 10-meter-deep shaft near the vertical contact zone tapped cassiterite disseminated in a feldspathic mass with a little quartz and muscovite and large, altered spodumene crystals. The south corner of the quarry is in a mass of fine grained lepidolite with translucent rubellite and achroite needles which reach 60 cm in length. Kaolinized feldspar with lamellar quartz, a little petalite and large prisms of quartz up to 1 meter near the adit entries irregularly surround this lepidolite.

In the northwest corner of the quarry, the feldspar mass above the quartz core has been mined in several stopes. Amblygonite is abundant there and industrial beryl scarce. Rare aquamarine and gemmy tourmalines were extracted in potassium feldspar and albite, where large, milky, double terminated or step-faced quartz crystals are abundant.

Lepidolite was the first actively mined economic mineral. Afterwards workings were substantially reduced and concentrated in the western part of the deposit, mainly on amblygonite. Presently, in the east, the stripping operation explores albite below the quartz core.

Foreman of the quarry is the friendly Senhor Ulício ("Ulysses") who always cooperates with any mineralogical investigations.

MINERALS FROM THE URUBU PEGMATITE

Quartz. Very abundant, it is either in huge milky crystals reaching up 1.0 m in length or in doubly terminated, milky, smaller prisms, parallel axis aggregates or step-faced ("cathedral" faces) groups. Large regular specimens are easy to collect. Transparent or translucent small prisms, singly or doubly terminated, are scattered in the feldspar to the south of the entry to the quarry.

It is noteworthy that milky quartz, crystallized or massive from the core, releases much H_2S when broken.

Feldspars. Potassium feldspar, light flesh* in color and massive, is without special mineralogical interest as is the albite. This latter, one of the principal components of the pegmatite body, rarely presents druses coated by small blades (cleavelandite). Good samples are not common.

Muscovite is very abundant locally near the quartz core, in books reaching up 2 decimeters or in twinned sheets ("fish tail" mica). Well formed crystals are rare.

Lepidolite. Pink to light purple, very abundant, it is always fine grained without single large crystals. Specimens enclosing rubellite needles are very decorative.

Elbaite from the Urubu pegmatite is very characteristic. It is bottle-green with a shade of yellow to apple-green and shows a darker color near the pedion that always terminates the prisms. These may reach up to 20 cm in length. Their core is of rubellite or dark pink lepidolite, very attractive, near the entry of the quarry, where the tourmaline grown on the border of the inner feldspar zone is imbedded in the milky quartz of the core. Good samples of large cabinet size with translucent crystals may be easily collected, however they are relatively brittle, probably on account of blasting.

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*Untanned Caucasian flesh, that is. Ed.

Figure 2. **Apple-green translucent elbaite prisms in a contact zone between feldspar and the quartz core, near the access road, east portion of the quarry.**

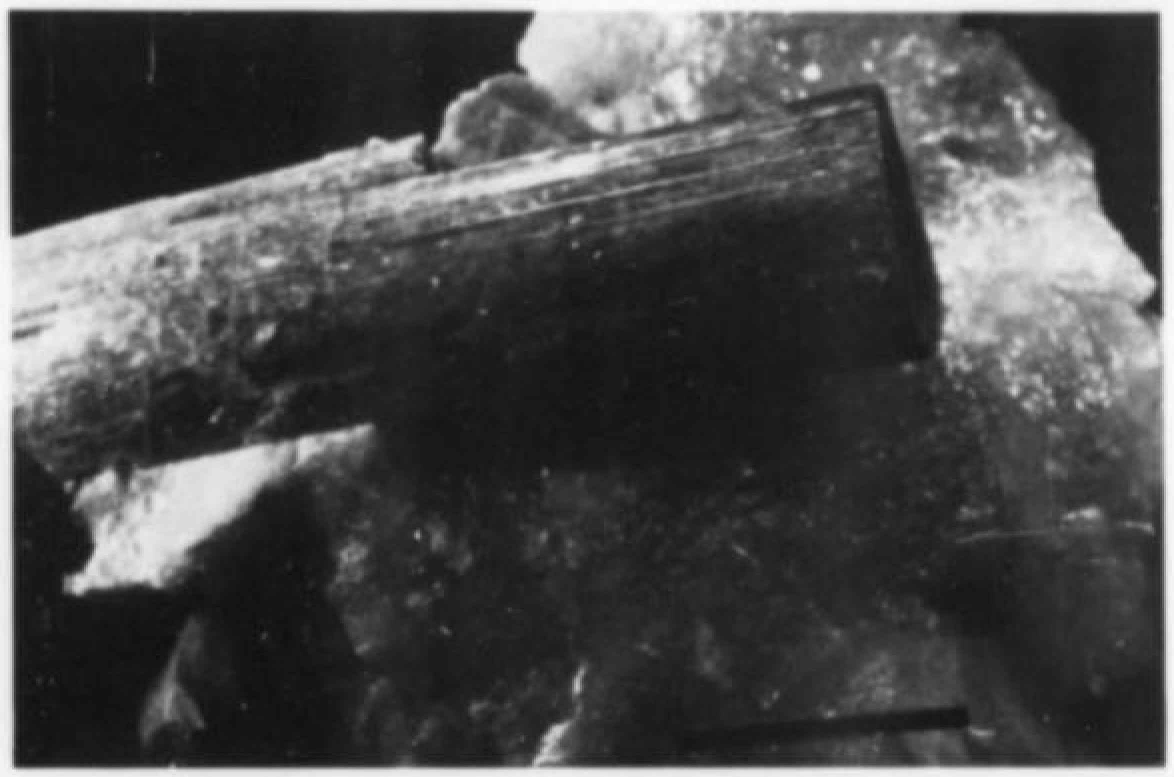

Figure 3. **Sample of apple-green elbaite, a pedion-terminated crystal in milky quartz matrix. Scale is 3 cm in length.**

Figure 5. **Rubellite in quartz. Sample from the dumps. Black scale is 3 cm in length.**

Figure 4. **Large rubellite needles in fine grained lepidolite, southwest portion of the quarry. The rock pick is for scale.**

Figure 6. **A group of milky terminated quartz crystals in the dumps.**

Figure 7. **A thoreaulite crystal fragment, 32 mm in length.**

Figure 8. **A group of "star mica" from Riacho Genipapo. Sample is 17 cm in length.**

In the west end of the quarry the elbaite (rubellite) is always translucent, in isolated prisms several cm in diameter, irregularly scattered in the fine grained lepidolite or in huge, compact clusters and fans reaching up to 1 meter in diameter. Samples are very abundant and easy to collect, but this material is only suitable for decoration or slab polishing, being spectacular but of poor gemmological quality.

Some green and rare pink gem elbaites are found in the northwest end of the open pit where achroite prisms more than 3 decimeters in length may also be collected. Achroite is generally milky and opaque, rarely translucent.

Petalite is in irregular concentrations scattered in the feldspar in the west end of the quarry. Petalite is milky, with a good cleavage and of industrial quality. Large samples are common, but no gemmy fragments are known from this mine.

Amblygonite is very abundant, milky to light gray or beige, frequently slightly altered, and is scattered in masses of more than 100 kg in the feldspar. Opaque, it is of industrial quality. Crystals seem very rare.

Beryl is concentrated in the northwest corner of the mine in small, cracked, grayish white to light blue crystals of industrial quality. Rare aquamarine fragments are also sporadically recovered in the same zone.

It is noteworthy that a berylometer survey showed in all the pegmatite a small amount of beryl, perhaps as disseminated microscopic crystals or as other mineral species (Cassedanne, 1969).

Cassiterite is scattered in small patches and multicentimetric aggregates in the feldspar. Crystals are rare but well formed.

Columbotantalite occurs similarly to cassiterite, mainly in the northwest portion of the quarry.

Thoreaulite. A sample, waxy yellow to bright on the fracture, the first found in Brazil, was found in this pegmatite. Its density is 6.94 ± 0.01. It is presently under investigation and shows one good and one medium cleavage. $Ta_2O_5 : Nb_2O_5 = 60 : 40$ (D. Appelman, personal communication).

Xenotime occurs as rare, multicentimetric, light gray, rounded patches in feldspar, sometimes associated with muscovite.

Monazite. Rare, it is scattered in small dots in the albite.

Spodumene was not recorded previously because it is always altered and of no mineralogical interest here.

CONCLUSION

The Urubu pegmatite is mainly rich in translucent elbaite and milky and transparent quartz from which many good samples may be easily recovered. In the neighborhood some other fine minerals may also be collected.

Note: All specimens and photographs by J. P. Cassedanne. Authors have no material to exchange or sell.

ACKNOWLEDGMENTS

Many thanks to our colleague R. V. Gaines who very kindly revised the English manuscript.

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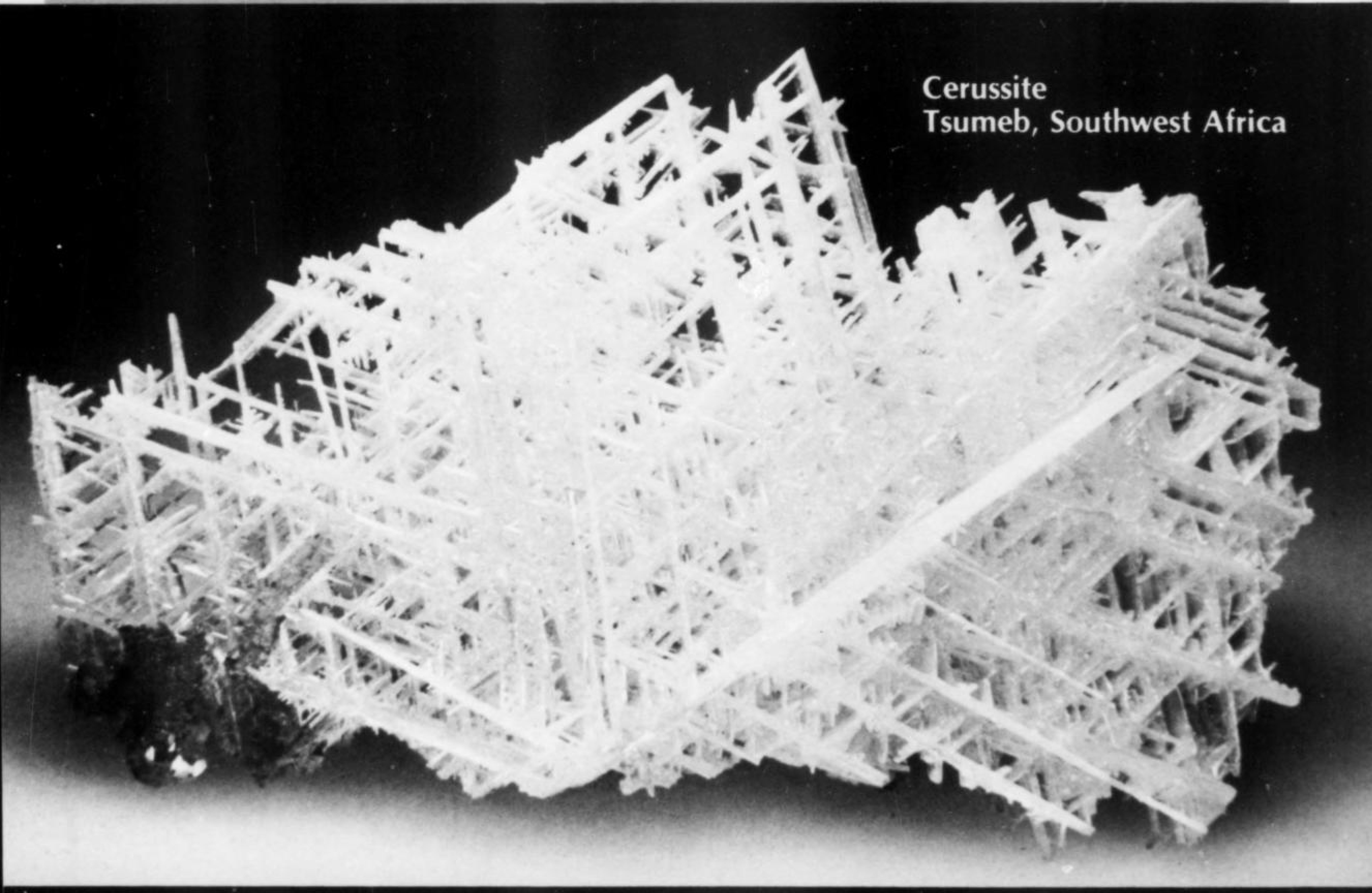
Mineral Kingdom

Miriam & Julius Zweibel



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Water-Clear Barite
from Muddy Creek, Colorado

by **Henry A. Truebe**
P.O. Box 227
Crested Butte, Colorado 81224

Barite was found, and forgotten, by early prospectors in the headwaters of the East Fork of the San Juan River, in south-central Colorado. More recently, it was noted during a geologic mapping program in 1978 and 1979. The locality and the barite deserve description.

Muddy Creek is an informally named tributary running east from Crater Creek, a fork of the East Fork of the San Juan River. These creeks and the river cut deep valleys into volcanic rocks of intermediate composition, which make up this part of the San Juan Mountains. A fault-controlled trend of brecciation, silicification, and barite mineralization extends east-west along the hillside northwest of Muddy Creek and north of Crater Creek. These relationships are summarized in Figure 1, derived from the Elwood Pass quadrangle (U.S. Geological Survey, 1966).

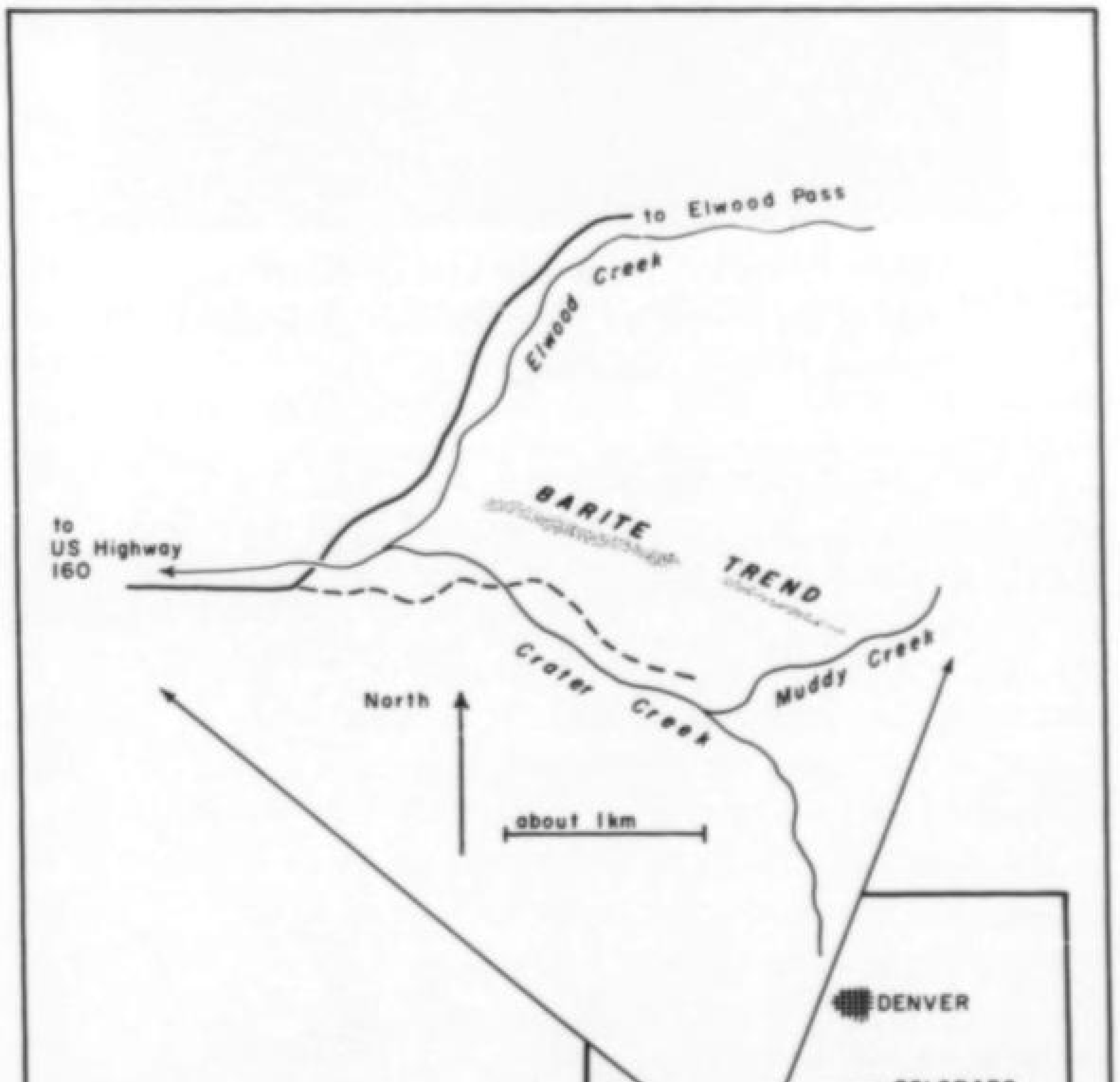

Figure 1. **General geography, and location of the Muddy Creek locality in western Colorado. (All photos and illustrations by the author.)**

MINERALOGY

The barite displays two distinct habits which can be correlated with its position along the barite trend. In the western part of the trend, barite is found in vugs or pods, 10 to 50 cm in diameter, in a silicified, brecciated fault zone. The barite lines the walls of the pods, and is attached to breccia fragments within the openings. The crystals are relatively large (3 to 7 cm), translucent, and of simple morphology. On the eastern end of the trend, the crystals are small (averaging about 1 cm), water-clear, and of complex morphology. Some small, white plates of barite are associated with base-metal mineralization along Crater Creek.

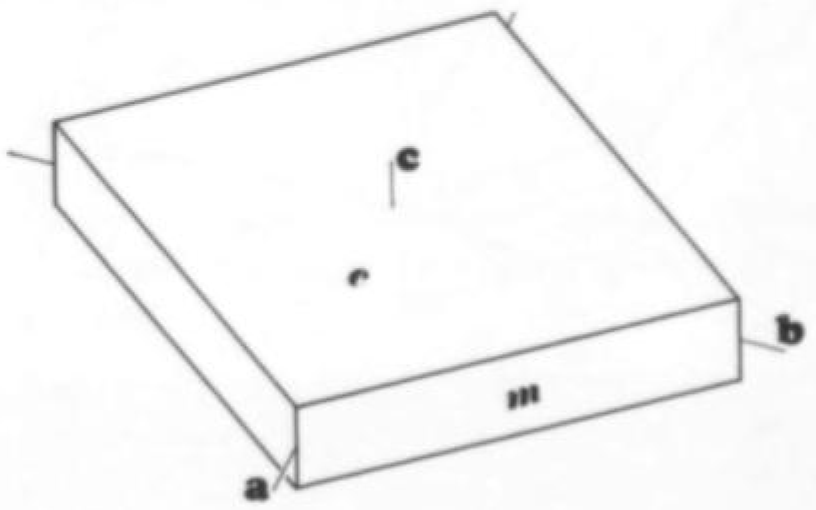

Figure 2. **Morphology of a typical barite crystal from the west end of the Barite trend.** ***c*** **= {001}, and** ***m*** **= {210}.**

Figure 3. **Barite in breccia, from the west end of the barite trend. Specimen is 10 cm wide across the top; Smithsonian specimen.**

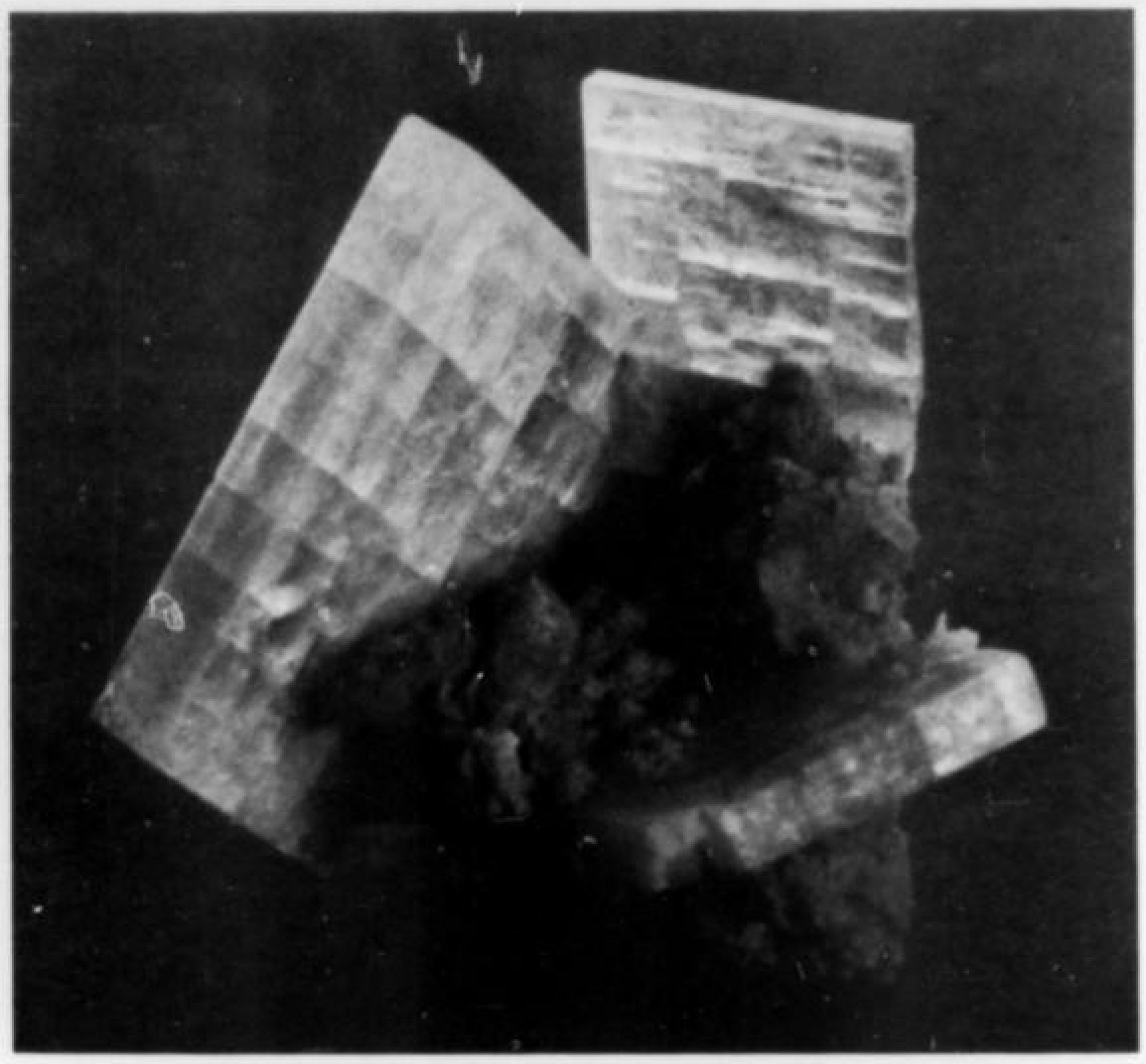

Figure 4. **Barite, from west end of trend. Large crystal is 3 cm on edge; Denver Museum of Natural History specimen.**

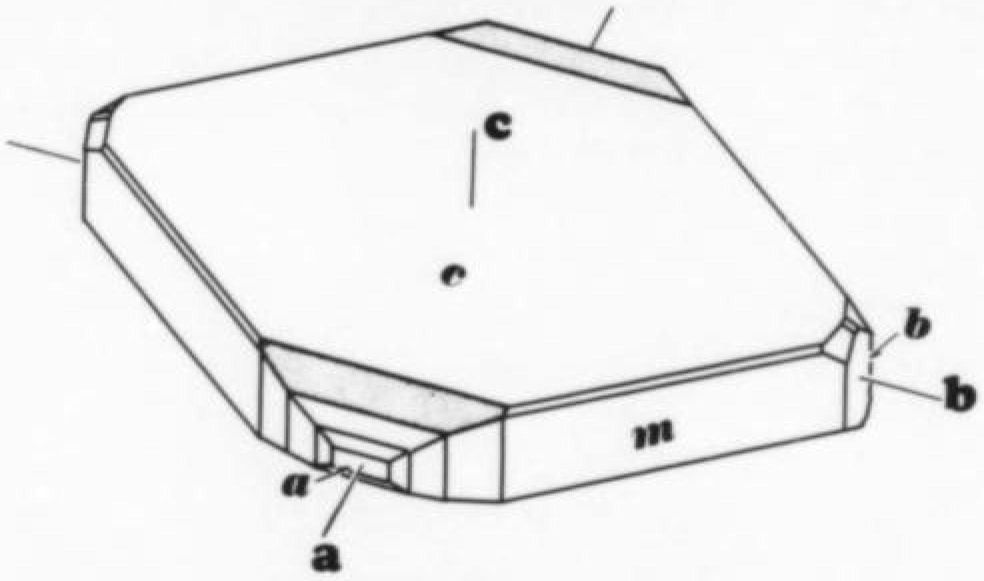

Figure 5. **Morphology of a typical barite crystal from the east end of the barite trend.** c **=** **{001},** m **= {210},** a **= {100}, and** b **= {010}.**

The only other species noted were microscopic, drusy quartz, which predates the barite, and late coatings of hydrous iron oxides.

Barite from the west end of the trend

One of the larger crystals from the west end of the barite trend measures 5 by 8 by 2 cm. The color of the crystals is light gray, with suggestions of blue near the centers of the crystals. All the material collected had been naturally exposed to sunlight for an indeterminate period of time, and perhaps the original color of the barite was blue, throughout. The barite fluoresces pale yellow (in shortwave and longwave ultraviolet light) in zones roughly surrounding the three crystal axes or diameter lines. One specimen shows a distinct whitening of the {210} faces, probably as a result of weathering. The morphology is sharply defined and crystals show only two forms: {001} and {210}. The shape of crystals from the west end of the trend is shown in Figures 2, 3 and 4.

Barite from the east end of the trend

The crystals from the eastern end of the barite trend are colorless, and completely transparent, except where cleaved or fractured internally. Their reaction to ultraviolet light is the same as the barite from the west end. The form of these crystals is most interesting.

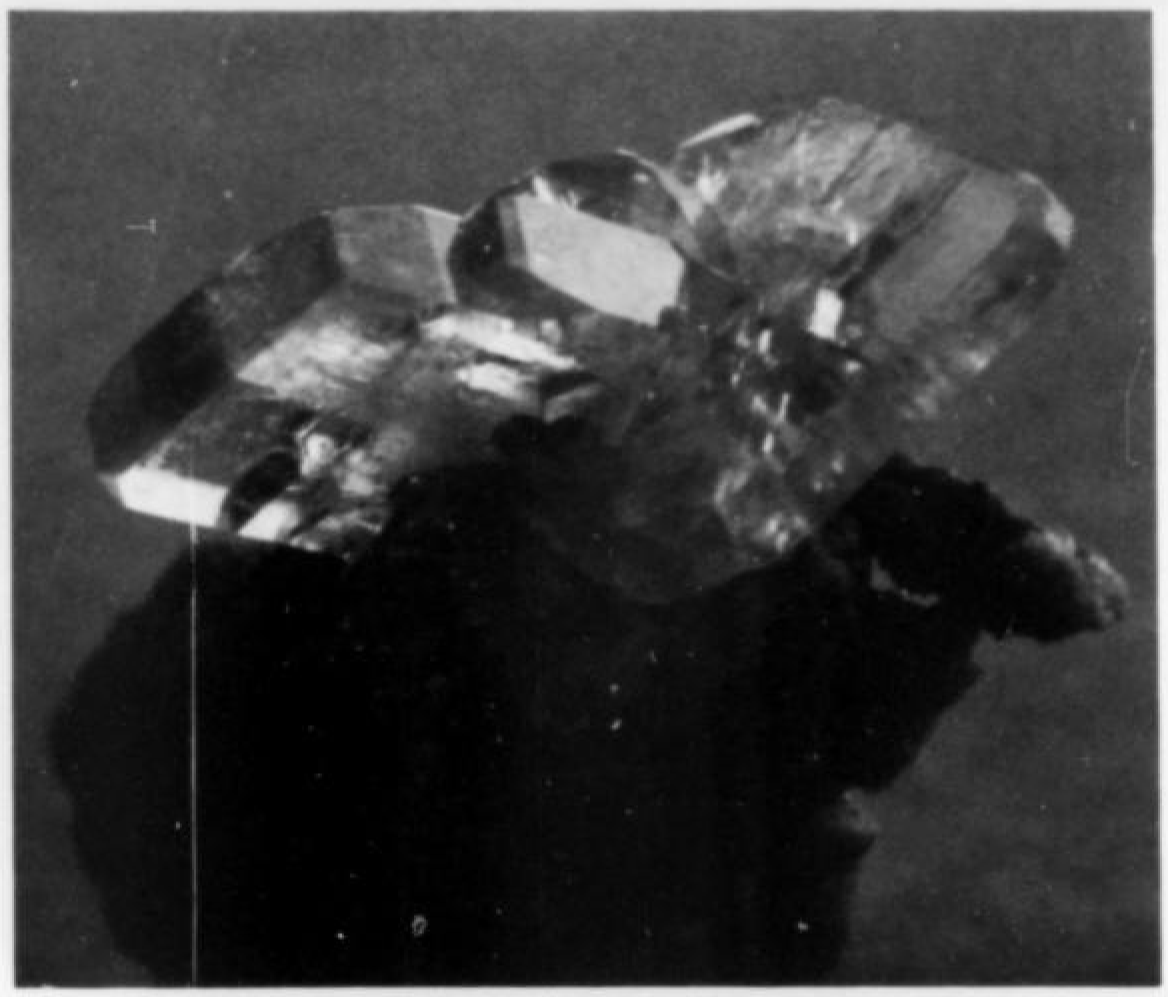

Figure 6. **Barite from east end of trend. Large crystal is 1.5 cm on edge; Truebe collection.**

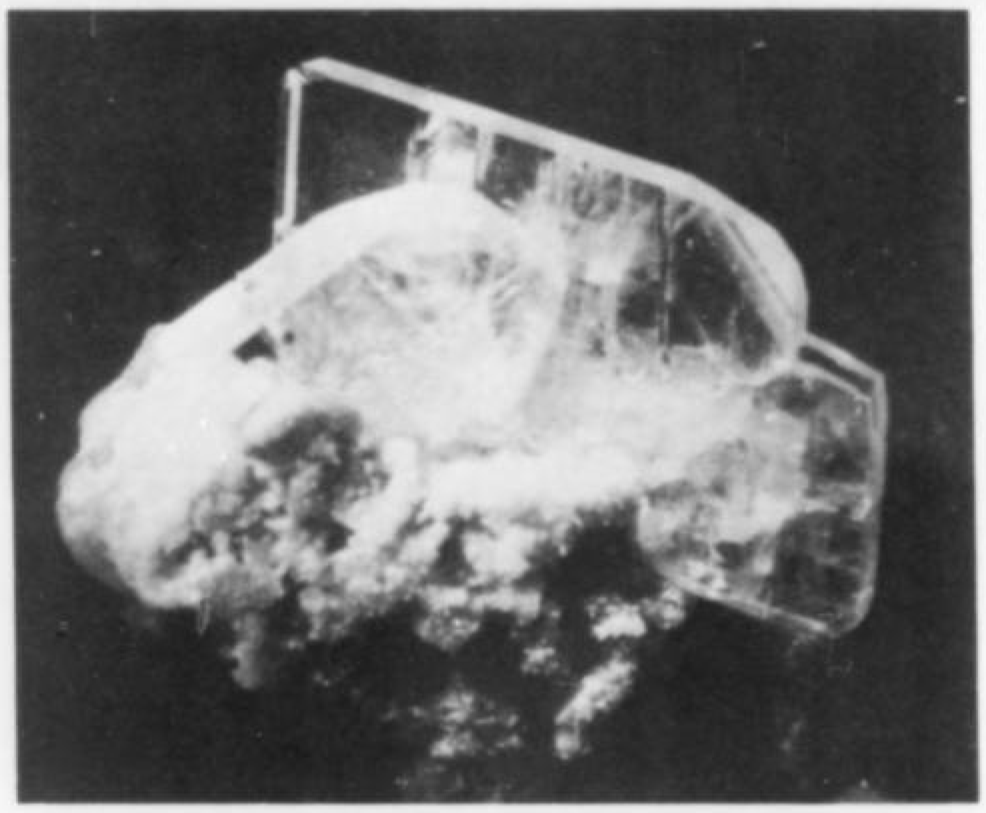

Figure 7. **Barite, from east end of trend. Top edge of the crystal is 1.5 cm; Denver Museum of Natural History collection.**

As with barite from the west end, the {001} and {210} forms predominate, but they have been modified by 11 other forms. The crystal morphology is sketched in Figure 5, and shown in the photos in Figures 6 and 7. The recognizable forms are labeled on the figure. Other forms are not labeled since I had no way of measuring the interfacial angles. It is worthwhile to compare Figures 2 and 5 with the illustrations in Palache *et al.* (1951, page 409). The {102} (?) faces on some crystals show a slight etching.

The remarkable clarity of the crystals facilitates the study of inclusions and phantoms. The phantoms suggest at least five growth pulses and a number of minor fluctuations in the solutions responsible for the deposition of the barite. Two of the pulses were major, resulting in the inclusion of debris and rare, minute pyrite (?) crystals at the phantom interface. Changes in the morphology of the crystals through time are indicated, but the phantoms are too vague to allow description of the changes.

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The Secondary Tungsten Minerals, a *Review*

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INTRODUCTION

The secondary tungsten minerals form a group of species with no crystallographic interrelationship. The species have crystallized mostly, if not always, at the expense of primary tungsten minerals such as scheelite. They are usually not considered products of atmospheric weathering but rather of hydrothermal or supergene alteration. The minerals occur as fine-grained to powdery masses with a white or yellowish color. Crystals suitable for micromounting are rare. The small grain size makes most of these species mineralogically difficult to characterize. This paper presents a review of the following species: anthoinite, mpororoite, ferritungstite, alumotungstite, hydrotungstite, tungstite, yttrotungstite and cerotungstite.

THE CENTRAL AFRICAN TUNGSTEN PROVINCE

This remarkable province with its numerous deposits extends from southwestern Uganda (Kigezi district) and Rwanda to eastern Zaire (Maniema and Kivu districts). The Fe-rich members of the ferberite-huebnerite series constitute virtually the sole economic source of tungsten (Pargeter, 1956; Varlamoff, 1958; de Magnée and Aderca, 1960; Corin and Snel, 1962). According to local miners' usage, two minerals of this series can be distinguished in the field. Wolframite, simply called *wolfram,* occurs in black crystals of uniform orientation recognizable by their large, shiny cleavage planes. The crystals are fresh, without traces of alteration. On the other hand, ferberite forms fine-grained masses of a dull-black color without visible cleavage. These two species simply reflect different generations.

The dull-black ferberite is an example of *reinite.* The name reinite applies to a variety of polycrystalline ferberite which is pseudomorphic after scheelite, the Ca of scheelite replaced by Fe. Such reinite masses, known from a number of localities throughout the world, commonly display the tetragonal crystal form of scheelite. In central Africa, tetragonally shaped reinite pseudomorphs (Fig. 1) are common and range up to 15 or 20 cm in length. On breaking a reinite crystal the inside is seen to consist largely of a yellow to white, fine-grained to cryptocrystalline mass referred to here by the mineralogically ill-definable name *tungstic ocher* (Fig. 2). The ocher material is enclosed in a margin of black ferberite which also penetrates the core in thin veinlets. In some pseudomorphs the ocher has been leached away leaving behind a porous honeycomb network of ferberite.

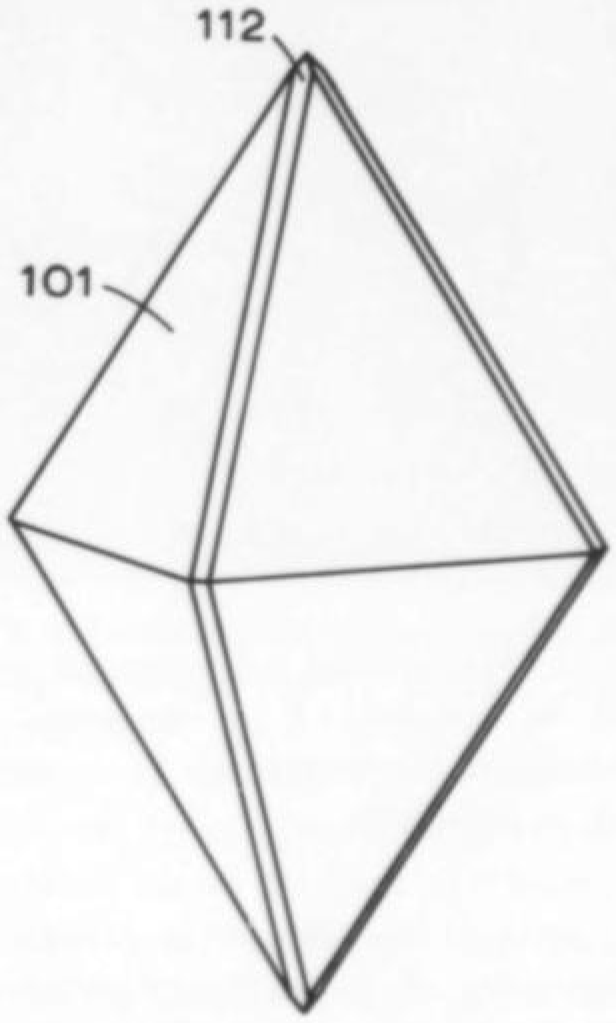

Figure 1. **Crystal habit of central African ferberite *(reinite),* pseudomorphic after scheelite.**

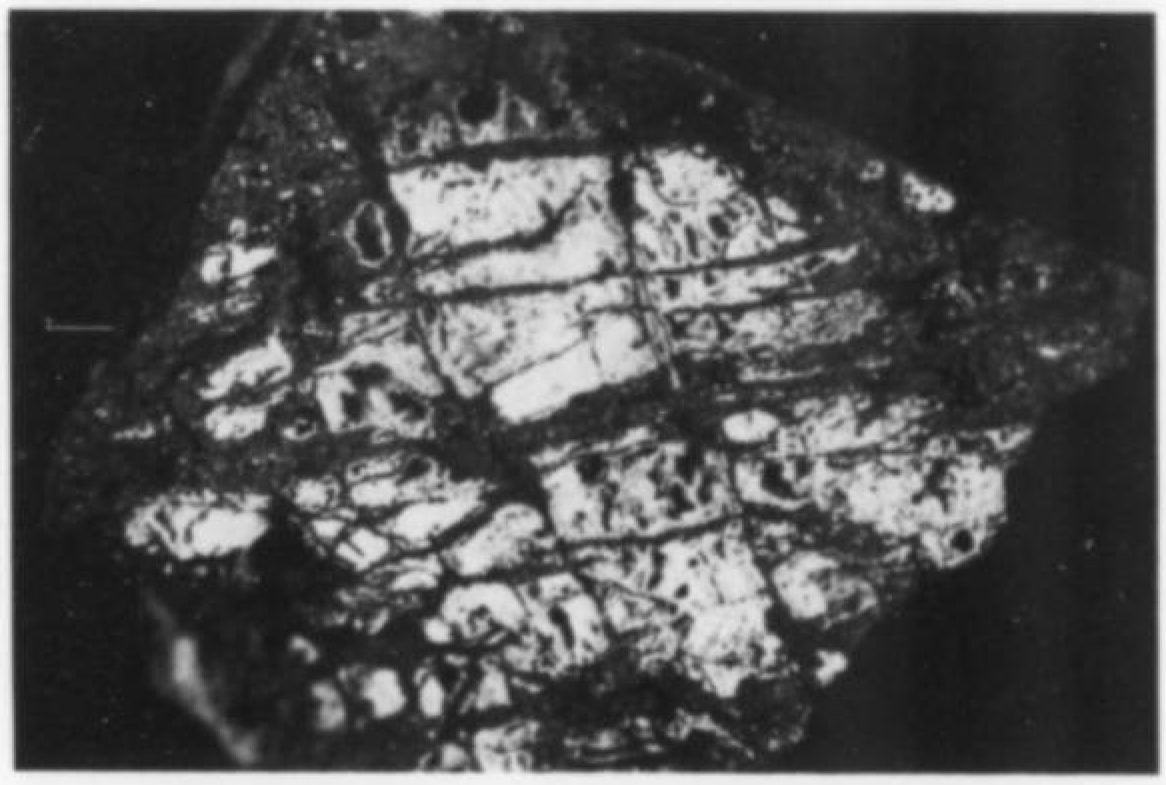

Figure 2. **Broken reinite pseudomorph showing black ferberite and yellow tungstic ocher. Nyamulilo mine, Kigezi, Uganda. Specimen size: 2.5 cm.**

The tungstic ocher is mineralogically complex and consists of a number of secondary tungsten minerals. The occurrence of these minerals in a cavity, as is commonly found under the microscope (polished section, reflected light), is schematically illustrated in Fig. 3. The equidimensional grains of the ferberite mosaic (F) become elongated in the vicinity of the cavity with the long axis perpendicular to the cavity wall. The ferberite crystals which grew on the wall against the tungstic ocher are beautifully euhedral with somewhat varying habit. An example is illustrated in Fig. 4. The

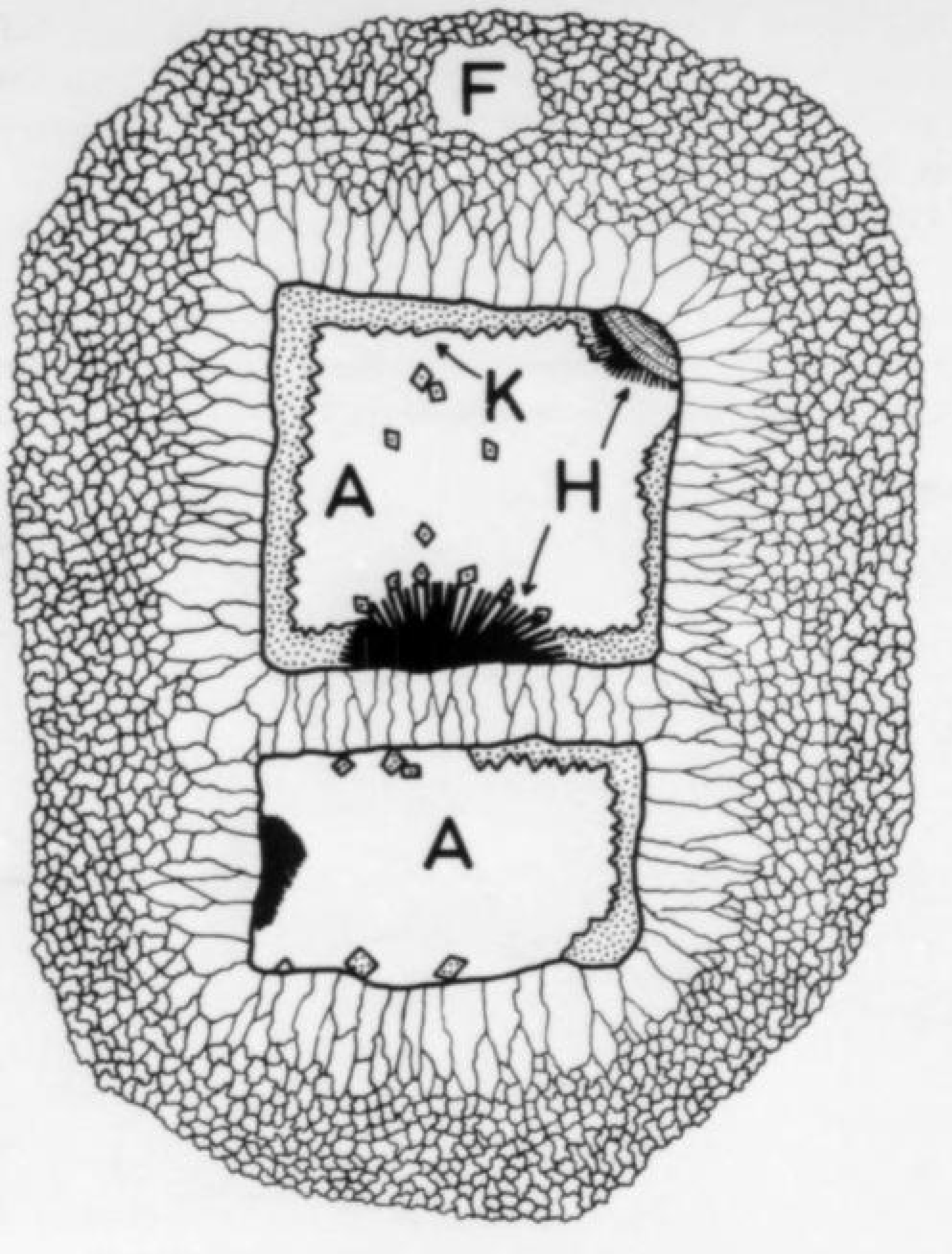

Figure 3. **Schematical cross-section of two cavities in ferberite. F = ferberite. K = alumotungstite (ferritungstite). H = cerotungstite. A = anthoinite.**

ferberite wall of the cavity is lined with ferritungstite-alumotungstite (K in Fig. 3) and radiating groups of cerotungstite (H). The cavity core consists of anthoinite (A), typically with some scattered ferritungstite-alumotungstite octahedra.

The reinite with its tungsten ocher occurs in central Africa in graphite-bearing, fine-grained schists (phyllites) and in the quartz veins contained in them. From the general geochemistry of tungsten it is known that the element favors late magmatic crystallization, pegmatitic or hydrothermal. The geochemical cycle of the element is still not among the better explored chapters of geochemistry. Pargeter (1956) presented an interpretation which, at that time, was courageously unorthodox for tungsten geochemistry. He suggested that the tungsten of the central African ferberite deposits is of a syngenetic origin. Since then, his interpretation has been adopted by several Belgian and British geologists and is supported by the mode of origin of tungsten in the metasedimentary host rocks of the ferberite deposits (Jedwab, 1958; Van Wambeke, 1976). This hypothesis was reviewed by Reedman (1973). Briefly told, the story of the secondary tungsten minerals in central Africa is this: tungsten was largely adsorbed in the depositing clayey sediments through the action of organic matter (now graphite) and iron hydroxide (Jeffery, 1959) and, in the initial stages of metamorphism, was mobilized and crystallized in the form of scheelite. Later, the scheelite was transformed into ferberite and tungstic ocher (Barnes and Pargeter, 1953).

The hypothesis of a syngenetic origin of tungsten in the central African ferberite deposits was recently rejected by Frisch (1975). Based on extended regional studies, especially around the Gifurwe mine in Rwanda, he considered the tungsten to be epigenetic in origin, derived from granite cupolas supposed to exist beneath the schists.

Regardless of the origin of tungsten the fact remains that the central African reinite offers an outstanding opportunity to study the mineralogy of many of the important secondary tungsten minerals. It is the reason for presenting here the above short description of this tungsten province.

ANTHOINITE

This mineral was originally discovered and described from the eluvium of the Mt. Misobo tungsten mine (Maniema, Zaire) by Varlamoff (1947). It is now known to be a quite common constituent of tungstic ocher throughout the central African ferberite occurrences. Beautifully euhedral anthoinite pseudomorphs after scheelite are occasionally found which measure up to 10 cm in length. The mineral is powdery and white in color when free from iron. The crystals are platy with grain sizes too small (a few microns) for single-crystal X-ray study or optical microscopic characterization. According to the choice of the crystallographic axes suggested below, the crystals are platy parallel to (010).

The X-ray powder pattern and the two-dimensional electron diffraction pattern of the platy crystals were studied by Niggli and Jäger (1957) and by Sahama *et al.* (1970a). A reinterpretation of the powder data presented by these authors and an interchange of the crystallographic axes to conform with the rule $b > a > c$ yields the following unit cell parameters: $a = 9.21\text{Å}$, $b = 11.36\ \text{Å}$, $c = 8.26\ \text{Å}$, $\alpha = 94°45'$, $\beta = 90°$, $\gamma = 92°35'$, volume $= 860\ \text{Å}^3$. The *d*-values of the powder lines from these cell parameters agree with those measured for anthoinite. However, such a cell does not necessarily represent the true cell of the mineral. Anthoinite is most probably triclinic with fairly large cell edges. The calculation of the X-ray powder pattern of such a mineral is unequivocal only if based on single crystal data. The above parameters are presented merely for illustrating the relationship between anthoinite and mpororoite.

The few existing chemical analyses (Varlamoff, 1947; Sahama *et al.*, 1970a) indicate a formula $(W,Al)_{16}(O,OH)_{48}$ or $(W,Al)(O,OH)_3$ with a small amount of excess non-stoichiometric water. Whether or not W and Al occupy equivalent sites in the structure cannot, at present, be determined.

The most reliable values for the density of anthoinite are 4.78 (anthoinite from Gifurwe; Frisch, 1975) and 4.87 (Kikagati, Uganda; unpublished), both measured on unanalyzed specimens. The density calculable for the analyzed specimen from Bugarama (Sahama *et al.*, 1970a) amounts to 4.84. The higher value for this specimen given by these authors, *viz.* 5.06, is apparently erroneous.

The occurrence of anthoinite outside central Africa has not been demonstrated in the literature.

As a mineral species, anthoinite is readily identified by its characteristic X-ray powder pattern with numerous sharp lines, but its X-ray crystallography remains unsolved.

Figure 4. **Euhedral ferberite crystals grown on the cavity wall of a reinite pseudomorph. Nyamulilo mine, Kigezi, Uganda. Size of the largest crystals: 30 microns. Scanning electron micrograph.**

MPOROROITE

This mineral is known only from the Mpororo tungsten mine (Kigezi, Uganda) which is unique among the central African deposits in containing abundant scheelite at all stages of replacement by ferberite (von Knorring *et al.,* 1972). The greenish yellow powdery mpororoite is indistinguishable from an iron-contaminated anthoinite in hand specimen. Under the electron microscope it is platy like anthoinite. Its X-ray powder pattern is different from that of anthoinite and indicates that mpororoite represents a distinct species, supposedly monoclinic. Some lines are, however, analogous to those of anthoinite. In addition, the two-dimensional electron diffraction patterns of the two minerals are markedly similar except for the intensities of the diffraction spots. Therefore, the powder pattern of mpororoite was recalculated in a way analogous to that of anthoinite, assuming triclinic symmetry. The following unit cell parameters were obtained: a = 9.40 Å, b = 11.46 Å, c = 8.20 Å, α = 94°20', β = 89°45', γ = 95°10', volume = 877 $Å^3$. Like those of anthoinite, these values are only tentative and should be tested on the basis of single crystal data.

The only existing chemical analysis of mpororoite yields the formula $(W,Al,Fe)_{14}(O,OH)_{42}\cdot 9.85H_2O$ or $(W,Al,Fe)(O,OH)_3\cdot$ ::. ≏ H_2O. The mineral may be considered a hydrated analogue of anthoinite formed at a beginning stage in the scheelite alteration. Mpororoite and anthoinite have not been found in the same deposit.

FERRITUNGSTITE AND ALUMOTUNGSTITE

Ferritungstite was described by Schaller (1911) as a new mineral from the Germania tungsten mine, Washington. Kerr (1946) reexamined the material and found it to be sulfur-bearing. Richter *et al.* (1957) concluded that the material on which Schaller based his description was actually a mixture of ferritungstite and jarosite. These authors studied ferritungstite from another locality, the Nevada scheelite mine, Mineral County, Nevada. They presented a chemical analysis and an X-ray powder pattern of the Nevada mineral, suggesting it to be tetragonal.

Van Tassel (1961) published a very detailed study of ferritungstite, mainly from central Africa where the mineral occurs in larger crystals (exceptionally up to 250 microns) than in the American localities. Two morphological habits of identical X-ray crystallography were described with illustrative drawings: strictly octahedral with penetration twinning according to the spinel law, and platy parallel to an octahedron face in six-sided cyclic twins according to the same spinel law. Crystals of both habits are weakly birefringent. Van Tassel remarked that the X-ray powder pattern of the Nevada ferritungstite could be indexed on the basis of a cubic cell and that the powder pattern of ferritungstite is closely similar to that of microlite. Single crystal X-ray rotation photographs about all three crystallographic axes of an octahedron from Nyakabingu, Rwanda, yielded identical patterns indicating that the mineral is cubic with an F-lattice.

Burnol *et al.* (1964) presented an X-ray powder pattern and two analyses of ferritungstite from La Bertrande, Haute-Vienne, France. The first analysis on hand picked material was made by wet chemical methods and the second one by microprobe on one homogeneous octahedron. The first analysis showed a remarkable content of alumina (Fe_2O_3/Al_2O_3 = 2) with no ferrous iron and the second one indicated absence of alumina.

Machin and Süsse (1975) presented an abstract of their crystal structure determination of ferritungstite from the Björdal (= Namulilo) mine in Uganda. They draw attention to the similarity in X-ray powder patterns between ferritungstite and the pyrochlore group. Ferritungstite was found to be cubic with the space group *Fd3m* and structurally analogous to koppite. Tungsten and iron were considered to occupy equivalent sites in the crystal structure.

Jedwab and Preat (1980) studied ferritungstite from Gifurwe, Rwanda, by scanning electron microscopy. They found that, besides W and Fe, the mineral contains Pb. The X-ray spectra also show the presence of Al.

Ferritungstite is abundant in some parts of the Borralha tungsten mine (Minho, northern Portugal) which produces both wolframite (roughly two-thirds of the production) and scheelite (one-third). An excellent ferritungstite-bearing specimen was available for this review (Fig. 5). Wherever pseudomorphic crystal faces or outlines could be traced in the ferritungstite masses of this specimen, they were found to reflect the crystal form of scheelite. Some few tiny inclusions of scheelite, on the order of 1 micron in size, could be identified by microprobe between the ferritungstite octahedra (this paper). The margins of the former scheelite crystals consist now of a layer of the platy ferritungstite variety known in central Africa from the description by Van Tassel (1961). Figure 6 gives an idea of the platy ferritungstite from Borralha, each plate representing a cyclic twin (sixling). Sometimes the plates form a complicated

Figure 5. **Ferritungstite (yellow) and wolframite (black). Borralha mine, Minho, Portugal. Specimen size: 7 cm.**

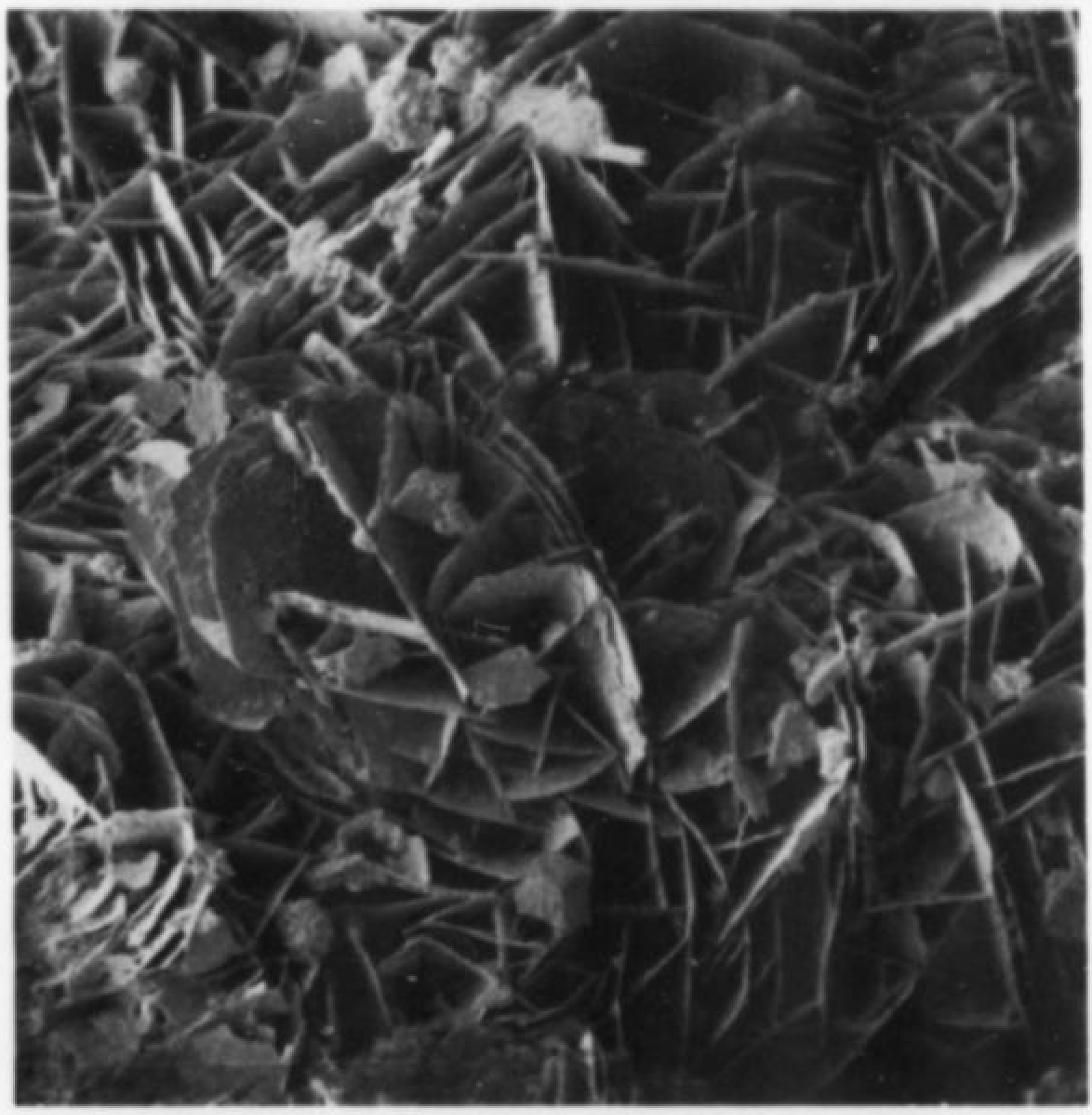

Figure 6. **Platy ferritungstite. Borralha mine, Minho, Portugal. Area of figure: 110 by 130 microns. Scanning electron micrograph.**

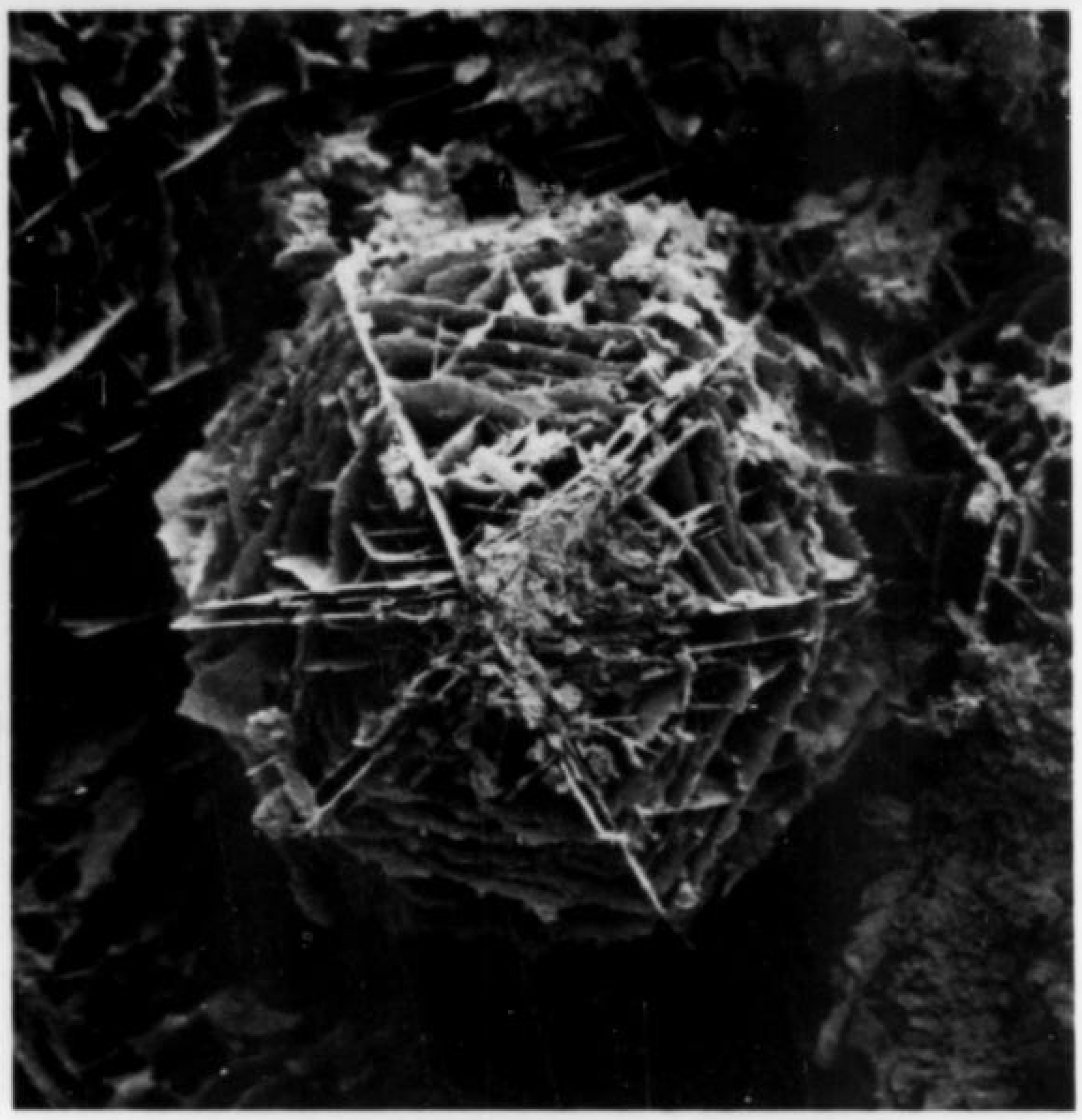

Figure 7. **Complicated rosette of ferritungstite. Borralha mine, Minho, Portugal. Diameter of rosette: 70 microns. Scanning electron micrograph.**

rosette (Fig. 7). Towards the core of the former scheelite crystal, now usually hollow, the habit of ferritungstite changes over to octahedral (Fig. 8). Both platy and octahedral crystals exhibit weak birefringence. Microprobe tests of the Borralha ferritungstite did not reveal any Al or Pb.

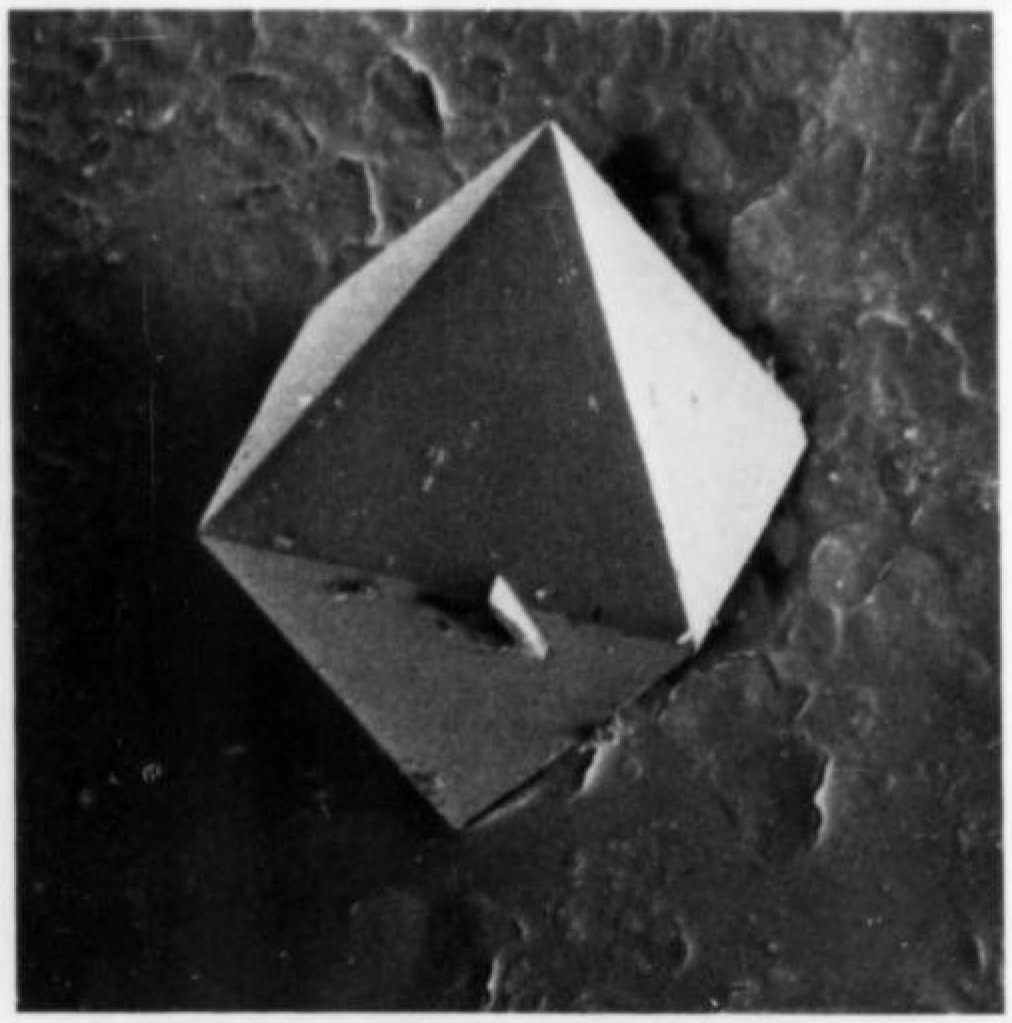

Figure 8. **Single ferritungstite octahedron. Borralha mine, Minho, Portugal. Crystal diameter: 40 microns. Scanning electron micrograph.**

Alumotungstite was first mentioned in the literature as the aluminum analogue of ferritungstite by Davis and Smith (1971, p. 262). The mineral was discovered in yttrotungstite specimens from the Kramat Pulai mine, Kinta, Perak, Malaysia. Later, the same mineral was mentioned from central Africa by Sahama *et al.* (1971). Alumotungstite is included in the list of minerals compiled by Fleischer (1980). To the knowledge of the author, no detailed description of the mineral has been published.

The central African alumotungstite is distinguishable from ferritungstite only through its chemistry and/or through its unit cell parameter. Both minerals occur together and may be found even in the same specimen. Like those of ferritungstite, the alumotungstite crystals are octahedral, usually less than 100 microns in size. Figure 9 shows a ferberite cavity with exceptionally large octahedra. The crystals are largely arranged in rounded groups (Fig. 10) and the single octahedra typically exhibit penetration twins according to the spinel law (Fig. 11). The crystals commonly show a thin skin visible in Figure 11 or contain an outer margin easily detached from the core (Fig. 12). Such crystals appear zoned with rather loose zone boundaries. The crystals are invariably weakly birefringent.

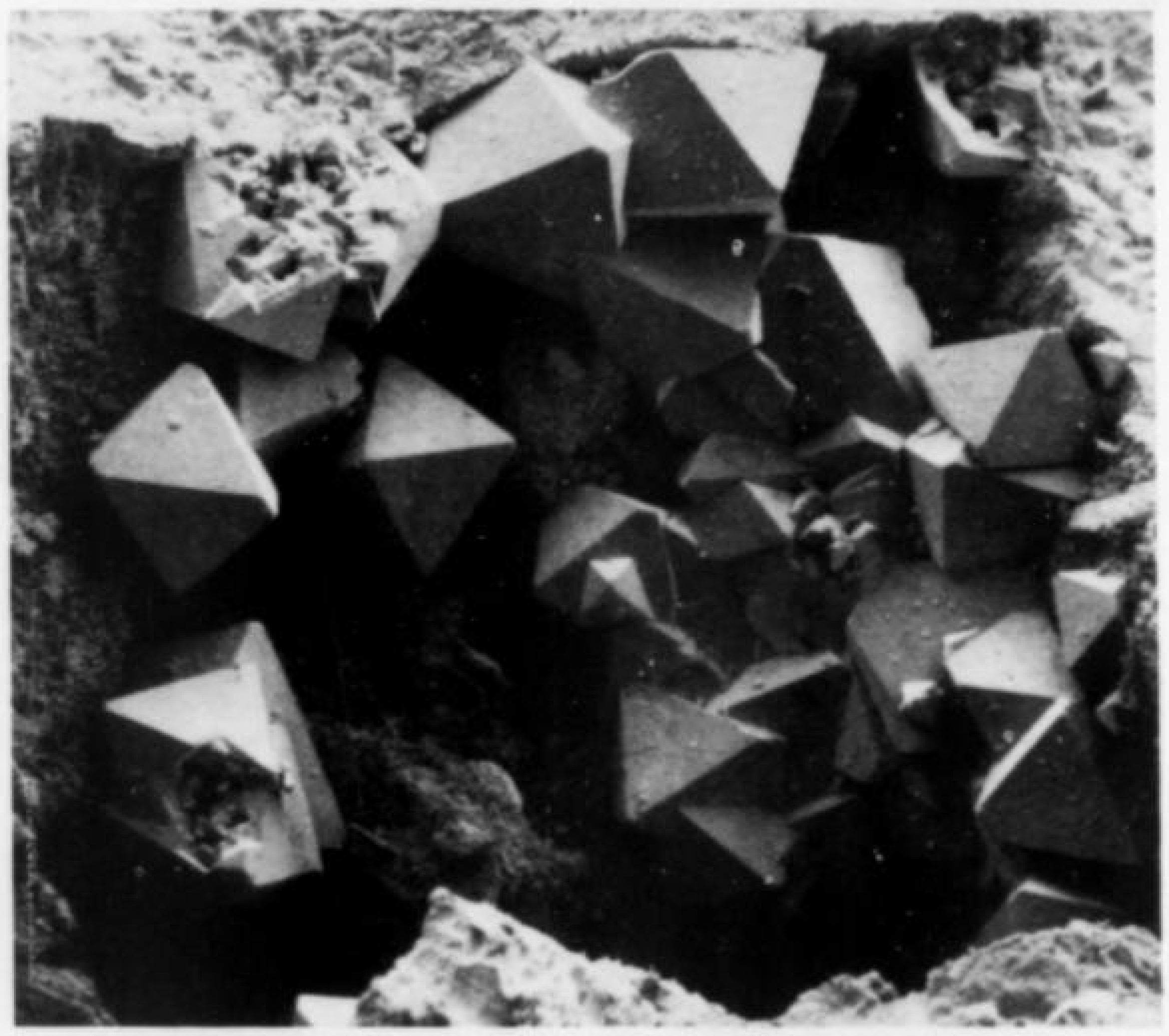

Figure 9. **Alumotungstite octahedra. Gifurwe mine, Rwanda. Average size of single octahedra: 250 microns. Scanning electron micrograph.**

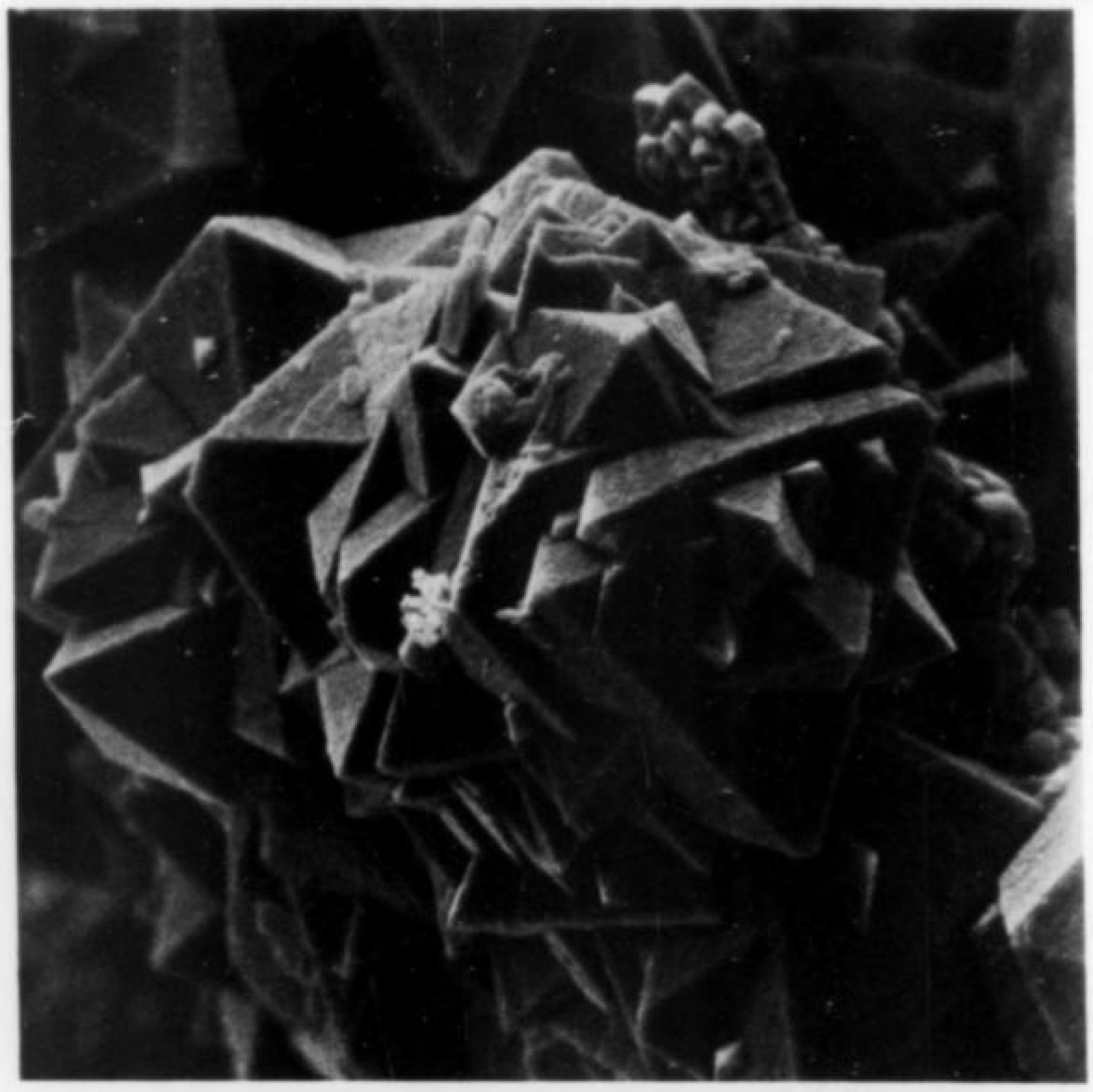

Figure 10. **Group of octahedral alumotungstite crystals. Nyamulilo mine, Uganda. Size of the group: 30 microns. Scanning electron micrograph.**

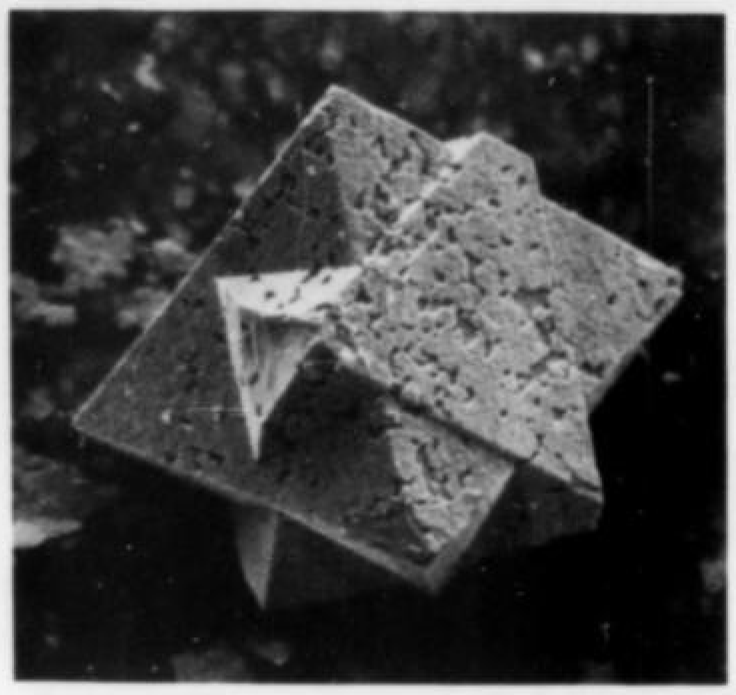

Figure 11. **Penetration twin of alumotungstite with a semi-loose skin. Nyamulilo mine, Uganda. Size of crystal: 70 microns. Scanning electron micrograph.**

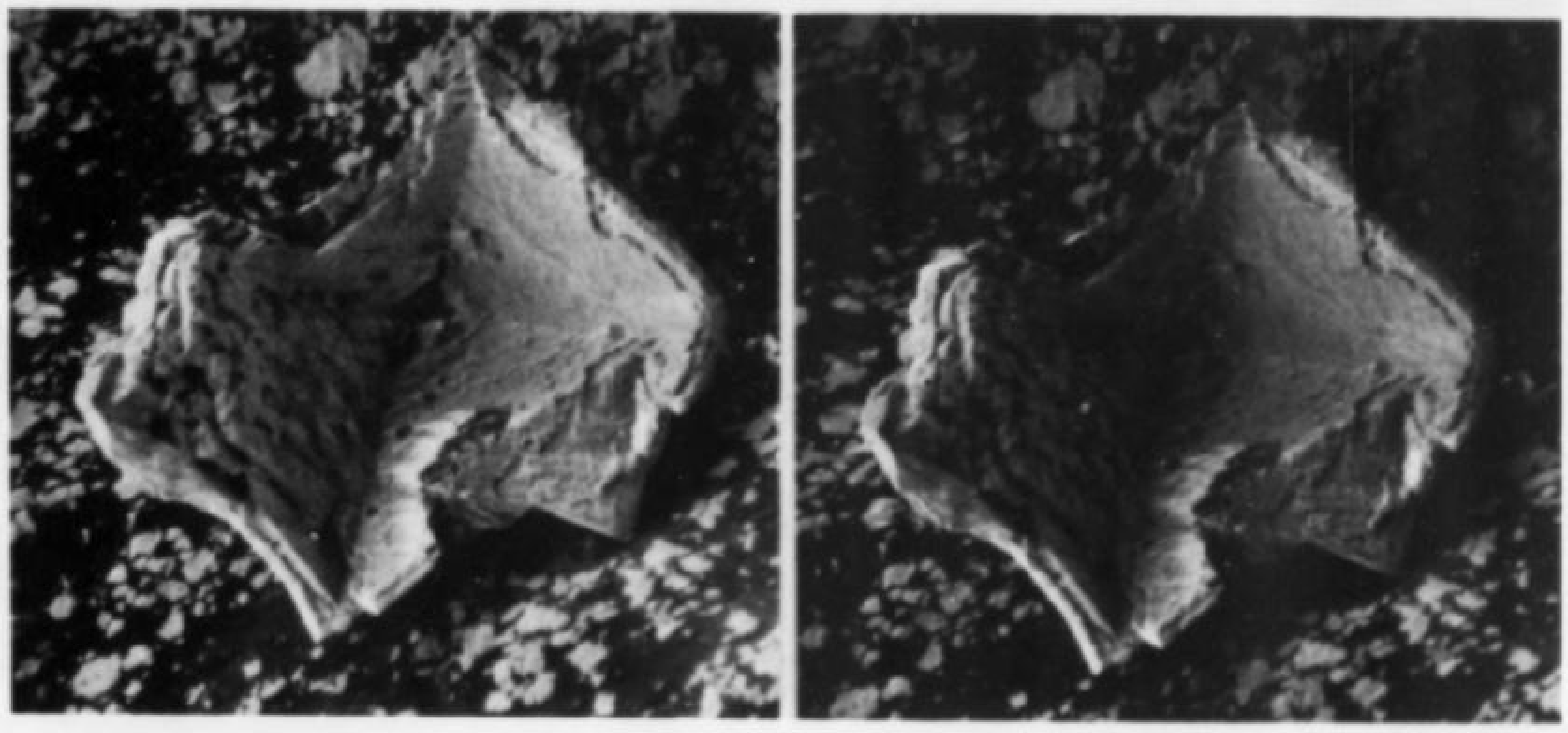

Figure 12. **Stereo pair of the loose, zoned skin of an alumotungstite octahedron. Kirwa mine, Uganda. Crystal size: 150 microns. Scanning electron micrograph.**

The chemical formulas to be assigned to ferritungstite and alumotungstite are not well established. The similarity in crystal morphology and in X-ray crystallography between the two minerals suggest analogous formulas.

The available analytical data, admittedly rather scarce, make it apparent that the atomic ratio of W to (Al + Fe) is not stoichiometric but variable. This circumstance, along with the crystal structure proposed by Machin and Süsse (1975), could indicate that W, Al and Fe occupy equivalent sites in the structure.

The Nyakabingu (Van Tassel, 1961) and Borralha (this paper) ferritungstites are reported to be free of Pb. The X-ray spectra of the Gifurwe ferritungstite (Jedwab and Preat, 1980) show quite appreciable Pb lines. A few provisional microprobe tests on alumotungstite from the Kirwa mine, Uganda, made for this review (not reproduced here) indicate variable contents of PbO, up to 10 wt. percent. It is concluded that Pb is not essential but just accessory for ferritungstite-alumotungstite.

Aluminum-free ferritungstite is known to exist (La Bertrande, Borralha, by microprobe tests). Some alumotungstite crystals from the Kirwa mine (microprobe tests for this review) are only slightly Fe-bearing. These few data seem to indicate that solid solution between ferritungstite and alumotungstite is very limited.

Taking the above data into account, the following formulas are proposed: for ferritungstite $(W,Fe)_{16}(O,OH)_{48}$ or $(W,Fe)(O,OH)_3$ and for alumotungstite $(W,Al)_{16}(O,OH)_{48}$ or $(W,Al)(O,OH)_3$, both with non-stoichiometric amounts of Pb, Ca and excess water. These formulas are merely tentative and should be revised when more data become available. It is worth noting that the ideal formulas suggested for anthoinite and alumotungstite are similar to each other, the only difference being in the ratio between W and Al.

X-ray data for ferritungstite and alumotungstite are conformable with a cubic symmetry of the space group $Fd\bar{3}m$. However, the invariably observable weak birefringence points to the possibility that these minerals are only pseudocubic and that the true symmetry is lower. Fleischer (1980) mentions that alumotungstite is trigonal. A tetragonal symmetry proposed for ferritungstite by Richter *et al.* (1957) is most probably erroneous. Numerical data for the parameter of the cubic or pseudocubic cell presented in the literature or calculable from X-ray powder patterns vary from $a = 10.20$ Å to $a = 10.31$ Å. The values have not always been obtained on materials of known composition but seem in some instances to apply to mixtures between ferritungstite and alumotungstite. If the powder pattern is recorded with a photographic camera of 57.3 mm diameter, then the measurement may just yield a weighted average of the parameters of these component phases. Summing up the information it seems that the cell parameter for pure ferritungstite is $a = 10.33$ Å, measured for the Al-Pb-free Borralha ferritungstite, and for pure alumotungstite $a = 10.20$ Å.

The few data for the density of ferritungstite found in the literature vary between 4.4 (Van Tassel, 1961) and 5.2 (Richter *et al.*, 1957). A value of D = 5.02 was measured for the octahedral crystals of the Borralha ferritungstite (Berman balance). No data for alumotungstite have been published. It seems that the variation in the ratios between W, Fe, Al and Pb affect the density to a considerable extent.

The species ferritungstite and alumotungstite are readily identified by their crystal morphology, especially if studied under the scanning electron microscope, and by their X-ray powder pattern. Attention should, however, be paid to the possibility that the material under study may consist of a mixture of the two species. The range of variation in chemical composition and in physical properties needs refinement.

HYDROTUNGSTITE

This hydrous tungstic oxide was discovered as a natural mineral from Calacalani, Oruro, Bolivia, by Kerr and Young (1944). At that locality it occurs as an initial alteration product of ferberite. Hydrotungstite is said to be dark green when freshly broken, but the museum specimens which have been exposed to air are yellow green. The crystals are platy and occur intergrown as crystal groups (Fig. 13). Under the binocular microscope such groups are not easily distinguished from other secondary tungsten minerals of a bladed or platy habit. Polysynthetic twinning is common. The only existing chemical analysis of the mineral was presented by Kerr and Young and corresponds to the formula $H_2WO_4 \cdot H_2O$. The *d*-values of the more intense X-ray powder lines were listed.

Mitchell (1963) reported the complete X-ray powder pattern of hydrotungstite and noticed that it is remarkably similar to that of synthetic molybdic acid ($H_2MoO_4 \cdot H_2O$). As no single crystal X-ray data were available for hydrotungstite, its powder pattern was indexed on the basis of the data for molybdic acid and the unit cell parameters were calculated. The mineral was tentatively considered monoclinic with the possible space group $P2/m$.

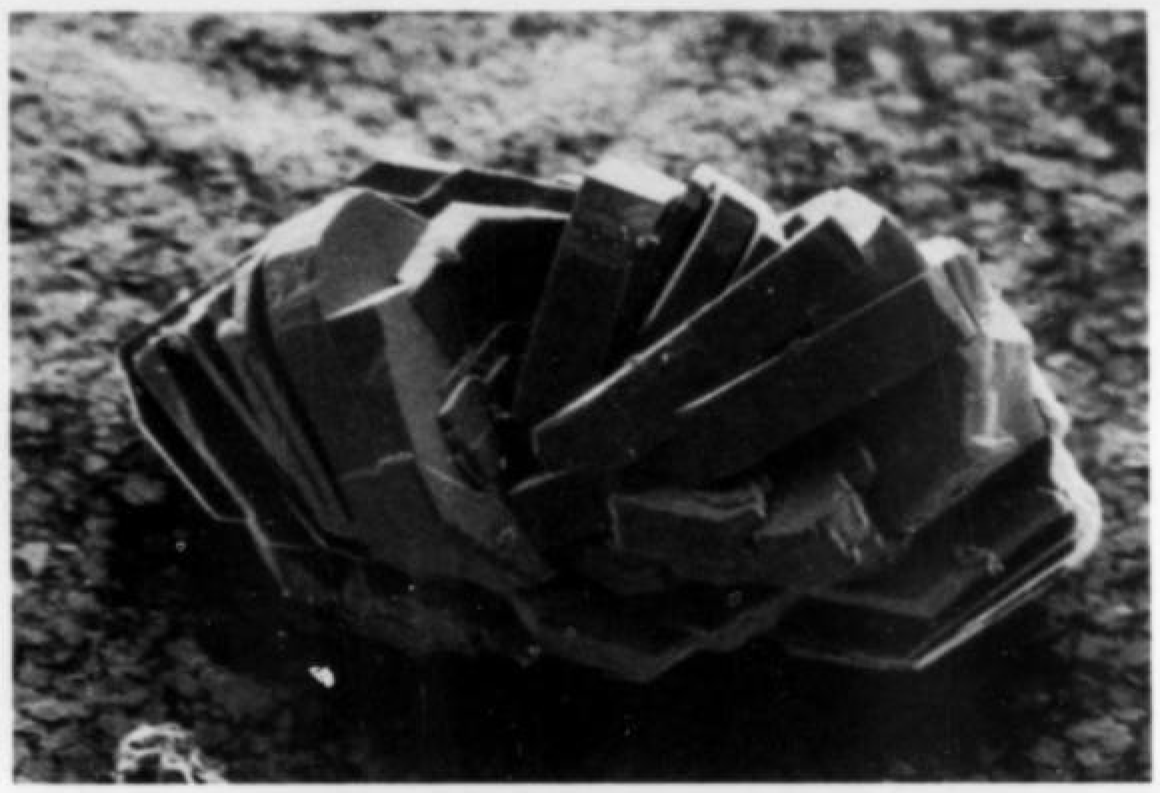

Figure 13. **Group of hydrotungstite crystals. Calacalani, Oruro, Bolivia. Specimen: Smithsonian 104901. Length of group: 240 microns. Scanning electron micrograph.**

Sahama and Lehtinen (1971) refined the X-ray powder data for hydrotungstite on the basis of data from the original specimen (Smithsonian #104901) used by Mitchell. These authors were able to select a single crystal for X-ray precession work. They found the following data: a = 7.379 Å, b = 6.901 Å, c = 3.748 Å, β = 90°22', monoclinic space group *P*2/*m* (*P*2, *Pm*).

The crystal structure of natural hydrotungstite has not been determined. It is most probably similar to that of the molybdic acid.

Hydrotungstite has been reported from some central African ferberite deposits, but the data are incomplete.

TUNGSTITE

The mineral name *tungstite* has been widely used in the literature to denote yellow, powdery tungstic ocher not subjected to valid mineral characterization. It seems likely that some specimens labeled tungstite in the collections are actually fine powdery ferritungstite (alumotungstite), hydrotungstite, etc. It is recommended that the name tungstite not be used unless the mineral has been shown to represent this species by X-ray or other means.

Natural tungstite was chemically analyzed using impure material from Salmo, British Columbia, by Walker (1908) who found it to correspond to the formula $WO_3 \cdot H_2O$. Kerr and Young (1944) presented a review of the early literature dealing with tungstite and studied specimens from Calacalani, Oruro, Bolivia, where it occurs in the same deposit as hydrotungstite. The chemical analysis reported by these authors confirms the formula suggested by Walker.

The yellow tungstite varies in color and occurs as earthy incrustations. The crystals are prisms which appear to be orthorhombic, terminated by the basal pinacoid or cleavage plane {001}. The length of the crystals ranges up to 75 microns in the Calacalani deposit. The mineral is generally considered to be orthorhombic on the basis of its optical properties. The X-ray powder patterns tabulated in the literature contain a large number of lines and are difficult to interpret without the aid of single crystal data. Therefore, the question of the true symmetry of the mineral must be left open. The characterization of the mineral is hampered by the fact that tungstite is difficult to obtain free from hydrotungstite or other admixture.

In central Africa, tungstite has been reported from Nzombe, South Kivu, Zaire, by Bourguignon (1953).

As a mineral species tungstite is still inadequately described and needs to be studied with modern laboratory techniques.

REMARKS ON MEYMACITE

In 1874 Carnot described a yellow tungstic ocher from Meymac, Corrèze, France, considered it to be a distinct species and named it meymacite. Since then it has been included in the mineral nomenclature as a doubtful species. Van Tassel (1961) presented a detailed review of meymacite and studied it from the original French locality, also using similar central African material. He found these materials to be chemically identical with hydrotungstite. Later, Pierrot and Van Tassel (1965) were able to examine the original specimen used by Carnot. They found that Carnot's meymacite is actually identical with finely crystalline ferritungstite. They redefined the name meymacite to apply to X-ray-amorphous $WO_3 \cdot 2H_2O$, the counterpart of crystalline hydrotungstite. This redefinition was approved by the Commission on New Minerals and New Mineral Names of the International Mineralogical Association.

YTTROTUNGSTITE

Yttrotungstite is known from the Kramat Pulai mine and from Tapah, Kinta, Perak, Malaysia. Its history has been reviewed by Davis and Smith (1971) who made a very detailed study of it including a complete crystal structure analysis. Yttrotungstite occurs as earthy, yellow material and, in small open vugs, as lath-shaped, elongated, twinned crystals, arranged in radiating groups. X-ray powder patterns and/or chemical analyses, including ratios between the rare earth elements, have been presented by Butler (1957), Bradford (1961), Semenov *et al.* (1965), Sahama *et al.* (1970b) and Davis and Smith. Following these last named authors, yttrotungstite is characterized as monoclinic with the space group $P2_1/m$, a = 6.95 Å, b = 8.64 Å, c = 5.77 Å, β = 104°56', simplified chemical formula $YW_2O_7(OH) \cdot H_2O$. In this formula Y represents strongly predominating yttrium among the rare earth elements.

Yttrotungstite has not been reported from localities outside Malaysia.

Among all secondary tungsten minerals reviewed in this paper, the mineralogy of yttrotungstite has been explored most completely.

CEROTUNGSTITE

From the tungsten ocher of the central African ferberite deposits a mineral is known which has been named cerotungstite (Sahama *et al.,* 1970b). This mineral occurs characteristically in radiating groups and represents a cerian analogue of the Malaysian yttrotungstite. Under the binocular microscope the habit and color of cerotungstite (Fig. 14) are similar to yttrotungstite. The mineral is

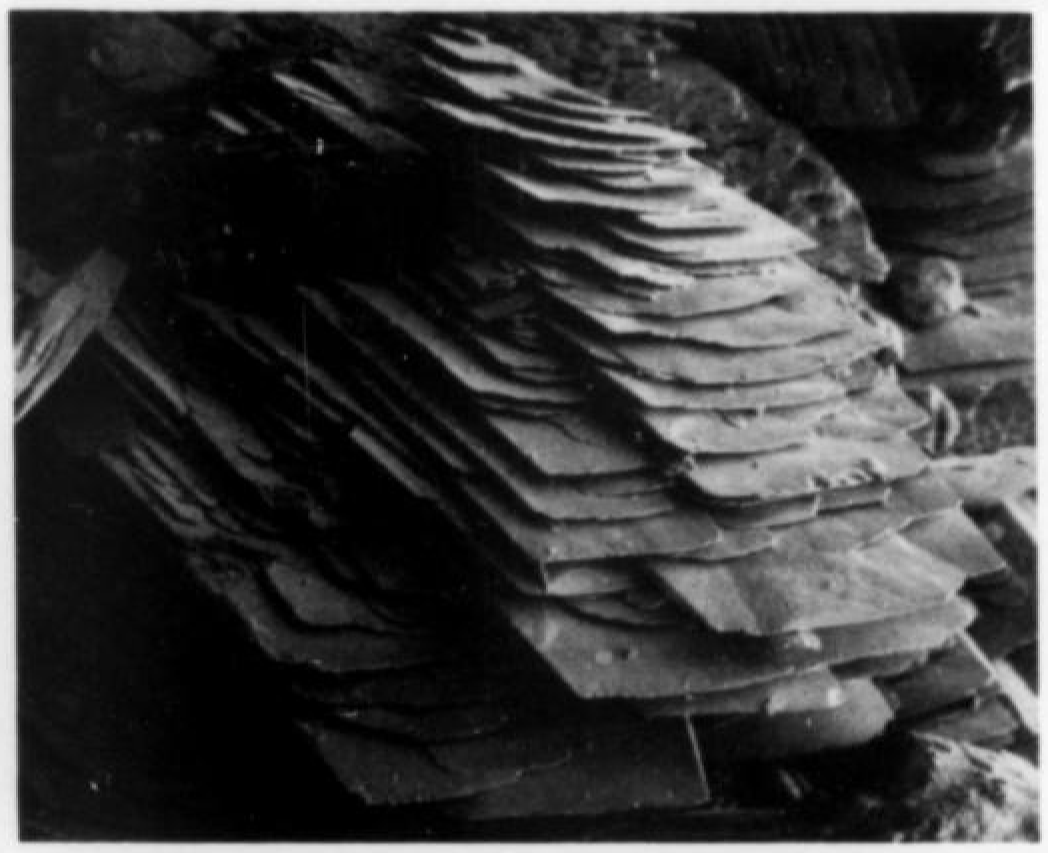

Figure 14. **Group of cerotungstite crystals. Nyamulilo mine, Uganda. Size: 260 microns. Scanning electron micrograph.**

monoclinic with the space group $P2_1/m$, $a = 7.07$ Å, $b = 8.70$ Å, $c = 5.87$ Å, $\beta = 105°27'$ (*a* and *b* interchanged to correspond to those of yttrotungstite). The simplified chemical formula may be written $CeW_2O_7(OH) \cdot H_2O$, where Ce indicates a strong predominance of cerium and neodymium among the rare earth elements.

Cerotungstite has not been reported from outside central Africa.

ACKNOWLEDGMENTS

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Lyman House
Memorial Museum, Hilo, Hawaii

by **John Sampson White**
Department of Mineral Sciences
Smithsonian Institution
Washington, DC 20560

***Figure 1.* The Lyman House Memorial Museum. The new building is in the center of the picture and a portion of the old Mission House may be seen on the left.**

The Lyman House Memorial Museum in Hilo, Hawaii, (hereafter called the Lyman Museum) was started as a general museum in 1932 by four members of the Lyman family in the old Mission Home built by David and Sarah Lyman in 1839. David and Sarah were early missionaries from Boston who arrived in Hawaii in 1832. Hilo is the major city on the island of Hawaii, the largest of the Hawaiian chain of islands and the only one boasting an active volcano. From the beginning of the museum a small collection of minerals was on display, the forerunner of today's collection. Those specimens were collected in the early 1800's and some are still on display today. A new, much enlarged building was completed in 1974. It contains three floors of exhibits as well as sizeable storage and shop areas. The museum became a tax exempt organization at the time of the completion of the new building and it has also been accredited by the American Association of Museums.

Various types of displays were prepared for the new building, including exhibits of the main ethnic groups (seven in number) found today in Hawaii. These depict the artifacts brought with each group when it first arrived on the Hawaiian Islands. There are excellent displays of *Hawaiiana* such as a grass hut of normal size and numerous artifacts used by the early Hawaiians. The old Mission House was then refurnished with antiques of the 1840–1880 period and reopened as part of the museum complex.

A fine, large collection of oriental ceramics, along with oriental furniture, large old Japanese screens and wall hangings, fill a portion of the top floor of the new building. To this has been added a collection of old American pressed glass goblets, an outstanding collection of cut glass and art glass. There is also a glass

Figure 2. **Part of the systematic mineral collection in the Lyman Museum.**

paperweight collection of some 400 items collected from all over the world. Glass collectors may spend time here to advantage as the displays are in large well-lighted cases and are very nicely arranged.

Natural History is well covered; there are exhibits on Hawaiian flora showing hardwoods and other types of Hawaiian-grown trees with examples of each type of wood. A recent addition shows enlarged color photographs of numerous indigenous plants found in greater or less extensive growth today. Native Hawaiian birds, colorful in their distinctive plumage, are displayed in their habitats. Other displays show small wild animals of Hawaii.

In the vicinity of the mineral collection on the top floor is one of the finest volcanological displays in the world, as noted by several volcanologists at the Hawaiian Observatory at Kilauea manned by the U.S. Geological Survey. According to local legend, Hawaii is the home of the volcano goddess "Pele." Shown are numerous types of basaltic formations including stalactites, stalagmites, *aa* and *pahoehoe,* volcanic spatter, ash and other strange and exotic flow formations. High on the walls around the exhibit is a collection of spectacular volcano eruption photographs, the likes of which are nowhere else to be found. These are enlarged photographs in color which dramatically portray the power and awesome beauty of volcanic activity.

Adjacent to the volcanological displays is a small geological exhibit and then begins the worldwide mineral collection, a collection which would be a credit to any museum but is especially outstanding in view of this museum's isolation in the middle of the Pacific Ocean.

Mineral specimens are a scarce commodity in this group of very young (geologically) islands. The older islands of Kauai, Oahu and Maui have produced a small number of interesting specimens of

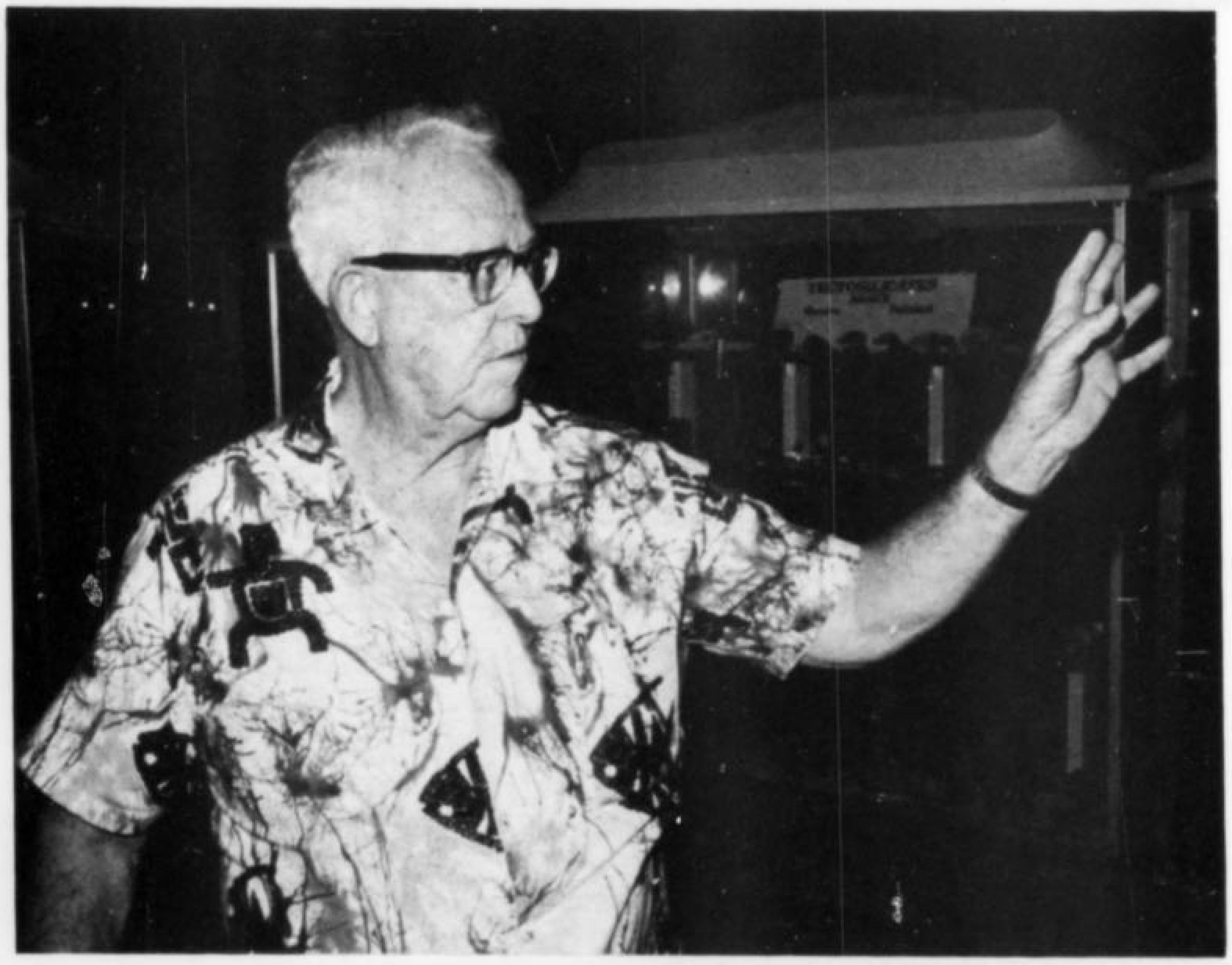

Figure 3. **Orlando Lyman, the Director of the Museum.**

calcite, aragonite, laumontite, quartz, forsterite (olivine) and augite. These are displayed as a group in the first large glass case. The systematic collection, begun in 1918, has steadily expanded with the addition of numerous smaller collections, including those of Dr. H. L. Lyon of Honolulu; Wal Gan Timur of Annerly, Australia; McKee Caton of Texas; and Wendell Stewart and Russ Hind, both of California; along with vast additions donated by friends and purchased from mineral dealers all over the United States.

This collection was developed by Orlando Lyman, the great-grandson of David and Sarah Lyman, the early missionaries to Hawaii. It covers nearly half of the 3600-square-foot top-floor gallery of the new building. As no other mineral collection is on view in any Hawaiian museum, this has become a much visited portion of the new museum. In 1975, Paul Desautels and the author visited the collection, offering advice and counsel to Orlando in order to assist in the expansion and improvement of the mineral collection. Today approximately 5000 specimens of more than 650 species are on view, with another 15,000 in the study and reserve collections.

The public portion of the collection is displayed in thirty 5 by 6 by 2-foot glass cases which are well lighted and labeled. Cut and polished examples of many species are exhibited along with uncut crystals. Every attempt possible is made to obtain new finds and to keep the collection current.

Visitors should make special note of a number of superior specimens which compare very favorably with those exhibited in more famous museums. The following are some of these although many other outstanding specimens are on view.

There are excellent and diverse suites of copper, pyrite, galena and cassiterite specimens in the initial cases. Graves Mountain, Georgia, is represented by a superb rutile crystal group. The sulfosalts are very well represented, especially tetrahedrite, tennantite and enargite. The rhombohedral carbonates are strong, especially calcite. There is malachite in profusion from a great number of localities and revealing a remarkable diversity of forms. One outstanding specimen is a cluster of powder-blue anhydrite crystals attached to one edge of a large colorless plate of gypsum from Mexico. Among many good barite specimens was one with unusually large crystals from Book Cliffs, Colorado. Sawed and polished variscite nodules, many of them quite large, are among the best from Fairfield, Utah. One of the very finest specimens is a large plate of white quartz crystals over which are scattered sharp, black 0.8 to 1.2-inch ferberite crystals. The locality is San Cristobal, Peru. Vanadinite and mimetite provide lots of color in their portion of the display. And once again diversity is the strength of the quartz collection. There are great numbers of quartz specimens of all colors and all forms, many of them as faceted stones. Among the silicates were especially noted outstanding specimens of rhodonite (Australia), hedenbergite (Sweden), dioptase, epidote (Alaska), kyanite (North Carolina), lazurite (Afghanistan), tourmaline, lepidolite, kämmererite (Turkey), spessartine, natrolite (New Jersey), and albite (Brazil). These and many more fine pieces compose the Lyman Museum mineral display.

***Figure 5.* Elsewhere in the carbonates, some of the extensive malachite suite.**

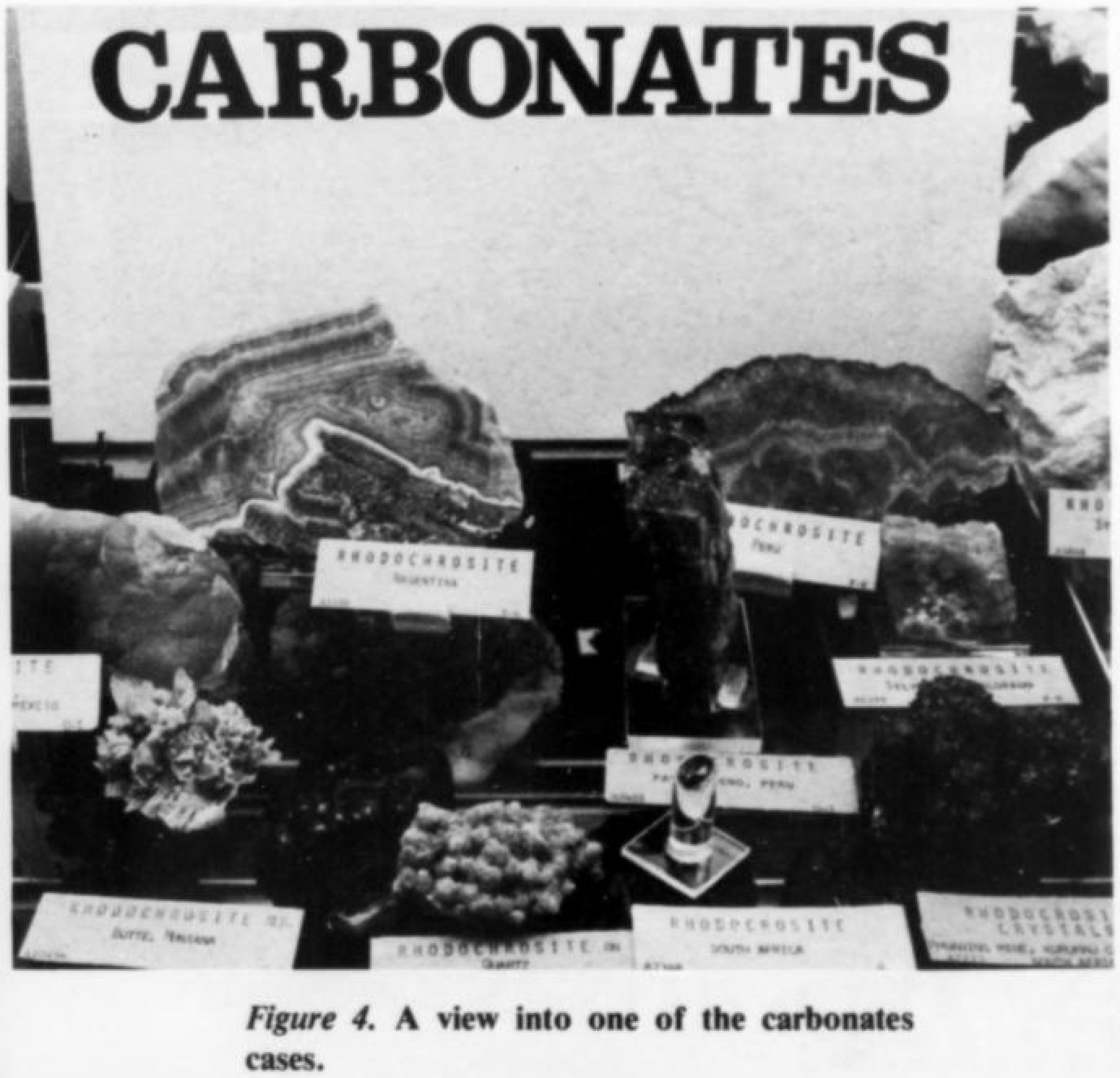

***Figure 4.* A view into one of the carbonates cases.**

Although the museum has a good mineral collection, it is always interested in upgrading and adding new species. With the tax exempt status, gifts are always welcome and greatly appreciated in the Mid-Pacific location where it is difficult to secure specimens.

The museum is also working on a Pacific seashell collection, which now numbers in the thousands. Some areas, however, are weak and could stand improvement, as in the mineral collection. Edward Swoboda visited the museum recently and graciously donated boxes of extremely fine shells and corals from the Swoboda collection. These will add much to the display when it is finally placed on view.

The Lyman Museum in Hilo, Hawaii, although not a large museum, has many exceptional things for one to see and enjoy. One may pass many pleasant hours visiting the collections, viewing the exhibits, especially the mineral display, and seeing the Lyman Mission House. The relaxed and friendly ambiance of the island provides an altogether delightful setting and strongly encourages making a leisurely study of the collection. The museum is open daily from 10:00 am to 4:00 pm and is large enough to accommodate tours. The address is: Lyman House Memorial Museum, 276 Haili Street, Hilo, Hawaii 96720.

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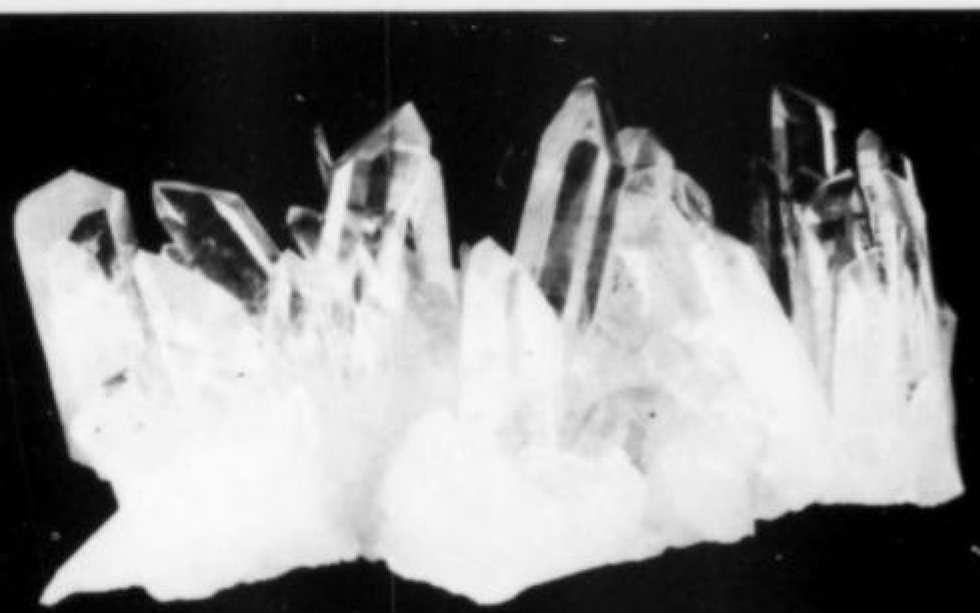

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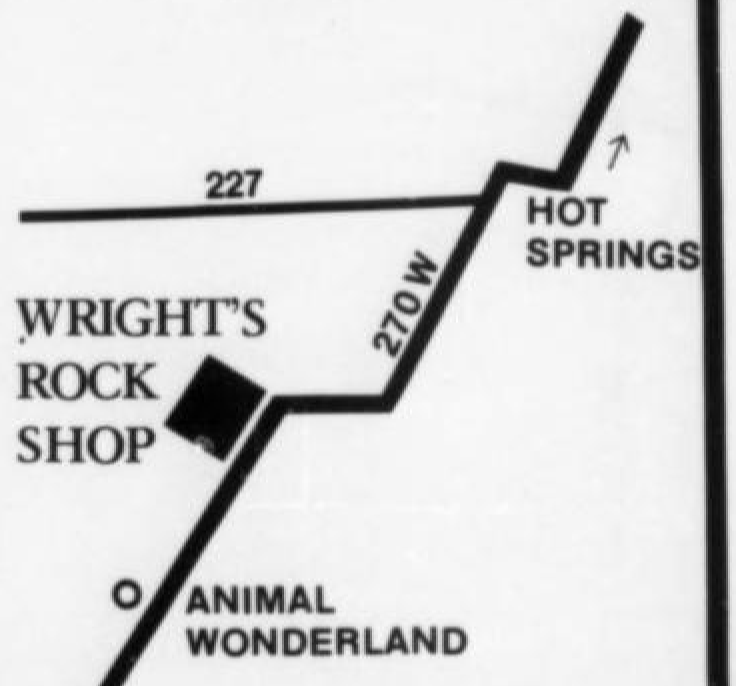

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Minerals of the Wausau Pluton

by **Al Falster**
920 McIntosh Street
Wausau, Wisconsin 54401

When one thinks of pegmatites, one thinks of Colorado, Maine, California and Brazil . . . not Wisconsin. However, there are pegmatites in Wisconsin, especially near Rib Mountain, where fine specimens of microcline (amazonite), smoky quartz, gemmy phenakite, gemmy beryl (aquamarine) and many other species have been found.

LOCATION

The pegmatite area described here is south of Rib Mountain, in the town of Rib Mountain, Marathon County. The zone measures roughly 2.5 by 3.2 km, though pegmatites occur in a much wider surrounding area perhaps 13 by 28 km.

HISTORY

Weathered quartz syenite, part of the Wausau pluton, has been quarried in the area for use as road gravel since the late 1800's. Several pits are still operating, but they are closed to collecting. Unquarried portions of the pluton are covered by dense forests and swamps which constitute a major inconvenience to collectors. Significant numbers of specimens have never reached the mineral market.

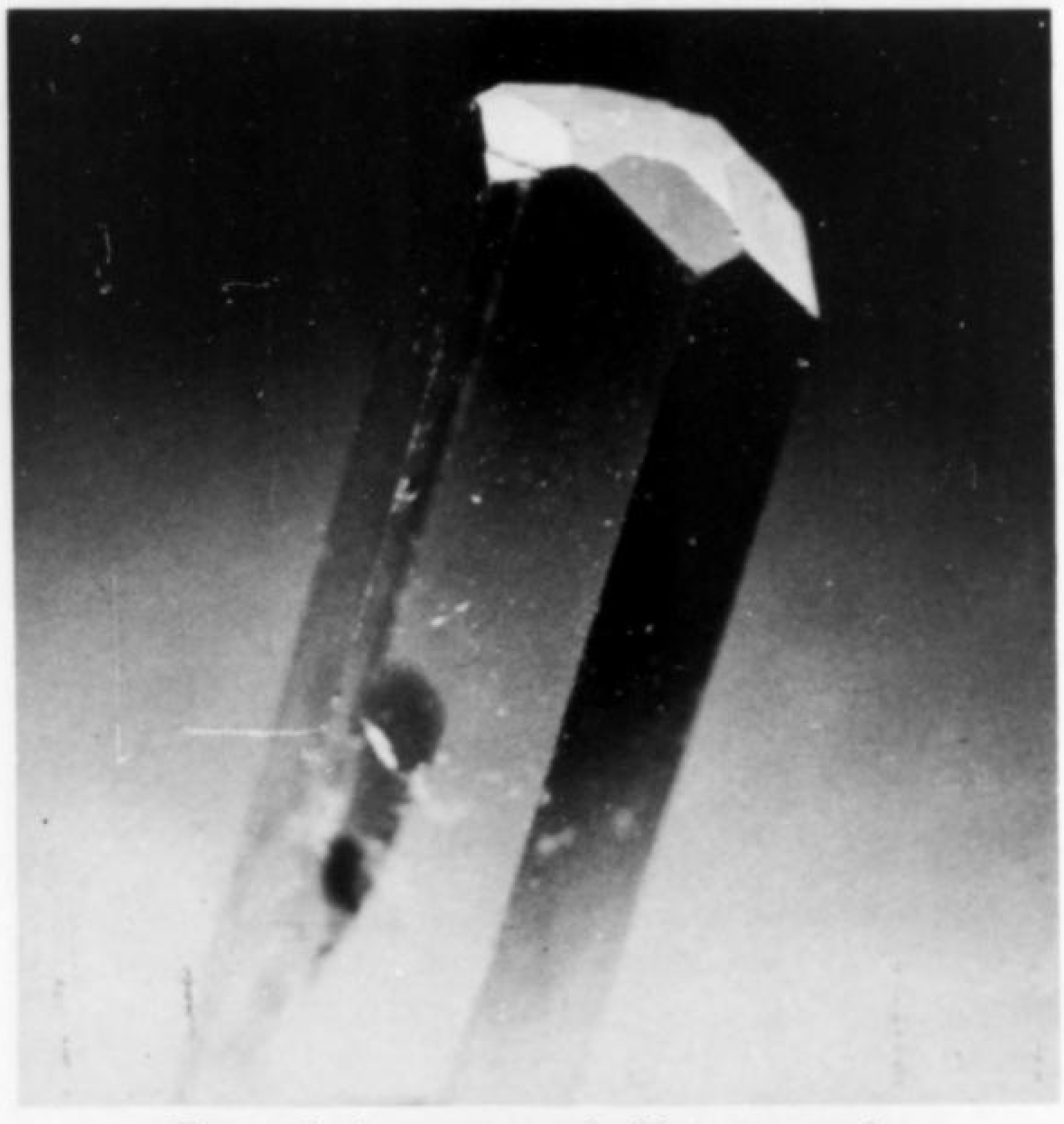

Figure 1. **A gemmy, pale blue aquamarine crystal 1.2 cm tall from the Rib Mountain pegmatite area, Marathon County, Wisconsin. Photo by Eric Offermann.**

GEOLOGY

Rib Mountain is the remains of an ancient volcano, part of the central Wisconsin volcanic belt which has been dated at about 1.6 billion years (Crowns, 1978), The Wausau pluton apparently represents the solidified magmatic core of that volcano, revealed by subsequent erosion (Wiedman, 1907). The pluton consists of quartz syenite which has weathered to a depth of 20 meters or more and which, in the weathered zone, is soft enough to be easily shovelled. The syenite is riddled with pegmatites ranging up to 80 meters in length and 3 meters in thickness; many are solid but some contain pockets ranging from a few centimeters to several meters in size.

Figure 2. **Location map. The area described is about 1 mile south of Rib Mountain.**

Figure 3. **An aerial view of part of the pegmatite area near Rib Mountain. Photo by Al Falster and Dean Matzke.**

Figure 4. **A large pegmatite vein can be seen in this cut, intersecting the surface at a low angle. The vein is about 1.2 m in maximum thickness. (All photos by the author except as noted; all specimens from the author's collection except as noted.)**

The magma body seems to have been fairly deep-seated, judging from the size and abundance of pockets, and also the abundance of spongy areas (P. B. Moore, personal communication). Several types of productive zones (with respect to specimens) exist in the area:

(1) Simple pockets, generally lenticular in shape.
(2) Complexly structured pockets, commonly spherical and containing layers of crystallized material.
(3) Spongy pegmatites, masses of finely vuggy material.
  (a) Titanium-rich, containing anatase, brookite, rutile, commonly xenotime, less commonly beryl and biotite.
  (b) Iron-rich, containing hematite, pyrite, pseudomorphs of goethite, poor albite, and rarely xenotime.

Thus far, more than 250 pegmatite pockets and about 35 spongy pegmatites have been found. The veins are more resistant to weathering and, in some cases, stand in slight relief above the surrounding syenite. In other cases the pegmatite veins have been located by observing vegetation changes, soil color, and through the use of infrared photography.

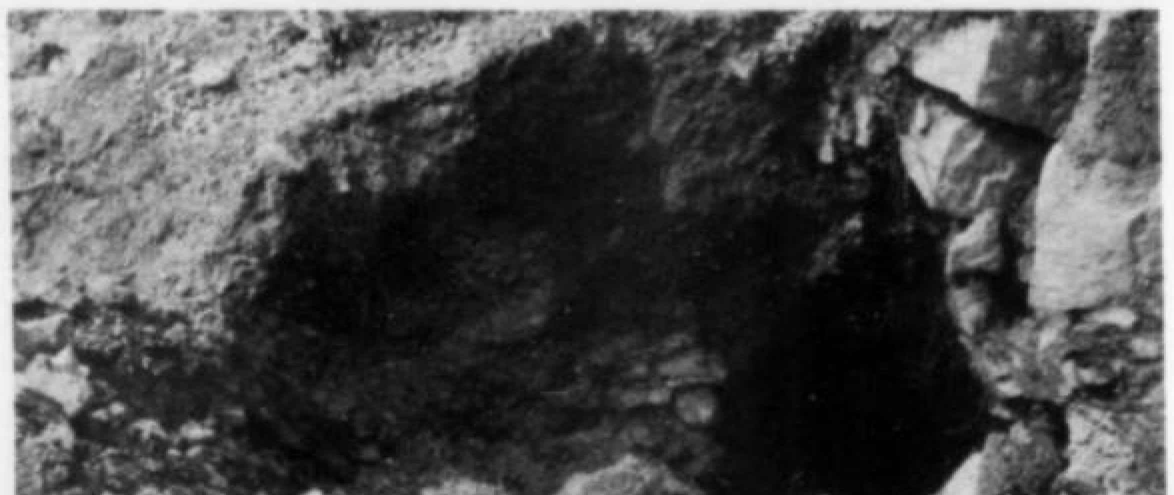

Figure 5. **A partially excavated pegmatite pocket filled with reddish brown clay.**

Figure 6. **Deep brown smoky quartz crystals to 31 cm in length. David Feck collection.**

Figure 7. **A deep brown smoky quartz crystal, 38 cm long, with boulangerite and hematite inclusions.**

Figure 8. **A crystal of smoky quartz 8 cm long, with an overgrowth of milky quartz.**

MINERALS

A surprising variety of minerals, at least 44 species, has been identified from the Rib Mountain pegmatites, though most occur as unexciting specimens. Nevertheless, a few are quite attractive. Following is a list of all species thus far identified.

Gold has been found as minute, crude crystals in and between quartz crystals.

Galena, in small crystals under 0.2 mm in size, has been found in only one pocket. It occurs as inclusions in smoky quartz (which protected it from weathering), primarily as cubes with minor octahedron and dodecahedron modifications.

Sphalerite in highly distorted, black crystals, occurs in quartz in the same manner as galena.

Calaverite is very rare, occurring only as thin, lath-shaped crystals in quartz. The crystals reach 5 mm long and 0.5 mm in thickness, and are commonly twisted.

Boulangerite and **jamesonite** occur sparingly as inclusions in smoky quartz. The hair-like crystals reach a maximum length of about 2 cm, and occur in parallel orientation just below the surface of the quartz crystals. They have been found in at least 6 different pockets.

Quartz is a major constituent of the pegmatite pockets, individual crystals of which range up to a meter in length. Most is smoky quartz, dull or lustrous, typically in prisms and flattened crystals. Two pockets have yielded Japan-law twins. A few scepter crystals have been found, consisting of a smoky shaft and milky second-generation scepter. One pocket yielded crystallized rose quartz similar in appearance to material from Maine. Reddish hematite inclusions commonly occur just below the surface of some crystals, and nearly all crystals are clouded by unidentified inclusions.

Opal, variety hyalite, forms botryoidal overgrowths on pocket minerals and fissure surfaces throughout the pegmatite area. It is always colorless and strongly fluorescent and phosphorescent (green and greenish blue).

Rutile, typically the variety sagenite, is a common accessory mineral. The 5 to 10 mm crystals are black to brown, greenish, straw-yellow or almost white in color.

Anatase is relatively common, typically associated with rutile. The crystals are always a lustrous black, generally less than 0.5 mm in size, but one pocket yielded crystals to 7 mm.

Brookite is abundant, occurring in a variety of habits from thin tabular to blocky to short prismatic. The color ranges from black to brown and almost colorless, and the size reaches a few mm.

Ilmenite is fairly common as crude, tabular crystals.

Stibiconite, as a yellowish coating, occurs on jamesonite and boulangerite crystals in quartz.

Psilomelane is rather widespread in small amounts, forming a black, botryoidal coating over other pocket minerals.

Hematite is very abundant as thin, shiny crystals flattened on *c*. Most crystals are in the mm range, though some reach 3 cm.

Goethite is as widespread as hematite, forming acicular to lath-shaped, brown to black crystals.

Lepidocrocite, though rarer than hematite, is still widespread as cherry-red coatings and inclusions in quartz.

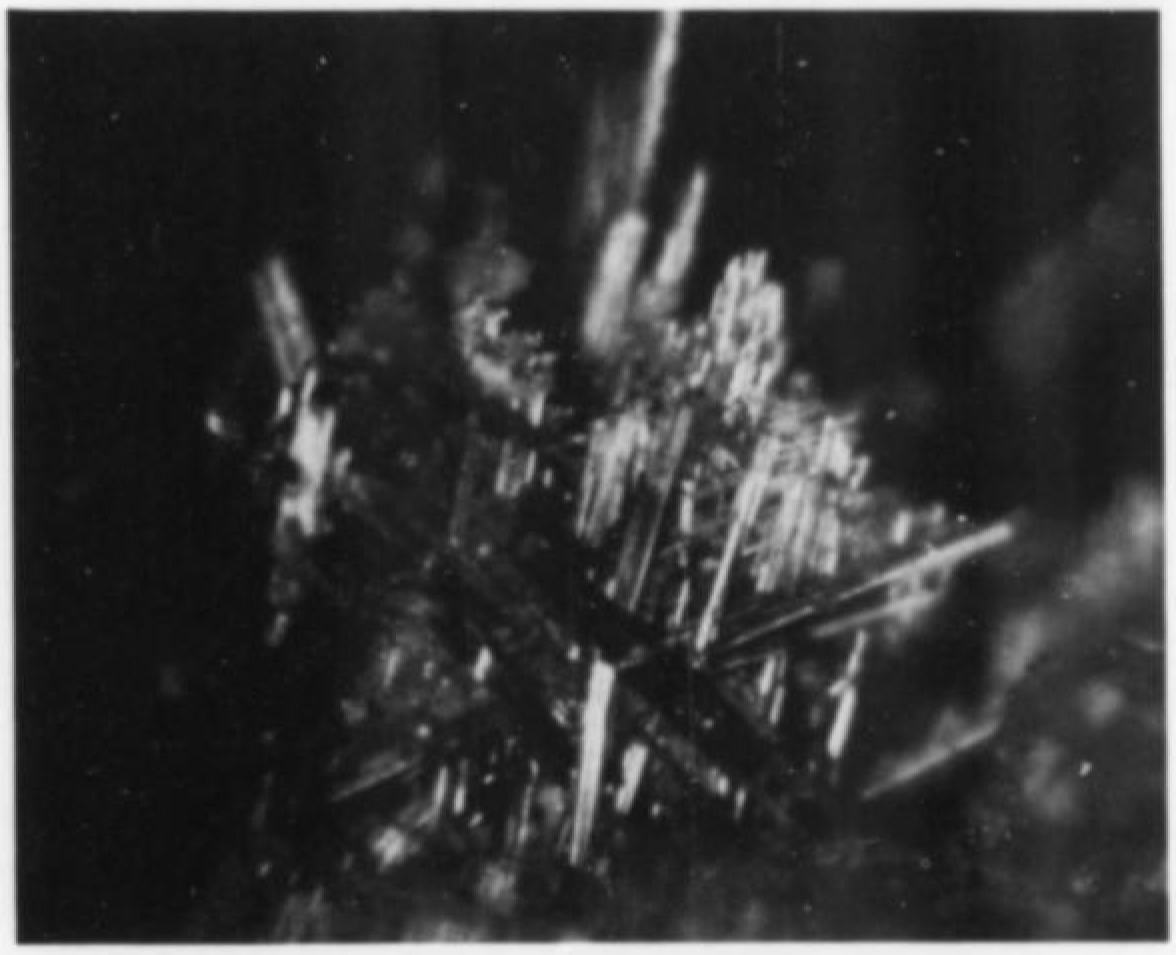

Figure 9. **Rutile, variety sagenite, forming a 0.6-mm network of pale yellow crystals. Julius Weber collection.**

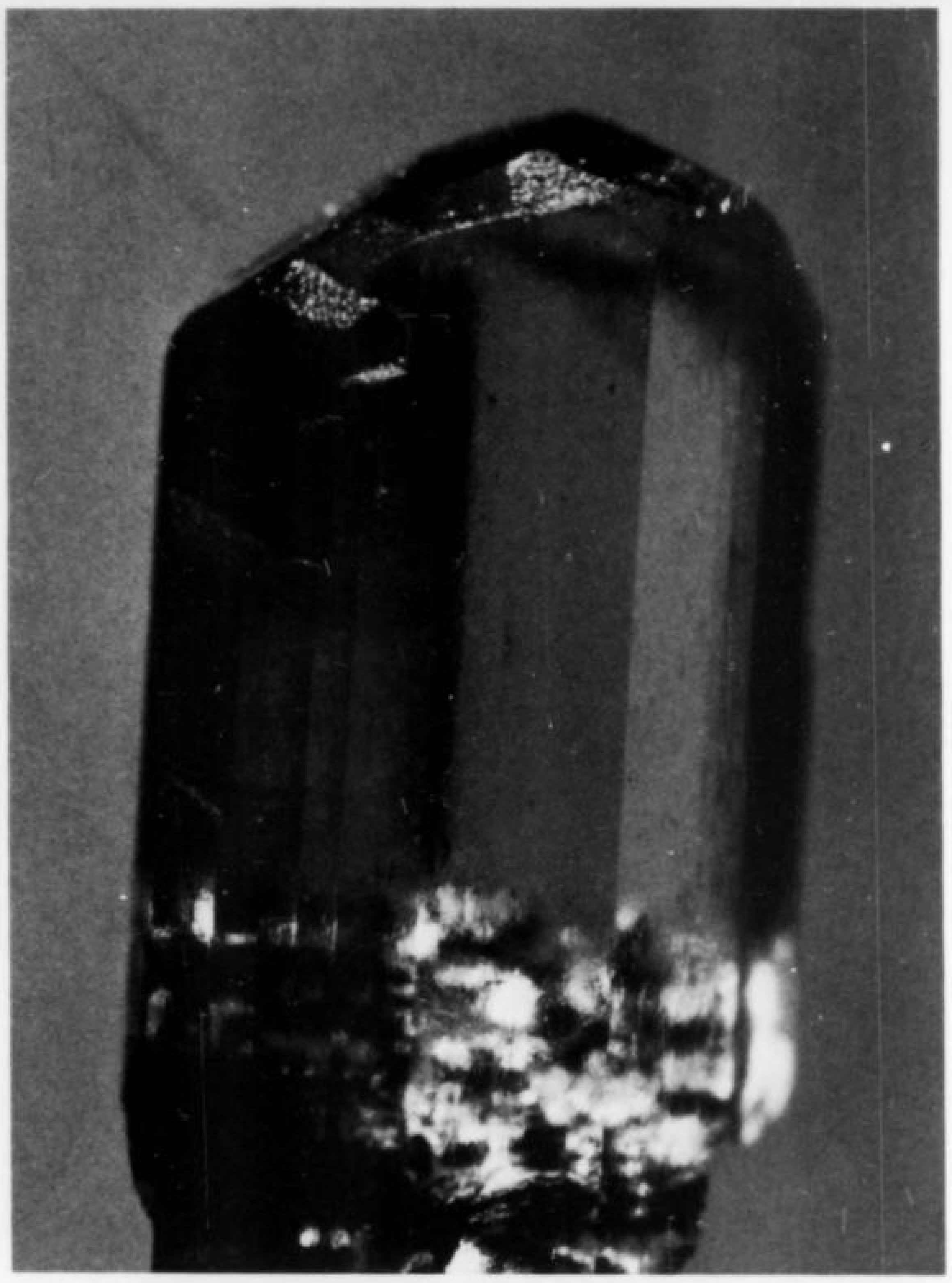

Figure 10. **A 6-mm phenakite crystal, colorless and transparent. Photo by Eric Offermann.**

Bertrandite is less common than phenakite but still occurs in a significant number of pockets. It forms very beautiful and complex crystals and twins to 8 mm in size and white or pinkish in color. It appears to have formed as an alteration of phenakite.

Clay minerals, unidentified as to species, are a major constituent of every pocket. A deep red-brown color is most common, but gray and greenish clays occur as well.

Albite is always present in pockets, at least as inclusions in microcline and commonly as fine, clear, colorless crystals. Polysynthetic, albite and pericline twins are common, and the color ranges from colorless to pink or reddish. Cleavelandite occurs in some pockets. Crystals reach a maximum of about 3 cm.

Microcline occurs in a wide variety of habits, including Baveno, Manebach and Carlsbad twins. The average size is around 2 cm, though crystals to 28 cm have been found. Amazonite is rare but does occur in fine crystals; otherwise the color is typical pale pink. Overgrowths of second-generation microcline in small, simple crystals are common.

Sanidine has been observed as a crust of light brown crystals in a few pockets.

Muscovite, as light gray to greenish sericite, is fairly abundant in many pockets.

Beryl, variety aquamarine, has been found in five pockets and in the spongy area of some pegmatites. Hollow crystals were found in abundance in one spongy pegmatite. The crystals are gemmy, unetched, and reach 1.2 cm in size.

Bavenite has been found in one pocket as whitish crusts of acicular crystals on and in quartz.

Almandine and **grossular** have been found in a number of pockets as small, brown to whitish crystals to 5 mm in size.

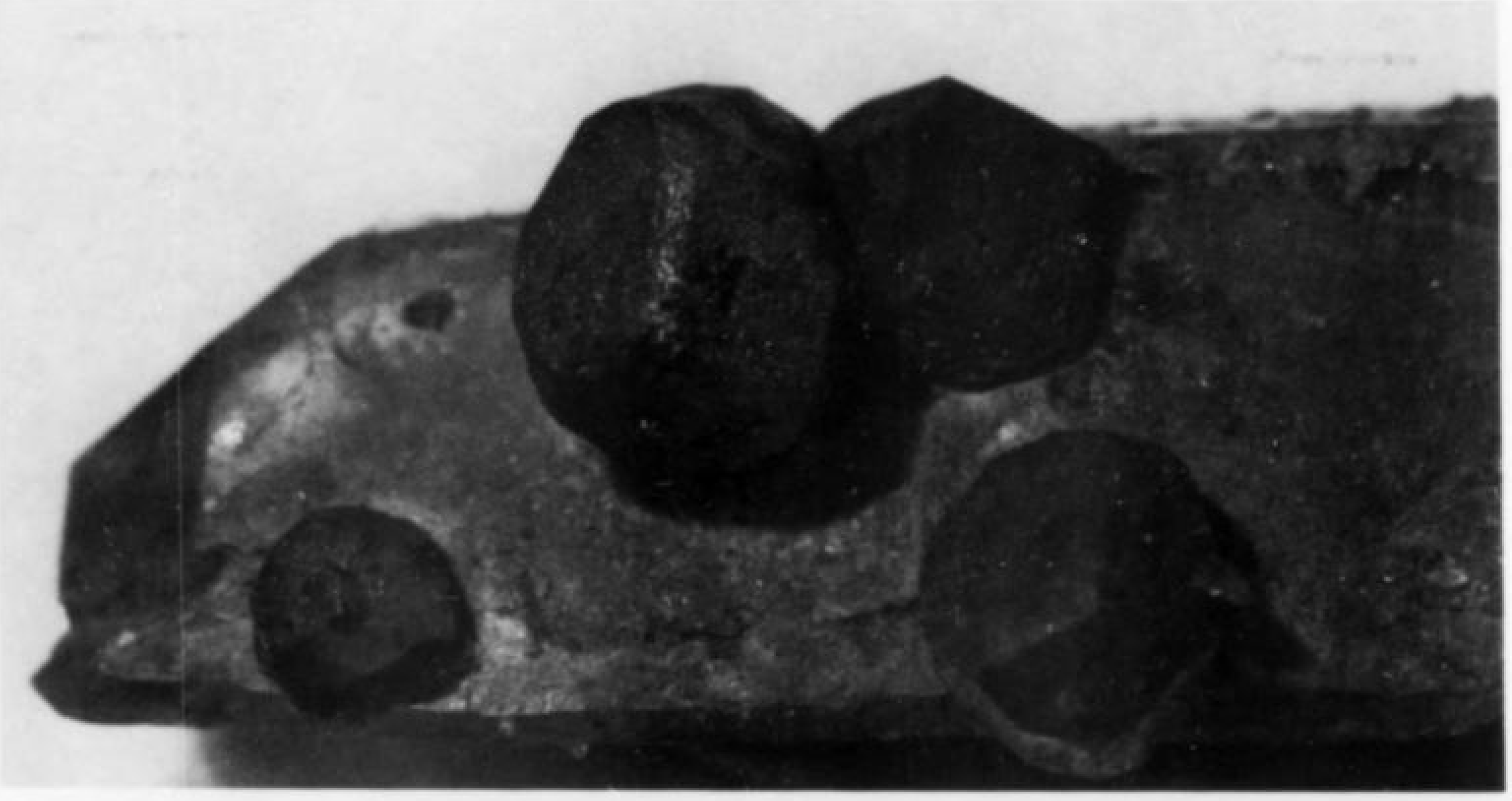

Figure 11. **Phenakite crystals to 9 mm, iron stained on the surface, on smoky quartz. Dean Rein Jr. collection.**

Fluorite occurs as deeply etched and partially dissolved cubic crystals which are purple when found but rapidly fade when exposed to sunlight. Good crystals have not been found.

Calcite occurs only as inclusions in quartz; it has apparently been dissolved away where unprotected. Mangano-calcite and **ankerite** also occur as inclusions.

Siderite occurs as yellow-brown crystals in quartz, and is otherwise represented only by goethite-lepidocrocite-hematite pseudomorphs. The crystals are rhombohedral, typically in parallel growth, and may reach 10 cm.

Parisite-synchisite occurs as altered, mm-sized crystals of striated, prismatic habit.

Phenakite is the most abundant of the rare minerals in the Wausau pluton. It forms rhombohedral to long prismatic crystals, commonly a few mm in size but reaching a maximum of 3 cm. Interpenetration twins are common. The color ranges from white or colorless transparent to wine-yellow, purple and pale pink.

Tourmaline (species undetermined but probably schorl or elbaite) is very rare, usually forming long prismatic crystals of a black to dark green color.

Chlorite is abundant as dark greenish black inclusions in quartz.

Cookeite has been found in only one pocket as greenish brown crusts on other pocket minerals.

Biotite occurs rarely in pockets, as well formed black crystals associated with tourmaline.

Stilpnomelane forms very rare, brownish clusters of crystals in two pockets.

Microlite has been found in only one pocket, as rounded octahedrons of dark brown color. Most are small, but one 2-cm crystal was removed.

Columbite-tantalite is fairly widespread in small amounts. The crystals are small (to 4 mm), lustrous, and black to reddish black.

Xenotime is fairly common, as small (to 1 mm), gemmy, lustrous crystals of simple habit. Crystals colored brown, red, pink, green,

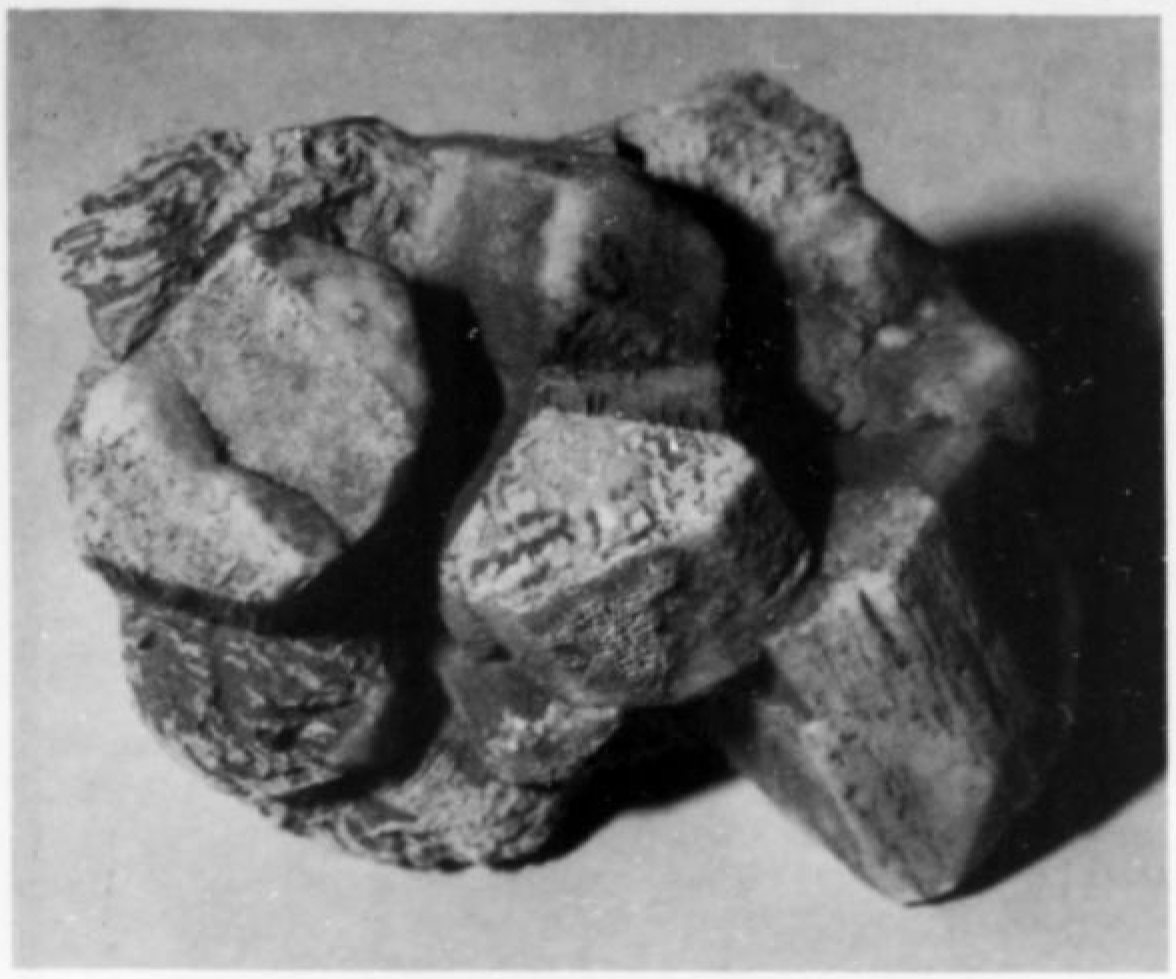

Figure 12. **Microcline, variety amazonite; a 13-cm specimen of bright turquoise-blue color.**

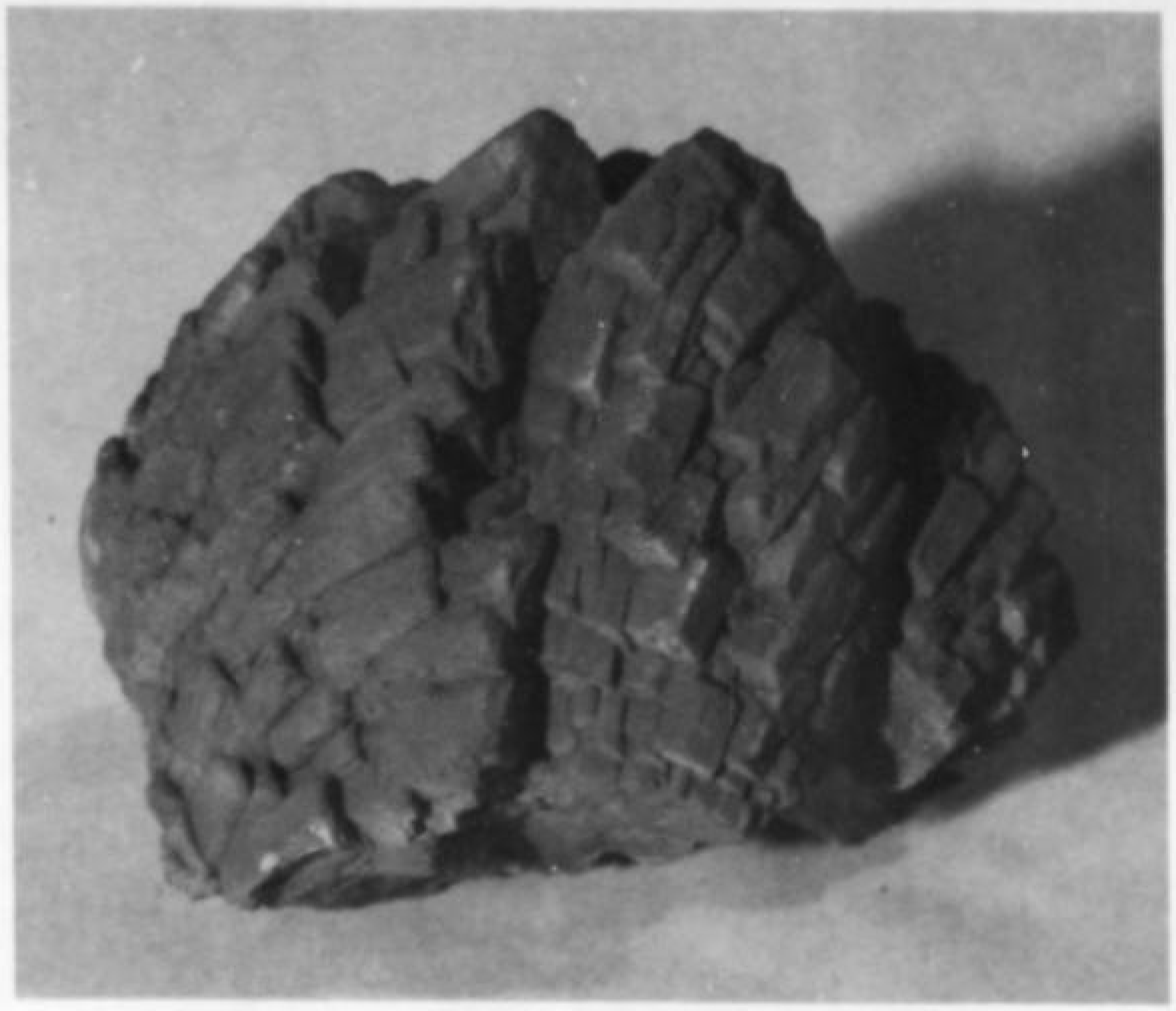

Figure 13. **A 9-cm group of light brown microcline crystals. David Bierbrauer collection.**

yellow, and almost amethystine have been found. The quality compares well to crystals from alpine clefts.

Monazite is much rarer than xenotime, and forms rather crude brown crystals under 1 mm in size.

Barite has been found in only one pocket, as a whitish material without crystal form.

Anhydrite occurs as colorless, clear, prismatic crystals included in quartz.

Other minerals, as yet unidentified, have been found. The potential of the locality for producing more minerals is good, but collecting conditions are difficult.

Identification of the various species was aided by wet chemical tests in nearly all cases. Beryl and bavenite were confirmed by X-ray analyses.

ACKNOWLEDGMENTS

I would like to express my gratitude to the following people: Walter Prey, whose continuing assistance in specimen recovery has been an invaluable help; Dean Matzke, who helped with aerial observations; Carl Wimmer, Robert Thurber, Harold Beilke and Earl Schuette for granting access to the productive areas of the pluton; and Dean Rein Sr., Dean Rein Jr., Walter Taminen, David Feck and David Bierbrauer for providing study specimens and information. (All of the above people are from Wausau.) I would also like to thank the staff of the Mineral Sciences Division of the Smithsonian Institution and Vandall King for help in identification; associate editors Eric Offermann and Julius Weber for photography; Paul B. Moore for helpful observations on the locality; and Wendell Wilson for assistant with the manuscript.

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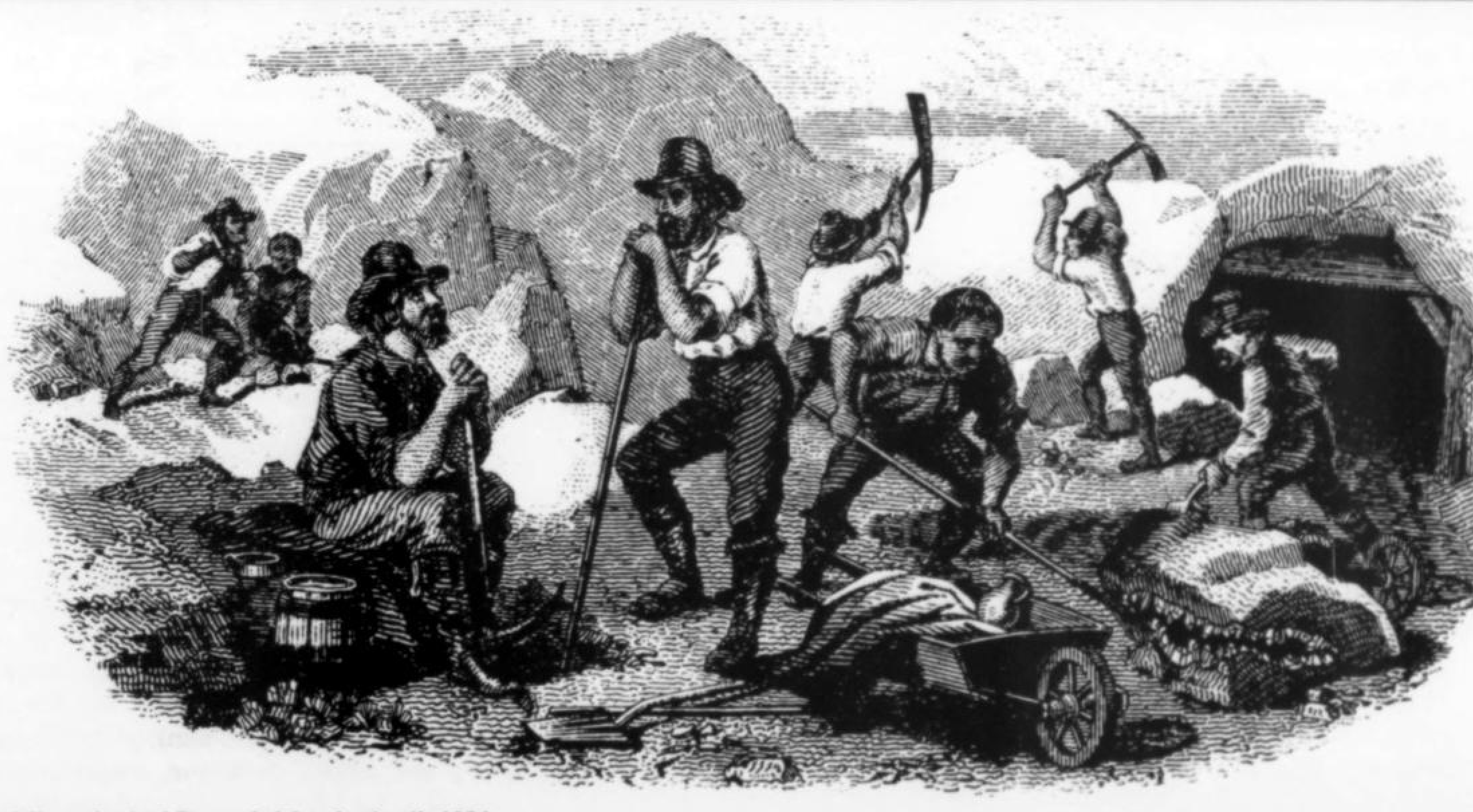

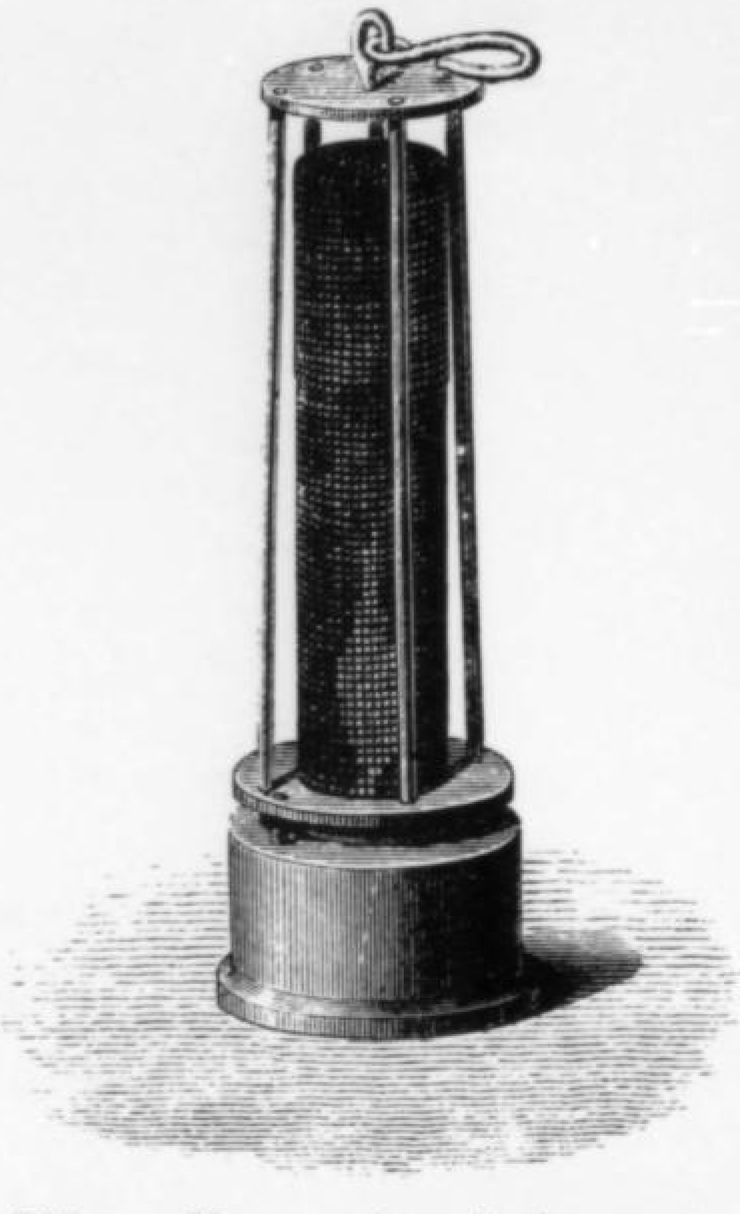

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the Rock Candy mine British Columbia

by **Joe Nagel**
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The Rock Candy mine, located near Grand Forks, British Columbia, is one of the best-known collecting sites in the province. Thousands of good quality specimens of fluorite, barite and quartz have been produced over the past 15 years, enough so that every serious collector has a good chance of encountering at least a few.

HISTORY

The deposit was discovered in 1918 by prospectors who thought the green-colored fluorite was a copper mineral. After further evaluation, the property was acquired by Cominco, Ltd. of Trail, British Columbia. The first production of a few hundred tons of fluorite was carried out by pack animals in 1918. Subsequently, a two-mile aerial tramway was built, and a mill established at the terminus. From 1918 to 1929 the mine shipped approximately 50,000 tons of fluorite, much of it hand-sorted. The mine was worked at three levels; the later stages of mining resulted in the upper and middle stopes breaking through to the surface. The lower adit probably collapsed relatively soon after the mine closed.

Figure 1. **Golden barite crystals on purple fluorite from the Rock Candy mine. The specimen is 4.5 inches across (U.B.C. #S-4835).**

During the summer of 1978, Cominco Ltd. undertook to close all underground openings for safety reasons. This has had the effect of drastically reducing the collecting potential. Fortunately, the company was most cooperative during the present study, and a number of excellent specimens were recovered for the University of British Columbia.

GEOLOGY

The mineralized area lies completely within a large body of syenite, probably Tertiary in age. Nearby is a granodiorite instrusion whose contact with the syenite is not exposed. A number of closely related dikes cross-cut both units; these may be related in some way to the mineralization (Wilson, 1922).

The deposit consists of a series of closely spaced, steeply-dipping veins striking north. The outcrop of this vein system extends approximately 500 feet, with a maximum width of 45 feet. The minerals present, in order of abundance, include fluorite, barite, quartz, calcite, pyrite and kaolinite (Wilson, 1922). The quartz occurs both as chalcedonic stringers and as drusy crystals lining vugs.

The most important feature of the deposit with respect to the collector is the abundance and size of the cavities. Small vugs less than 2 inches are exceedingly common throughout the deposit. The largest vug I have seen was approximately 15 feet long, with a diameter of 3 feet! A thick mud, probably kaolinite-rich, fills most of the large cavities; in many cases it exhibits small-scale layering. Almost all of the large vugs are surrounded by concentric fracture systems, and are at least in part collapsed, the collapsed debris often cemented with barite. The larger pockets have produced wall-plates weighing over 100 pounds. As luck would have it, the better barite crystals were generally on the floor of the vugs and suffered damage from the collapse.

The paragenesis of the deposit is complex. Both the fluorite and barite usually

Figure 2. **The Rock Candy mine, photographed during the summer of 1978.**

Figure 3. **Location map.**

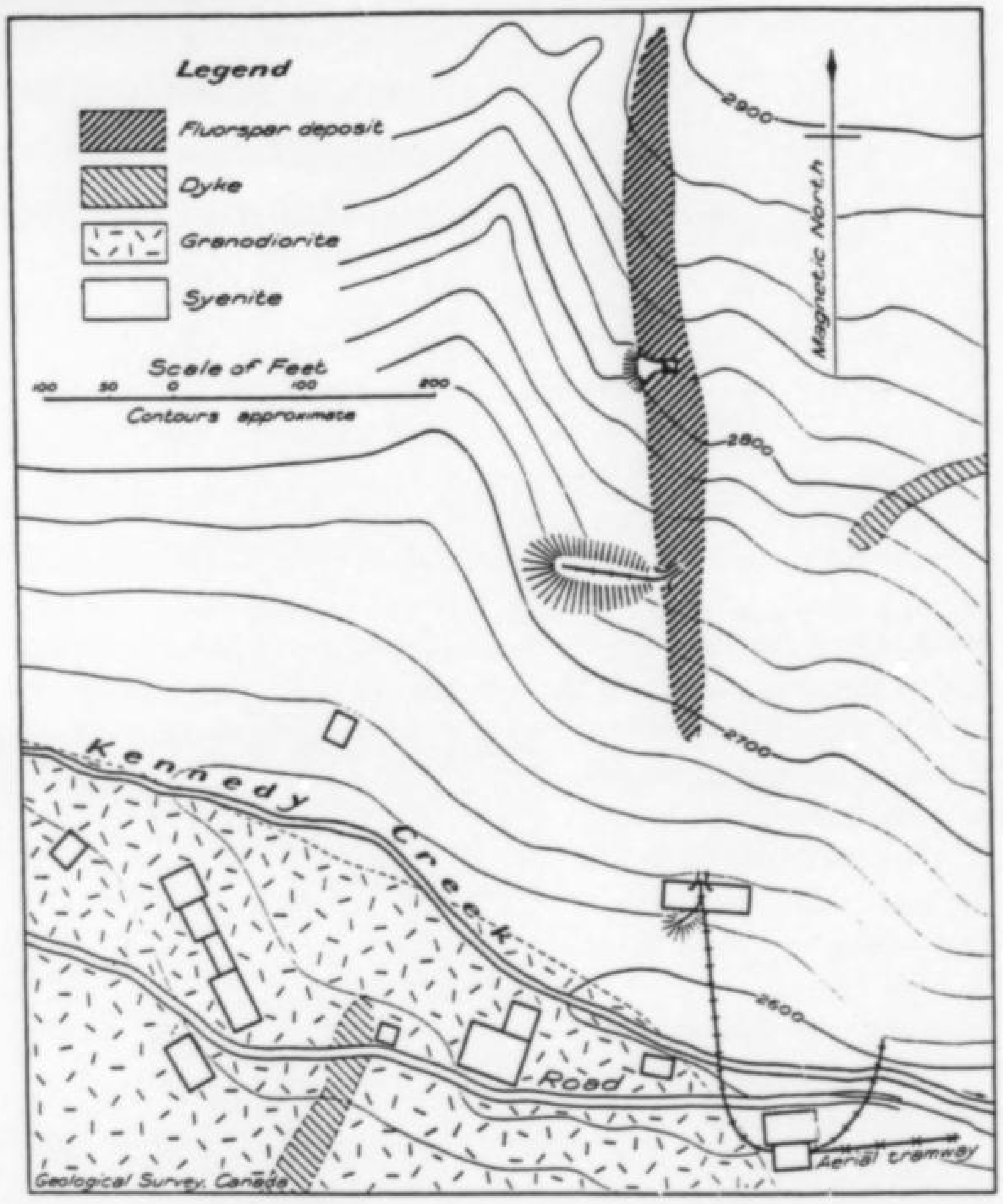

Figure 4. **Geological map of the Rock Candy mine (from Wilson, 1929).**

show many growth zones, commonly alternating with quartz. At least two distinctly different generations of barite are present, the later one usually of better specimen quality. Although a detailed study of the paragenetic sequences has not been done, fluorite was generally the first phase to form, barite and quartz were the last. This observation, of course, is based upon the present exposure, which represents less than 30 percent of the original workings.

MINERALS

Three minerals are of interest to the collector, namely barite, fluorite and quartz. Well crystallized pyrite and calcite are mentioned in an early report (Wilson, 1922), but to my knowledge none have been recently collected. Some of the barite and fluorite combinations are superb and rival specimens from many other localities.

Fluorite is the predominant mineral in the deposit. Most is green, although some is colorless or shades of purple. The cube and octahedron forms dominate, with crystals ranging from sharp cubes to sharp octahedrons. When both forms are developed equally and alternated, the result appears botryoidal. Dodecahedral faces are less common, but not unusual. Other forms are present as well but have not been identified. Most common are octahedral crystals composed of stepped cubes. Some specimens have a very high surface luster, which greatly adds to their appeal, and crystals exceeding 5 inches along the octahedral edge have been collected.

Barite is relatively abundant in the deposit, and usually occurs as well formed, stout, tabular crystals up to 4 inches across. Most are golden yellow, although colorless and grey examples are not uncommon. Some are glassy and transparent, and have furnished faceting material. The barite is found in distinct zones within the mine; pockets in these zones, of course, furnish the most desirable specimens. In the larger vugs "floater" crystals up to 4 inches are occasionally found.

Quartz, as drusy linings, is found in almost all parts of the mine. These specimens are not remarkable in themselves, but provide an attractive matrix for barite and fluorite, in that the quartz is generally white and lustrous. In many specimens the quartz has encrusted underlying octahedral fluorite crystals, whose shapes are clearly visible. These have often been mistakenly labeled as pseudomorphs, but no replacement has occurred.

Worth mentioning is the fact that, although the collapsing of the pockets damaged many potential specimens, it also made possible the formation of "floater" plates. These are generally less than 6 inches across, and may be coated on all sides with barite crystals.

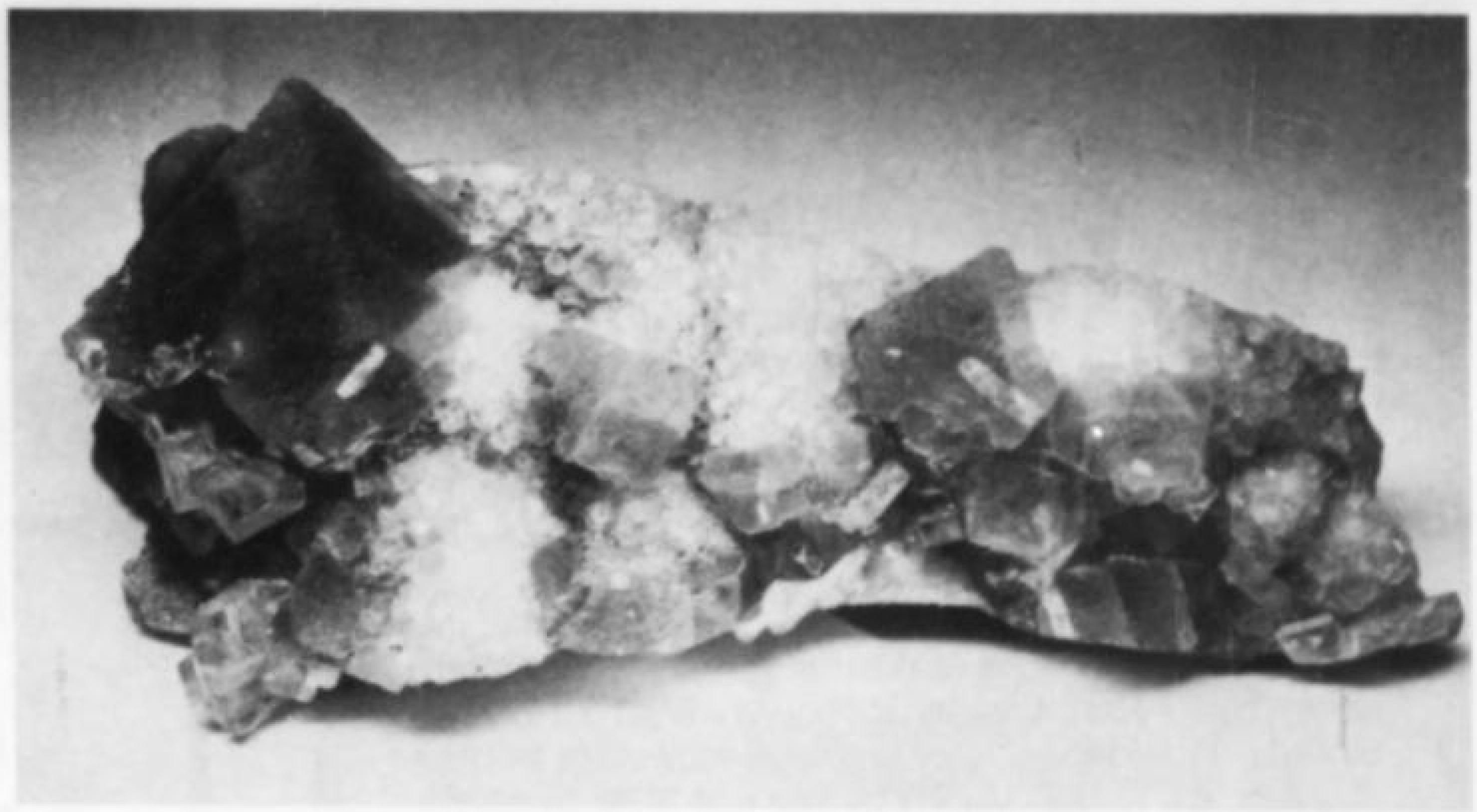

Figure 5. **Green fluorite "octahedrons" composed of stepped cube faces, with golden barite on white fluorite. The specimen is 7 inches across (U.B.C. #S-4868).**

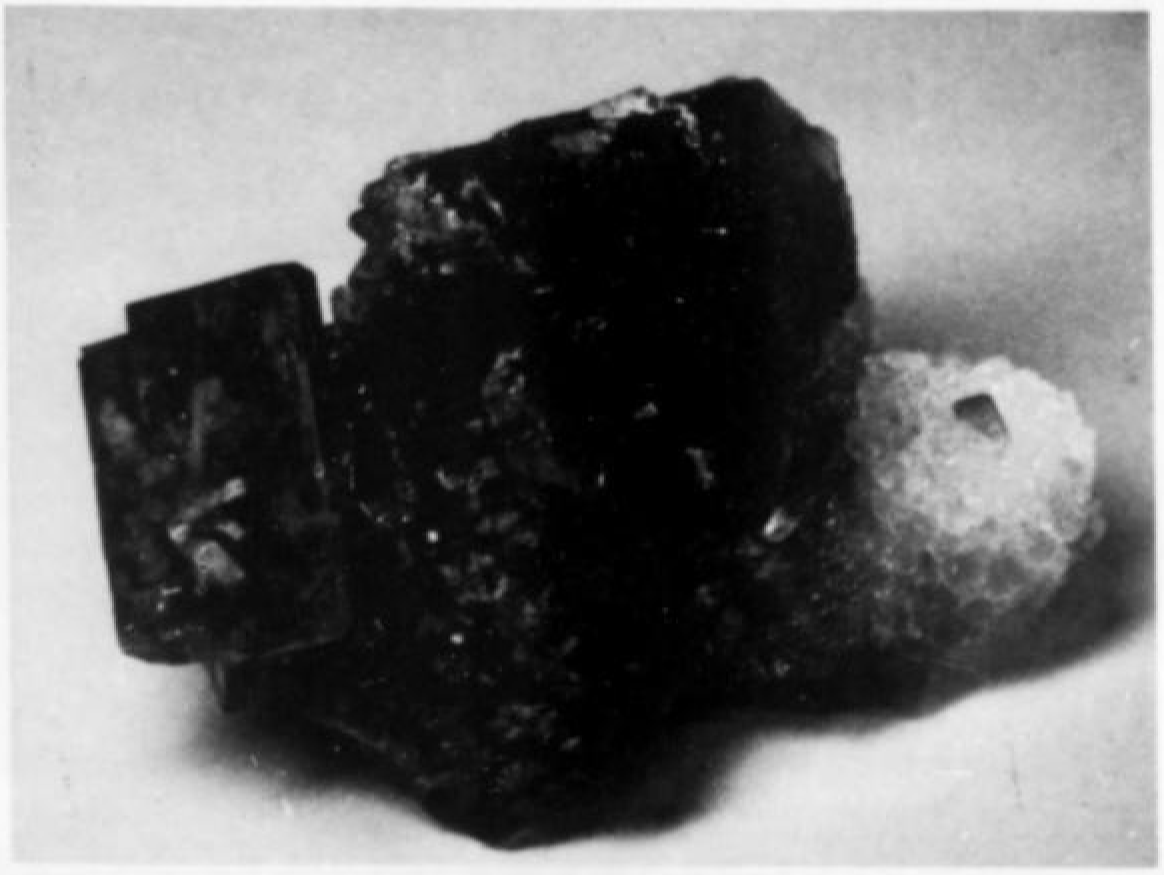

Figure 6. **Dark green fluorite octahedra with a large golden barite crystal perched on the left side. The specimen is 4.5 inches across (U.B.C. #S-4847).**

Figure 7. **White drusy quartz encrusting fluorite octahedra. The specimen is 5.5 inches across (U.B.C. #S-4852).**

Figure 8. **Lustrous golden barite crystals on purple fluorite. The specimen is 10 inches across (U.B.C. specimen).**

These are sometimes difficult to display, as the best side is not always obvious!

FUTURE COLLECTING

Although the property is presently posted and fenced, it is possible that it will be opened to collectors in the future. As a result of extensive blasting, however, there is an abundance of rubble and little exposed outcrop, so the chance of encountering any more large pockets has been greatly reduced.

The rubble undoubtedly contains some specimens, although their recovery will be a matter of luck and hard work. The old dumps still hold some promise; the best fluorite specimen I have collected came from one of these. Anyone wishing to see examples of Rock Candy mine specimens is welcome to visit the M. Y. Williams Geological Museum at the University of British Columbia, where some of the better ones are on display.

ACKNOWLEDGEMENTS

I wish to thank Cominco Ltd. and White Mine Development Ltd., of Vancouver, B.C., for their cooperation during the salvage project. They are to be commended for their attitude at a time when all too often the corporate response to collecting requests is an immediate and expedient NO. Ernie Perkins and Dave Schneider assisted in collecting during part of the recovery. Special thanks go to Rod Tyson and John Gorham of Edmonton, Alberta, whose experience and hard work made much of the specimen recovery possible. I also thank Carlo Giovanella, Rod Tyson and John Gorham for comments on the manuscript.

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Hexoctahedral Fluorite Crystals *from* Old Chelsea, Québec

by **J. D. Grice**
National Museum of Natural Sciences
National Museums of Canada
Ottawa, Ontario K1A 0M8

During 1974, road construction near Old Chelsea, Québec, revealed some exceptional fluorite specimens. The road cut is on Highway 105, Hull Township, Gatineau County, located 10 km northwest of Ottawa-Hull. The country rock in the immediate area is primarily a diopside-rich marble while the main constituent of the fluorite-bearing pocket was fine grained calcite. Only one pocket was discovered and it measured approximately 100 cm long, 50 cm high and 30 cm deep; this pocket yielded some 20 good crystals and 100 fragments. The fluorite was associated with well developed crystals of calcite, chalcopyrite, marcasite and pyrite.

The pale blue-green, translucent octahedra are deeply pitted (Fig. 1). The most spectacular specimens are the octahedra that have transparent, pale blue-green oriented overgrowths on each apex (Fig. 2); these resemble the fluorites of Rossie, St. Lawrence County, New York (Whitlock, 1910). On some specimens the overgrowths are not complete. The largest crystals measure 3 cm along the *a*-axis. Reflecting goniometric measurements on the overgrowths yielded the following forms: dominant hexoctahedron *s*{731} with minor cube *a*{100}, octahedron *o*{111}, dodecahedron *d*{110} and trapezohedron *n*{10.1.1} (Fig. 3). Octahedral and dodecahedral faces are pitted, hexoctahedral faces are frosted and cube and trapezohedral faces are bright. Trapezohedral faces developed consistently in pairs with respect to the four-fold axes of symmetry. This prevalent pseudobilateral symmetry resulted from crystals having one slightly-preferred growth direction during formation (Fig. 4). Many specimens show well developed parallel growth.

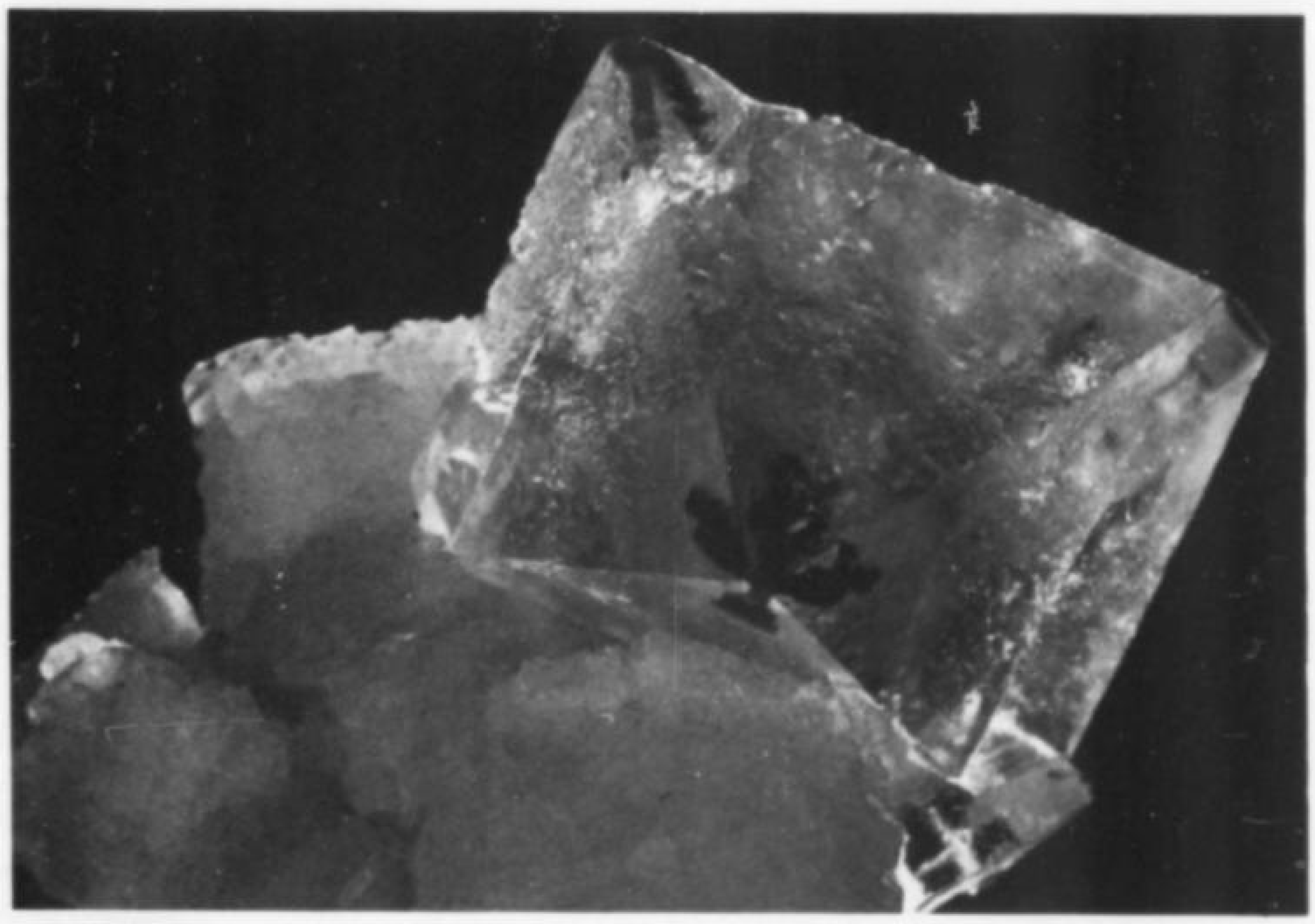

Figure 1. **Pale blue-green fluorite on cream-colored calcite. Octahedron measures 1.1 cm across (NMNS #34644). Photo: H. Foster.**

Figure 2. **Pale blue-green fluorite octahedron with hexoctahedral overgrowth. Crystal width is 2.3 cm (NMNS #34681).**

In addition to the unusual habit of these fluorites, mention should be made of the violet color-centers oriented along the four-fold axes and concentrated at the octahedral apices (Fig. 1) of the primary crystal. The square plates of violet color parallel the (100) plane (Fig. 4). Spectrochemical analysis on a bulk sample did not detect titanium, vanadium or chromium; indicated traces (less than 100 parts per million) of strontium and cerium; and measured 0.02 weight percent iron and 0.03 weight percent yttrium. Probe analyses were not sensitive enough to indicate any difference in chemical composition between the blue-green and violet color-centers. Light blue coloration has been attributed to minor contents of yttrium (G. Calas, 1972). The yttrium ion (Y^{3+}) is associated with a vacant fluorine ion (F^-) site, which is referred to in the literature as an F^- center. The F^- center traps a non-bonded pair of electrons to maintain electrical neutrality throughout the crystal. These free electrons interact with visible light to give an overall blue color to the crystal. Of particular interest in the Old Chelsea fluorite are the violet color-centers. The strict adherence to symmetry of the violet indicates structural control rather than random inclusions; their positioning at points of maximum crystal growth rate (i.e. octahedral apices) suggests crystal defects as a likely cause of color. The nature of these defects is a subject of much discussion. Braithwait *et al.* (1973) attributed the purple color in fluorite to the trapping of calcium atoms in much the same manner as the trapping of electrons discussed above.

ACKNOWLEDGEMENTS

The author would like to thank two staff members of the National Museums of Canada: H. Foster for the excellent photographs and J. Van Velthuizen for the drafting.

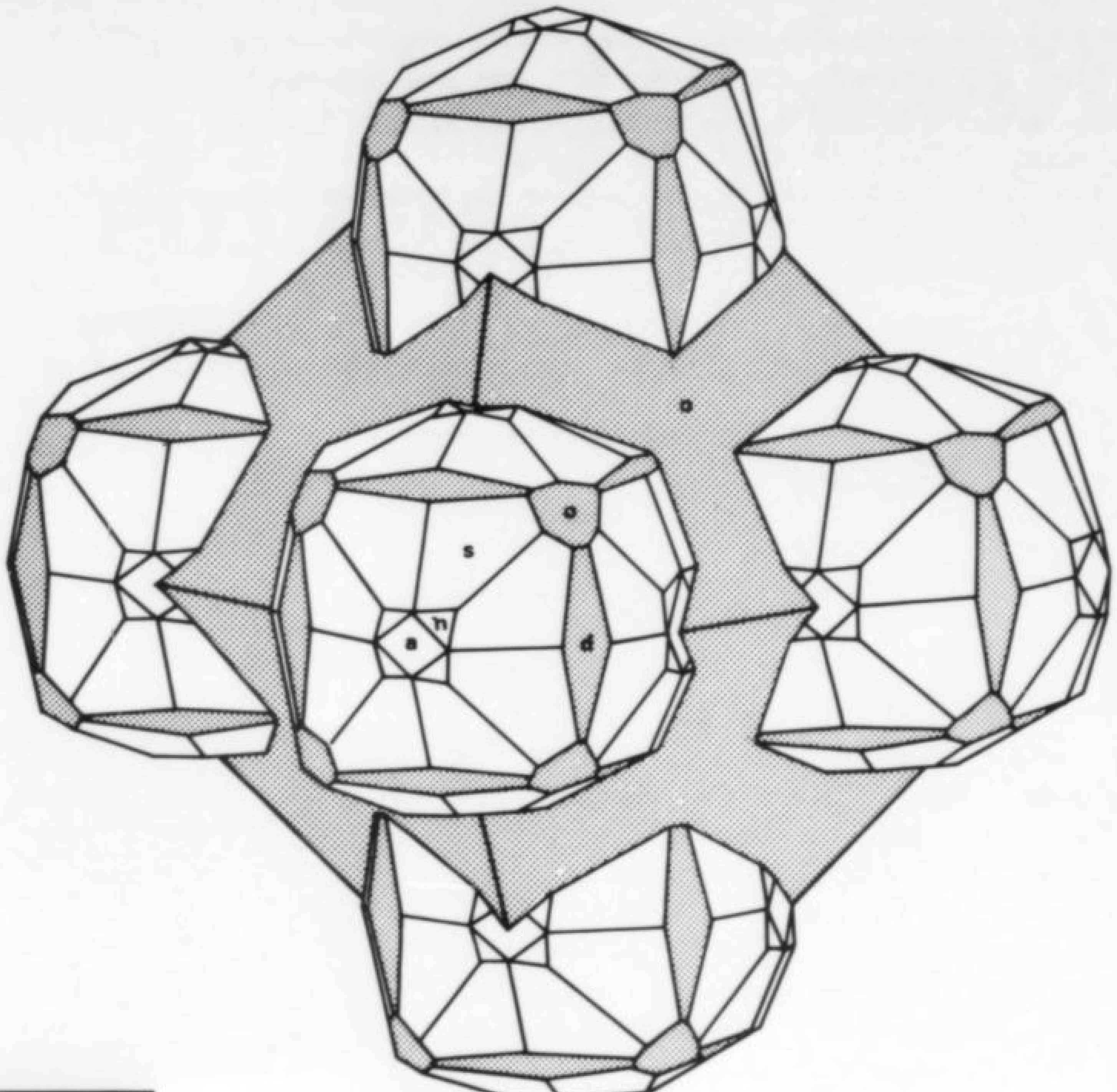

Figure 3. **Idealized drawing of fluorite octahedron with complex overgrowth. Crystal forms are octahedron $o\{111\}$, hexoctahedron $s\{731\}$, dodecahedron $d\{110\}$, trapezohedron $n\{10.1.1\}$ and cube $a\{\bar{1}00\}$.**

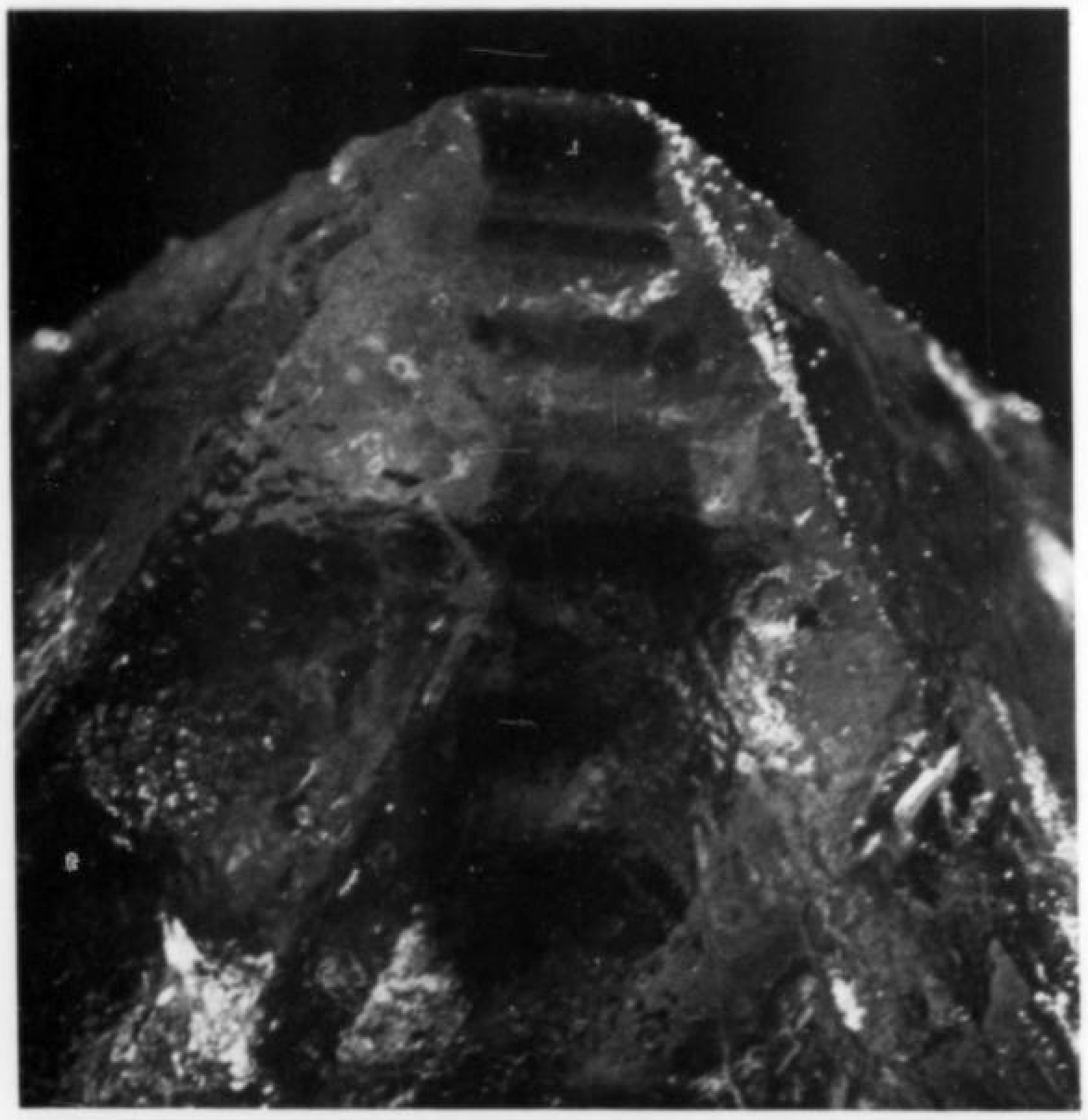

Figure 4. **Fluorite octahedral apex with violet color planes paralleling (100). Width of field of view is 0.8 cm. (NMNS #43171). Photo: H. Foster.**

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Microminerals

by **Bill Henderson**

AUSTRALIAN MICROMINERALS

When I was young, most of the kids in my neighborhood firmly believed that if they dug a hole straight down, they would come out in China. With the cynicism of old age, I checked this out lately, and it is not so! They would have reappeared just off the southwest coast of Australia. Inspired by this revelation, I decided to write this column on the surprising number of excellent microminerals found in Australia, and on Australian micro localities and collectors. I have arranged the mineral descriptions by states, and a section on swapping with Australian collectors follows. Localities are shown in the maps in Figure 1.

South Australia

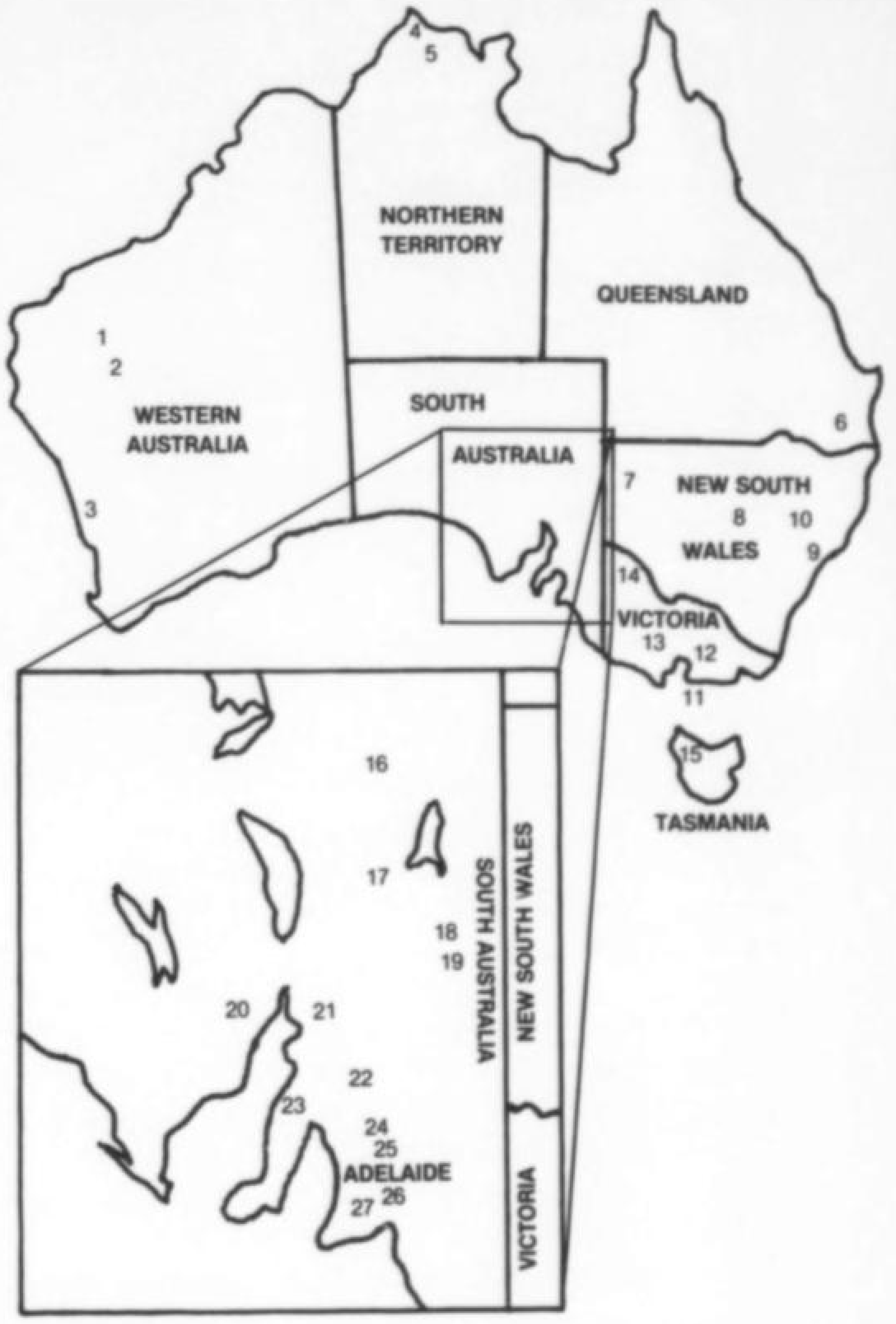
Far more than half the microminerals in my collection from Down Under are from South Australia, and the same is true for the number of localities represented. It is a heavily mineralized area, and much mining activity is currently going on.

One of the finest localities in the state is Reaphook Hill, known for its superb phosphate minerals. An excellent article on this location written by Chris W. Johnston and R. J. Hill appeared in the January–February 1978 issue of the *Record*. Chris is a schoolteacher by profession, but has held a lease on the property in order to work it for specimens. He is a collector/dealer and, by exchange and purchase from him and Jim Johnson, about whom more later, I have acquired specimens of most of the interesting species found there. The finest mineral from Reaphook Hill is scholzite (Fig. 2), which occurs in columnar and radiating crystals up to a centimeter or so in length. Some of the larger crystals are a pale green in color, and the mineral occurs in a variety of habits. In addition to scholzite, I have obtained fine specimens of tarbuttite, parahopeite, collinsite and phosphophyllite. Some of the pseudomorphs from Reaphook Hill are extremely interesting, as for example, phosphophyllite after parahopeite and hemimorphite after smithsonite on the same specimen!

Another fantastic phosphate locality in South Australia is the Iron Monarch quarry at Iron Knob. Barry Porter (who would like to exchange with overseas micro collectors) sent me a fine assortment of specimens recently, plus a description of the locality. He writes:

"The quarry is about 30 miles west of Whyalla. The original hill was about 900 feet above the surrounding plain and, at the moment, mining is down to 150 feet below ground level. To date, approximately 130 million tons of plus-60 percent iron ore have been mined, and about three times this amount of lower grade ore and mullock. The geology involves a large core zone of high grade hematite ore cut by numerous basic igneous dikes of very fine grained amphibolite. To the north, the ore is bordered by a huge body of jaspillite. The other boundaries of the ore are schists and gneisses enriched with low grade hematite. The high grade ore contains very little in the way of specimen material, and it is the enriched border zones and the jaspillite that produce most of the good material."

Besides the phosphate minerals, many of which are superior to or unlike any I have seen previously, there are a number of excellent manganese minerals to be found. A partial list of the specimens sent me by Barry is as follows: montgomeryite (Fig. 3) in sharp, radiating white laths with white wardite octahedrons and white balls of crandallite; long, pink to white wavellite crystals with crandallite crystals; superb, glassy, clear apatite crystals on and enclosing yellow cyrilovite crystals; white, doubly terminated, strengite crystals with and altering to bright



Western Australia
1. Ashburton Downs
2. Milgun Station
3. Minyulo Well

Northern Territory
4. Rum Jungle
5. Moline

Queensland
6. Wolfdene

New South Wales
7. Broken Hill
8. Tottenham
9. Unanderra
10. Warrumbungle and Cassilis

Victoria
11. Flinders
12. Narre-Warren quarry
13. Tylden and Trentham
14. Ouyen

Tasmania
15. Dundas

South Australia
16. Billy Springs
17. Reaphook Hill
18. Dome Rock
19. McMahon pegmatite
20. Iron Knob
21. Spring Creek
22. Burra
23. Port Clinton
24. Kapunda
25. Angaston
26. Preamimma mine
27. Noarlunga

Figure 1. **Map of localities in Australia; inset: southeastern South Australia.**

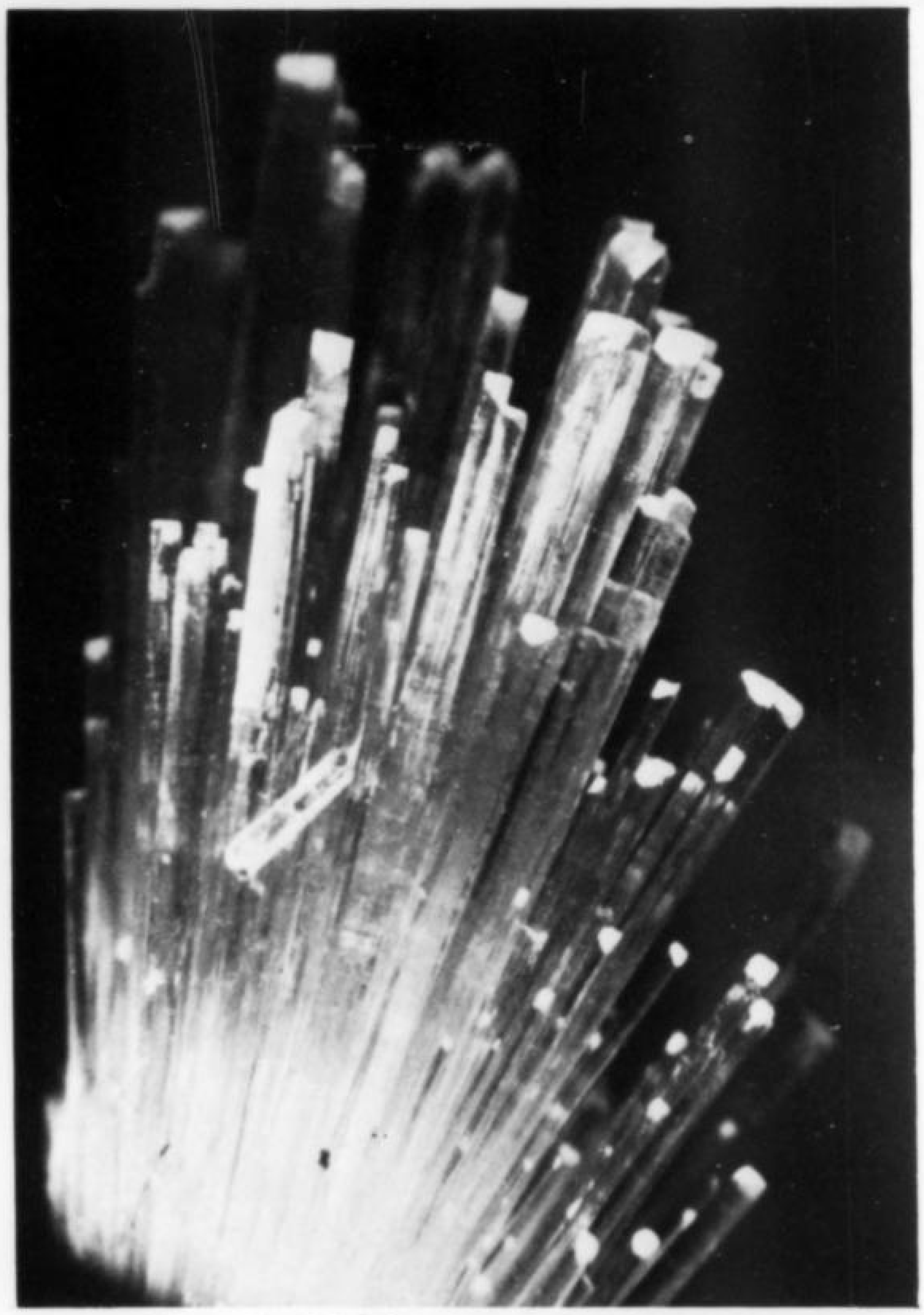


Figure 2. **Scholzite, spray of 1.5-cm transparent, colorless crystals, tips of crystals pale yellow-green; Reaphook Hill, South Australia. Bill Henderson photo.**

lemon-yellow cyrilovite (Fig. 4); crude crystals of deep blue turquoise; pea-green kidwellite balls with euhedral strengite; gorceixite casts after apatite (Fig. 5); white montgomeryite laths on deep pink ferrian variscite; woodhouseite after wavellite associated with euhedral woodhouseite; crandallite after or enclosing wardite; pyrolusite; pyrolusite after manganite; wavellite, crandallite and millisite. Interestingly, although this location seems to be Barry's home turf, Jim Johnson has sent me the finest ferrian variscite from Iron Knob in the form of fair size, rounded aggregates of deep raspberry-red crystals on dark grey, almost black manganese oxides (Fig. 6). These specimens make a truly superb color combination. At the moment, there seems to be some dispute as to whether this material is variscite, ferrian variscite, strengite or hureaulite, but it is pretty enough so that I hardly care.

Figure 3. **Montgomeryite, 4-mm group of white laths with white wardite octahedrons; Iron Monarch quarry, Iron Knob, South Australia. Photo by Vi Anderson.**

Australia seems to have a monopoly on minyulite, a rare potassium aluminum phosphate. Jim Johnson has sent me the mineral from the Moculta quarry in Angaston and from Olivers quarry in Noarlunga, while Barry Porter has sent it from St. Johns quarry in Kapunda. All these localities are in the state of South Australia, while the type locality is at Minyulo Well in Dandaragan, Western Australia. Jim even tells me there is still another locality at Wolfdene in Queensland. At least at Olivers quarry and St. Johns quarry, the minyulite occurs with wavellite. Since both are in a radiating, columnar habit most frequently and both are colorless and transparent, it is possible to confuse the two. However, as shown in Figure 7, the minyulite crystals have a tetragonal or pseudotetragonal form much like natrolite, while wavellites have a flat or diamond-shaped cross section. Thus, the terminations and cross sections of the two minerals are quite different.

Fluellite, an aluminum fluorophosphate, occurs at the Moculta, St. Johns and Wolfdene localities as well. It is interesting that the minyulite-fluellite-wavellite association is found so often in Austra-

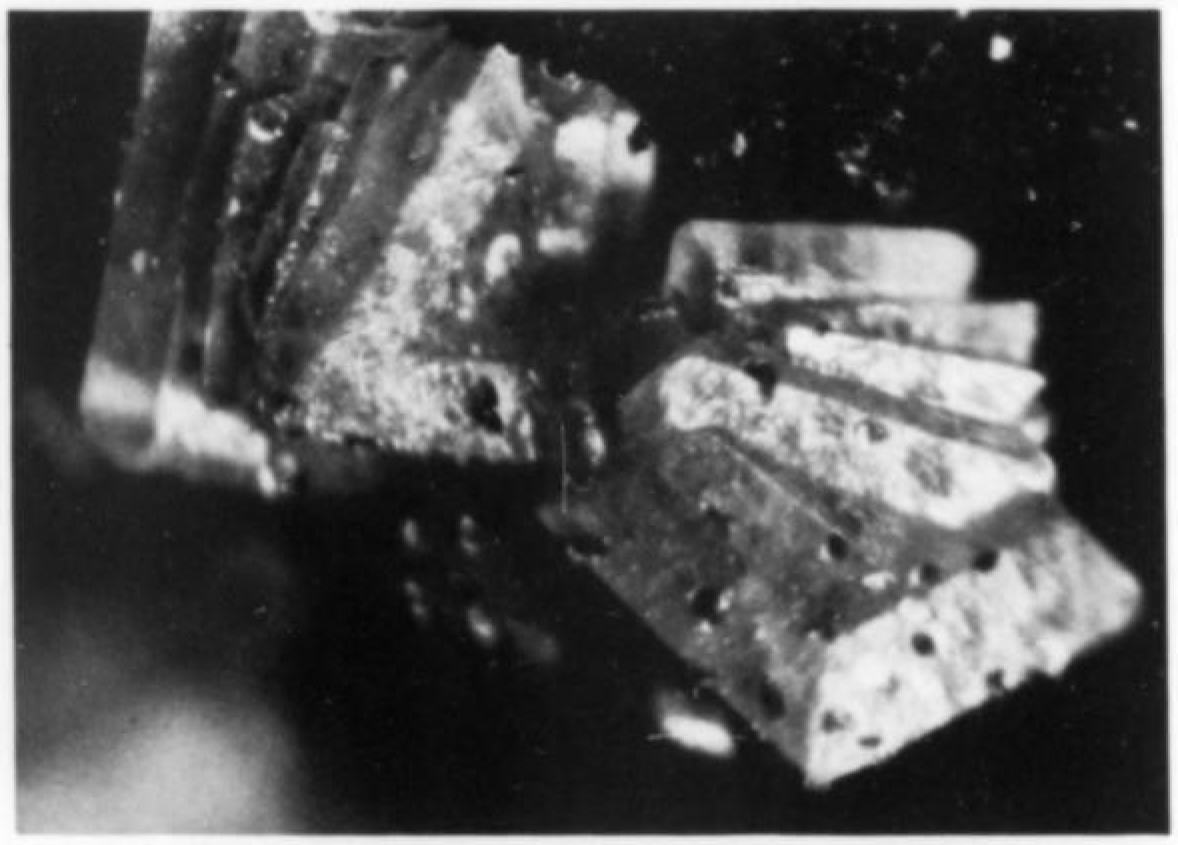


Figure 4. **Opaque, deep yellow cyrilovite pseudomorphs after strengite with unaltered, pale pink, translucent crystals, about 1 mm groups, on jaspillite; from Iron Monarch quarry, Iron Knob, South Australia. Vi Anderson photo.**

Figure 5. **Opaque, pink, 2-mm casts of gorceixite after apatite with red-black hematite plates on hematite and quartz; Iron Monarch quarry, Iron Knob, South Australia. Photo by Bill Henderson.**

Figure 6. **Raspberry-red, 5-mm group of ferrian variscite crystals on black manganese oxides; Iron Monarch quarry, Iron Knob, South Australia. Photo by Bill Henderson.**

lia, and I wonder why these minerals are not reported more often elsewhere. The best fluellite crystals (Fig. 8) are quite large, very well formed, transparent to translucent, and far superior to the only others I have (from Hagendorf-Sud, West Germany). The single specimen I have from the St. Johns quarry shows all three minerals in association. Jim Johnson and Barry Porter, as well as other Australian micromounters, appear to have these species. In addition, Joe Mooney has sent me fluellite of a completely different habit from a locality near Port Clinton. There, the fluellite occurs as aggregates of white, almost opaque crystals. Jim Johnson writes that the fluellite at three of these localities occurs in altered breccia, probably originally a bone breccia.

From the Billy Springs mine in the northern part of South Australia, Barry Porter has sent me some really superb zinc minerals. The color combination and clean, sharp nature of the material is absolutely breathtaking, the species present being sky-blue aurichalcite in radiating laths on and with snow-white hydrozincite and colorless, glassy, very well formed hemimorphite crystals. I have never seen better. Col Price tells me that excellent, pseudocubic anglesite and acicular pyromorphite with wulfenite are also found there.

Jim Johnson has sent me material from a number of other locations in South Australia. From the Preamimma mine, an arsenate locality near Callington, he sent azurite, jarosite, scorodite, pharmacosiderite, olivenite and lavendulan. Not all of these are exactly photogenic, but the lavendulan is extremely nice. It occurs as robin's-egg blue crystals and crystal aggregates, and also as pseudomorphs after arsenopyrite. According to Jim this is the third occurrence of lavendulan in South Australia, which is not bad for such a rare mineral. From Dome Rock, Jim sent clinoclase and conichalcite pseudomorphs after olivenite (are all Australia micro specimens pseudomorphs, or does it just seem that way?). He has also sent superb, elongated barite crystals, glassy clear (Fig. 9) from the northern Flinders Range, bright red, very tiny bermanite crystals on triplite from McMahon's pegmatite, and nice leaf gold from the Balhannah mine, south of Adelaide.

As if the list of localities in South Australia were not yet long enough, I will list still two more described by Col Price in a long letter he sent me about Australian micro minerals. He writes:

"The open cut operation at Burra in the northern part of the state recently gave up fine specimens of libethenite, azurite after libethenite, pseudomalachite after libethenite, and pseudomalachite. Most of this material is still under investigation.

"Brian Beyer of Laura has also found a number of very interesting species from an old cópper mine at Spring Creek that for years had only yielded malachite and cuprite. Now that a few micro collectors are viewing the material under a glass, all sorts of things are coming to light. These include nice crystals of olivenite, pseudomalachite, chlorotile, connelite and what I believe to be rosasite. Curiously, rosasite was officially reported from Australia for the first time only a few months ago."

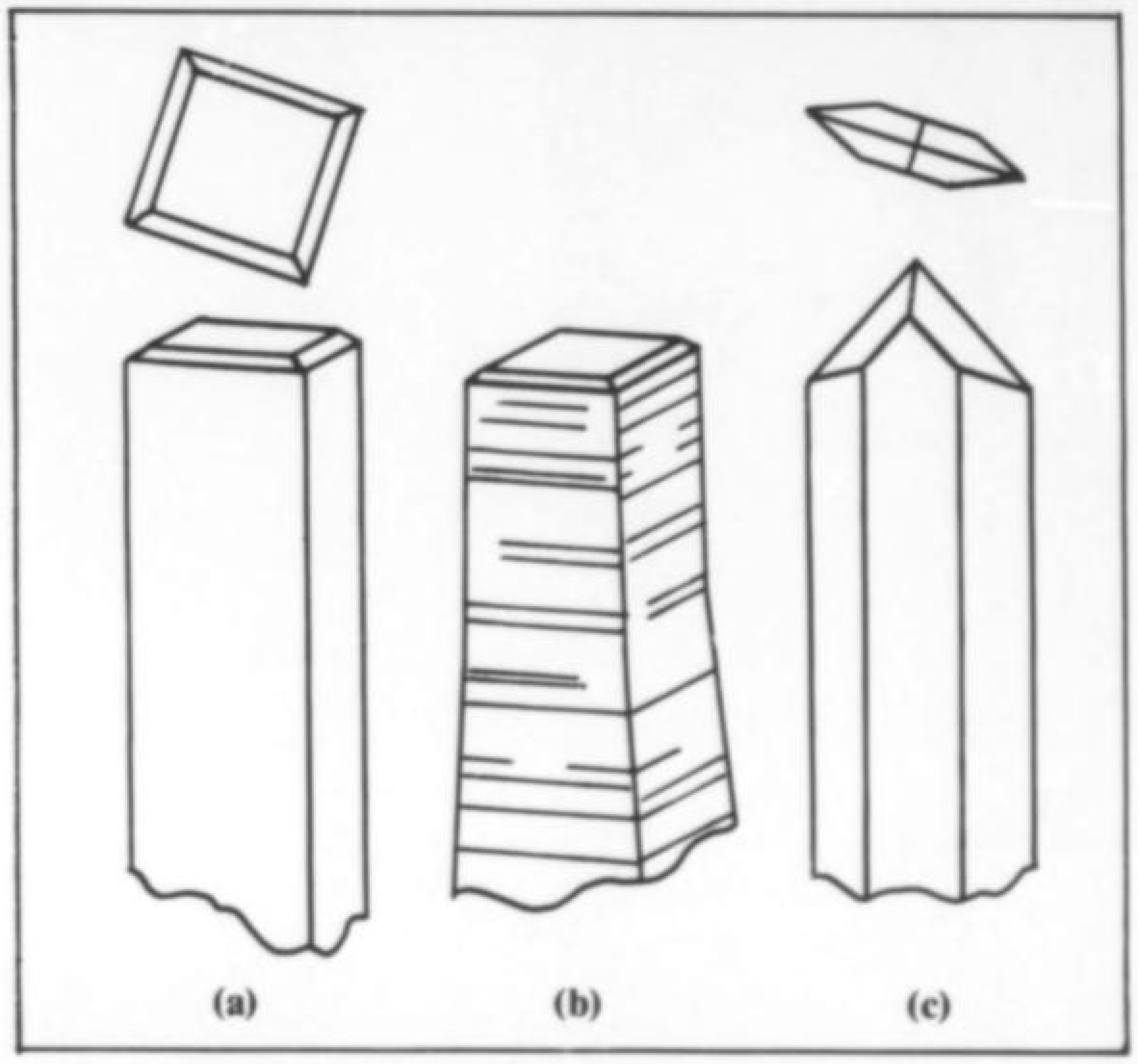


Figure 7. **(a) Minyulite, transparent, colorless, tetragonal or pseudotetragonal crystals; St. Johns quarry, Kapunda, South Australia. (b) Minyulite, striated, tapering, colorless transparent crystal; from Olivers quarry, Noarlunga, South Australia. (c) Lath shape, typical form for wavellite; Olivers quarry, Noarlunga, South Australia.**

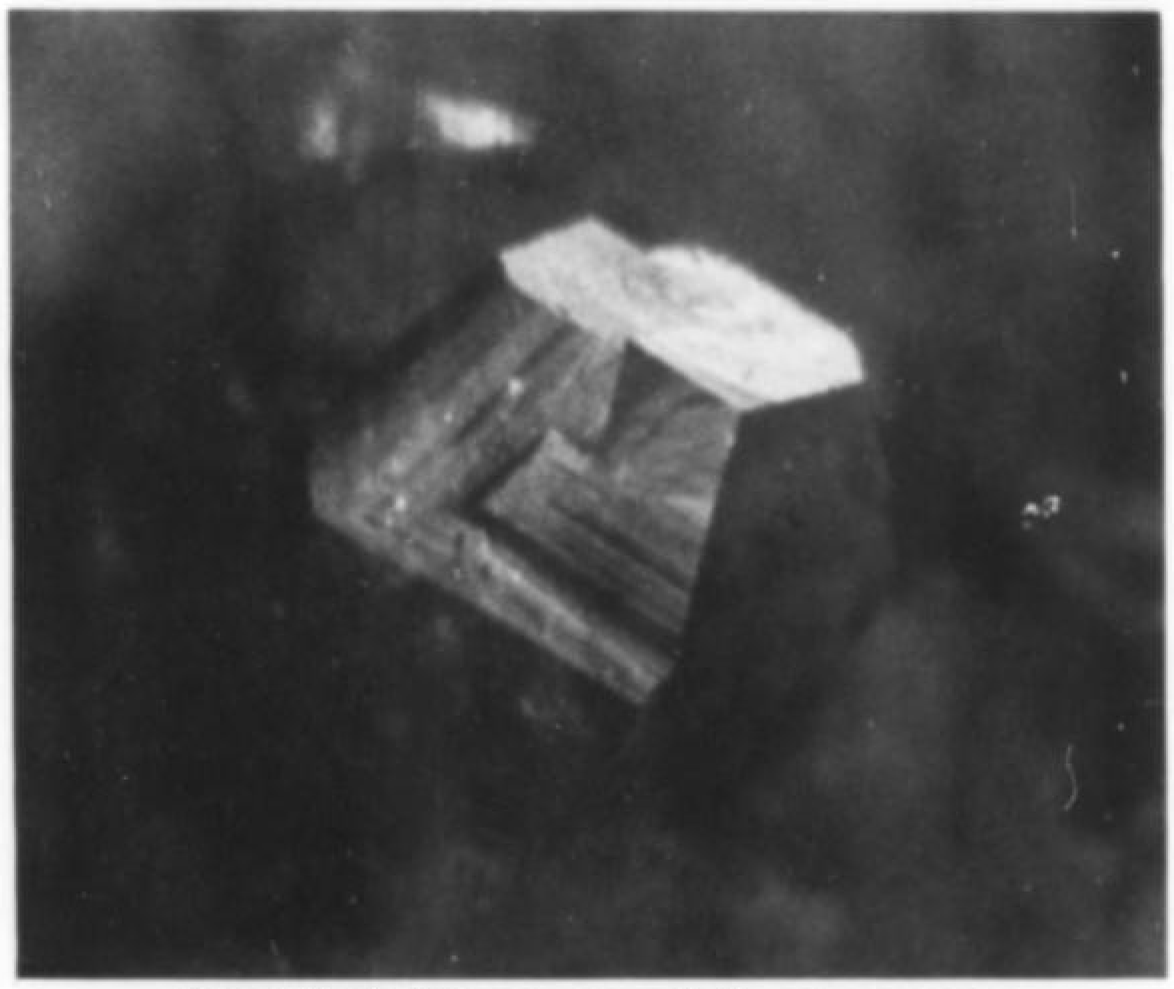


Figure 8. **Fluellite, 1-mm, colorless, transparent crystal; Moculta quarry, Angaston, South Australia. Photo by Bill Henderson.**

Victoria

The state of Victoria is noted for its superb zeolites. The finest of

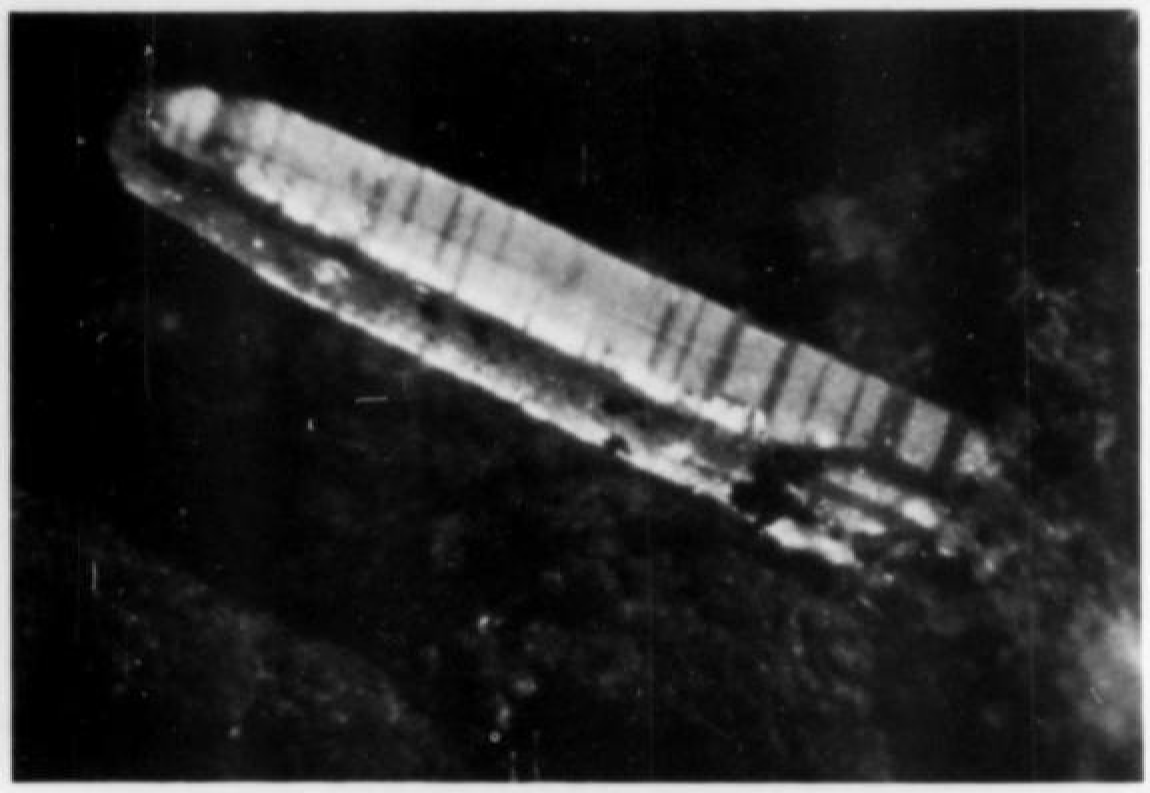


Figure 9. **Barite, colorless 3-mm crystal on goethite; from the north Flinders Range, 30 km north of Hawker, South Australia. Photo by Bill Henderson.**

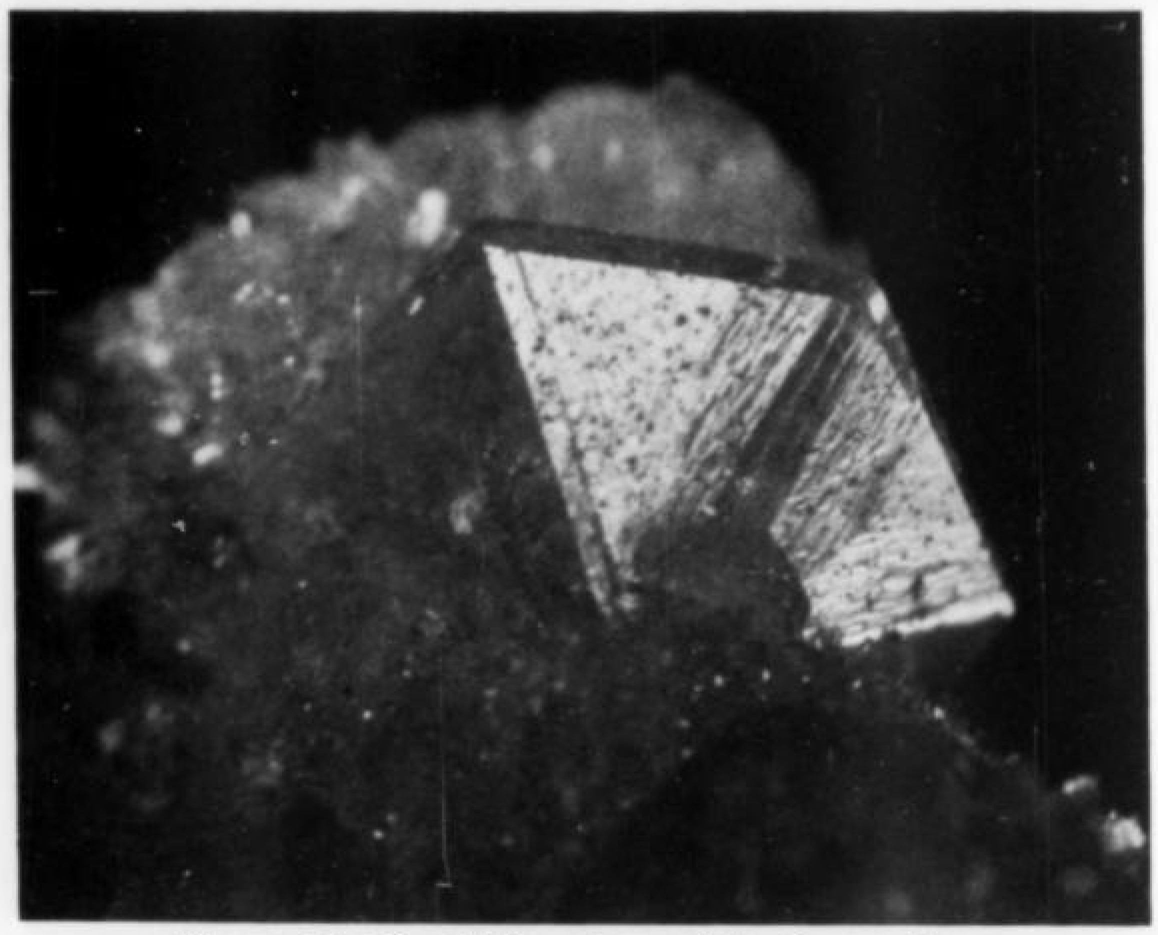


Figure 10. **Gmelinite, deep pink, 6-mm, hexagonal, tabular crystal with colorless natrolite; Flinders, Victoria. Bill Henderson photo.**

Figure 11. **"Hairy," 3-mm colorless, transparent natrolite crystal with normal natrolite on analcite; Kitty Miller Bay, near Flinders, Victoria. SEM photo by Carol Garland.**

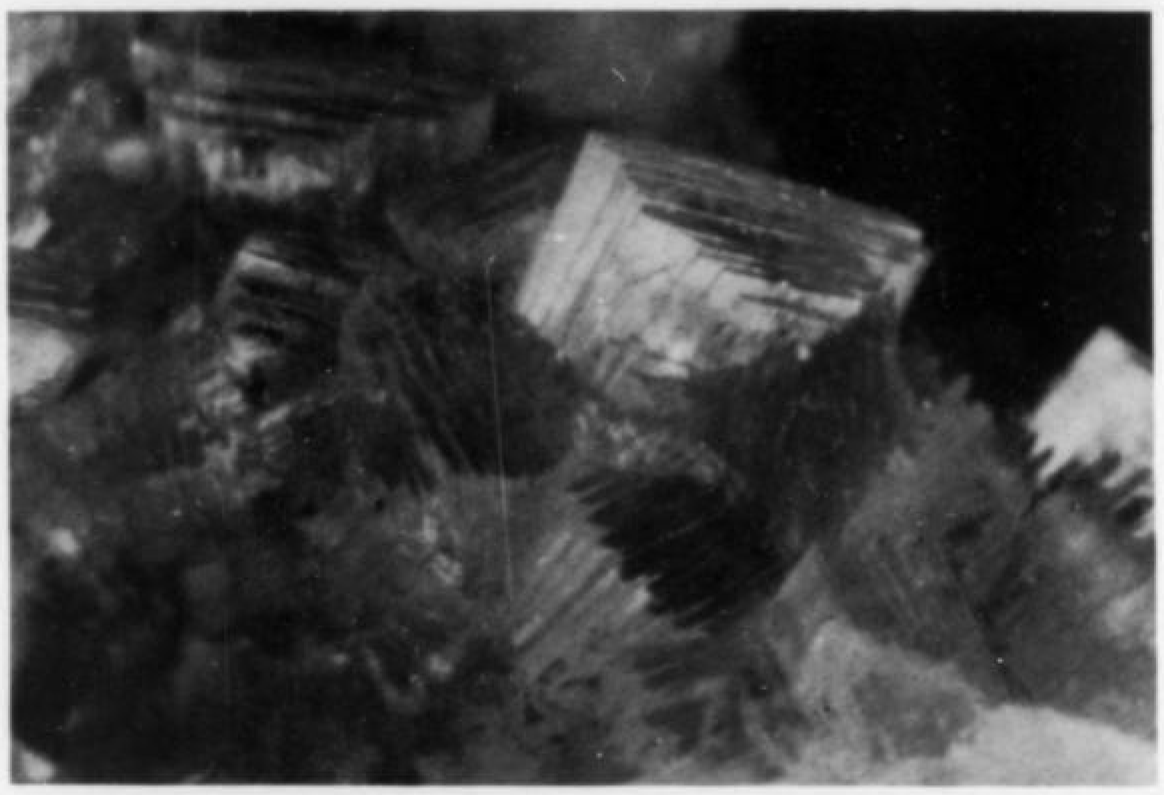


Figure 12. **Thomsonite, 2-mm groups of radiating, colorless, transparent crystals; Simmons Bay, near Flinders, Victoria. Vi Anderson photo.**

these are, I think, the gmelinites from the Flinders area. These are perfect in crystal form (Fig. 10) and vary from colorless to deep pink in color. Col Price writes that, like the Bay of Fundy zeolites, these are found in the sea cliffs along the coast. In addition to gmelinite, natrolite and analcime are found, and all of these may be colored light pink to deep red by hematite inclusions. Levyne-offretite has recently been found near Flinders, and ferrierite has been discovered at Phillip Island.

Both Joe Mooney and Jim Johnson sent natrolite on analcime from Kitty Miller Bay, near Flinders. While the combination is hardly rare, the natrolite is unusual, to say the least. From most other localities, natrolite occurs in single, columnar crystals, or perhaps in radiating groups. This material, as shown in Figure 11, grows largely in the normal fashion, but frequently crystals branch into finer and finer individuals. (Jim speculates that this branching habit is formed by nucleation of new crystals at the site of screw dislocations.)

Joe Mooney has also sent some very nice thomsonite in colorless, transparent crystals from Simmons Bay, near Flinders. As shown in Figure 12, the crystals have excellent form for this mineral.

Jim Johnson sent superb phillipsite in glassy clear, colorless, textbook twins on a light blue background. The phillipsite occurs with and on irregular spheres and mammilary growths of light to dark brown sphaerosiderite (Fig. 13). The material would be very nice were it to contain either of the two minerals alone, but the combination is especially striking. These specimens are from the Narre-Warren quarry, near Berwick, Victoria, and occur in a vesicular basalt. I am told they were collected by Alex Johnston, who works at the quarry and fortunately is a mineral collector as well.

Ouyen in northern Victoria is a locality for fine glauberite crystals, not all micro as they reach 2 cm across. Tylden and Trentham are both good zeolite localities, according to Jim.

Tasmania

No discussion of Australian minerals would be complete without a mention of the remarkable crocoite occurrences of Tasmania. My oldest specimen of crocoite is really quite poor, but I like it for its original label. It was sold by A. E. Foote, an old time mineral dealer, and is labeled simply, "Crocoite, near Dundas, Tasmania." Far better material is available from a number of Australian collectors, notably Chris Johnston. Most of the current specimens seem to come from the Kapi mine and, as shown in Figure 14, are made up of extremely sharp, well terminated crystals. The combination of bright orange crocoite and deep green pyromorphite is very pretty. Less common associated minerals at the Kapi and other mines are dundasite and cerussite. The dundasite occurs in white,

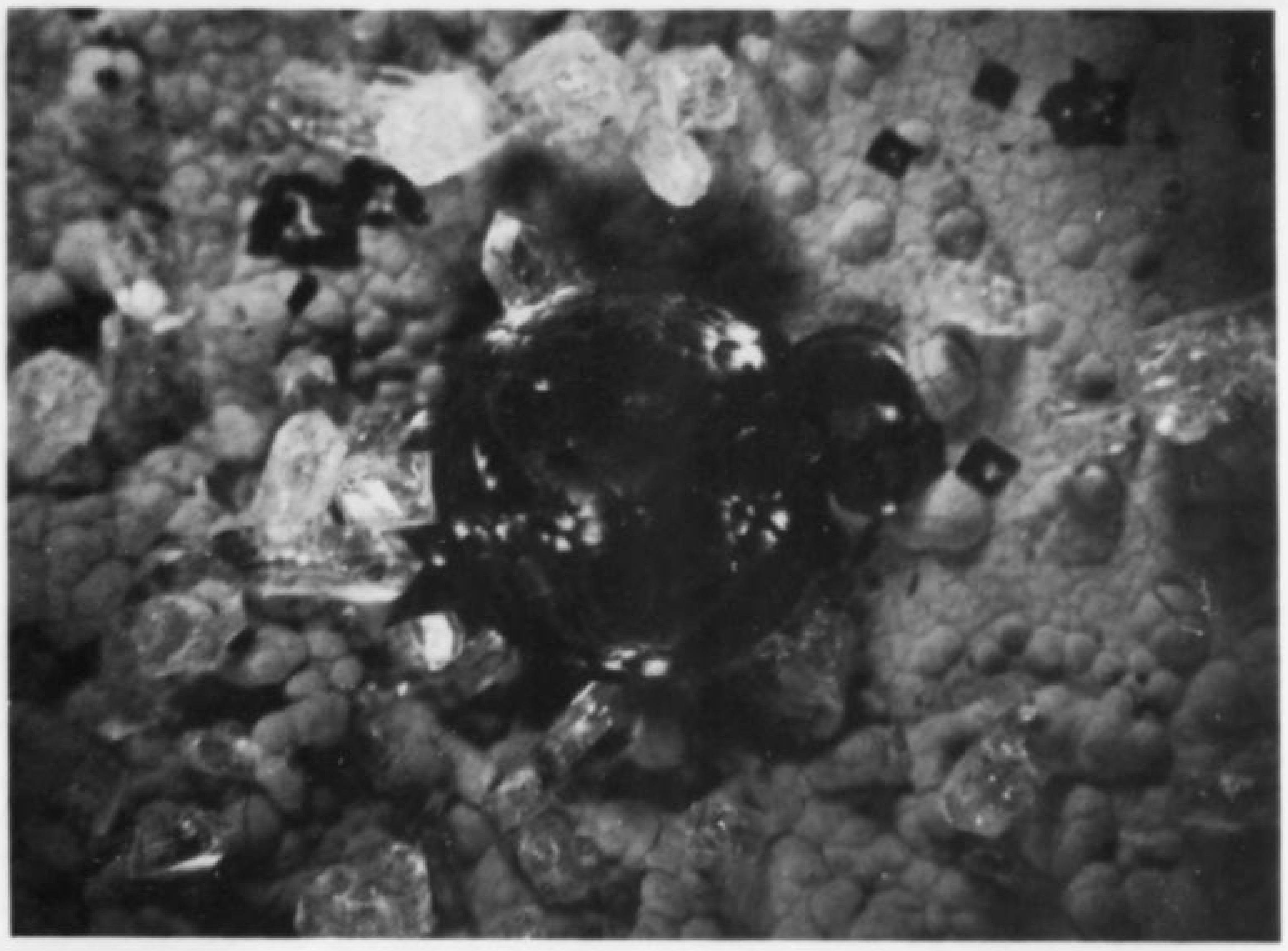


Figure 13. **Sphaerosiderite, yellow-brown, 5-mm botryoid with colorless, transparent phillipsite crystals; Narre-Warren quarry, near Berwick, Victoria. Bill Henderson photo.**

Figure 14. **Crocoite, brilliant orange, well terminated, 3-mm crystal with bright green pyromorphite; from the Platt mine, Dundas, Tasmania. Bill Henderson photo.**

Figure 15. **Native copper group 13 mm across, dark red-brown crystals showing cube and octahedron; Broken Hill, New South Wales. Photo by Bill Henderson.**

tufty crystals and velvety coatings. The cerussite I have seen is in extremely well formed crystals, frequently of a light greenish yellow color, and then referred to as chromian cerussite. Some of the crystal groups, without showing distinctive cerussite-type twinning, are made up of extremely deeply indented individual crystals looking like cogwheels.

In 1974, I received some very nice crocoite specimens from John Thigpen, a mining engineer and mineral collector who spent a year in Tasmania and returned to the U.S. His material was especially desirable since it came from several other mines besides the Kapi mine, including the West Comet mine, the Platt mine, and the Red Lead and Adelaide mines. All but the last, John reported, produced good crocoite specimens only sporadically. Incidentally, these mines and others in the crocoite area are discussed in an article in the January–February 1977 issue of the *Record.*

New South Wales

By far the best known of New South Wales localities is Broken Hill. Not ever having been there myself, I will rely on the description of one who has: Jim Johnson.

"The mine is very large and has a complex mineralogy. Lying in a semi-desert environment, it has a well developed zone of oxidation containing some real 'odd balls,' and is very rich in halides. In addition, the 'Main Lode,' of high temperature origin, has been injected by low temperature silver-lead-antimony mineralization.

"Although the Broken Hill 'Main Lode' is a sulfide deposit and Franklin (New Jersey) a silicate deposit, the two have much in common. Both are highly metamorphosed sedimentary deposits and share the same rhodonite-bustamite-wollastonite gangue, as well as rarities such as 'knebelite,' tephroite, pyrosmalite, etc." (Australian collectors tell me that the two cities also have in common a population of extremely avaricious miners, many of whom charge like wounded buffaloes—WAH.)

"Broken Hill is now adopting block caving to extract the ore, so there will be fewer miners and specimens. Fortunately, Broken Hill oxidized ores are common in old collections, and a little knowledge and a hand lens will often yield a rarity. Not everything turns up, though. I have spent twenty years looking for a Broken Hill boleite, and haven't seen one yet."

While Jim Johnson has not yet sent the proverbial boleite, he has sent a number of choice things from Broken Hill. One nice thing about them is that Jim is very careful about his identifications, so when he says something which looks like stolzite is wulfenite, for instance, you can believe it. Jim has sent Broken Hill native silver showing quite sharp octahedron and cube faces. Further, I would swear that one specimen shows the dodecahedron as well. The wulfenite mentioned earlier is equant, orange, and looks much like the stolzites in my collection. A major difference is that my stolzites are on a black matrix (manganese oxides?), while Jim's wulfenites are on a white matrix. Other extremely beautiful specimens from Jim are very sharp copper crystals (Fig. 15), anglesite in colorless, transparent "swords" on cerussite, smithsonite bow-ties (Fig. 16), and colorless, very sharp, equant smithsonites scattered in small groups on very shiny, dark brown goethite. Among the Broken Hill halides, Jim has sent yellow-green embolite with native silver and garnet and, the real prize, extremely well formed, lemon-yellow crystals of iodargyrite after miersite. These crystals show the cube, the tetrahedron, and most combinations of the two. According to Jim, of 20 "miersites" X-rayed at Adelaide University, all have turned out to be iodargyrite. Apparently, miersites in our collections should be viewed with some suspicion. Still further, Jim has sent Broken Hill pyromorphite of an unusual, tabular habit (Fig. 17), fine cuprite, and species such as millerite and friedelite, the last two of less than surpassing beauty but rare from this locality. (Readers may wish to look up the excellent article on Broken Hill written by Brian Mason in the January–February 1976 issue of the *Record.*)

I might mention a couple of lesser localities in New South Wales. The West Bogan mine near Tottenham was written up in the September–October 1978 issue of the *Record* as a source of large specimens of massive pseudomalachite. While nobody has been so kind as to send me a large, massive specimen, I have received very nice micro libethenite in drusy crystals and small, fairly crudely formed crystals of pseudomalachite. In addition, Jim Johnson has sent really superb (for the species) crystals of ferrimolybdite from Glen Innes.

Northern Territory

Scraping the bottom of the barrel now as far as my own holdings are concerned, I come to the Northern Territory. A suite of very nice copper-zinc minerals is found at Moline. The hydrozincite there occurs in large, well separated, white, acicular crystals, most unusual for the species, with clear hemimorphites. Also found at Moline are bright blue aurichalcite and rosasite crystals, all these from Jim Johnson.

Figure 16. **Smithsonite bow tie, 8 mm across, colorless crystals on dark brown goethite (?); Proprietary mine, Broken Hill, New South Wales. Bill Henderson photo.**

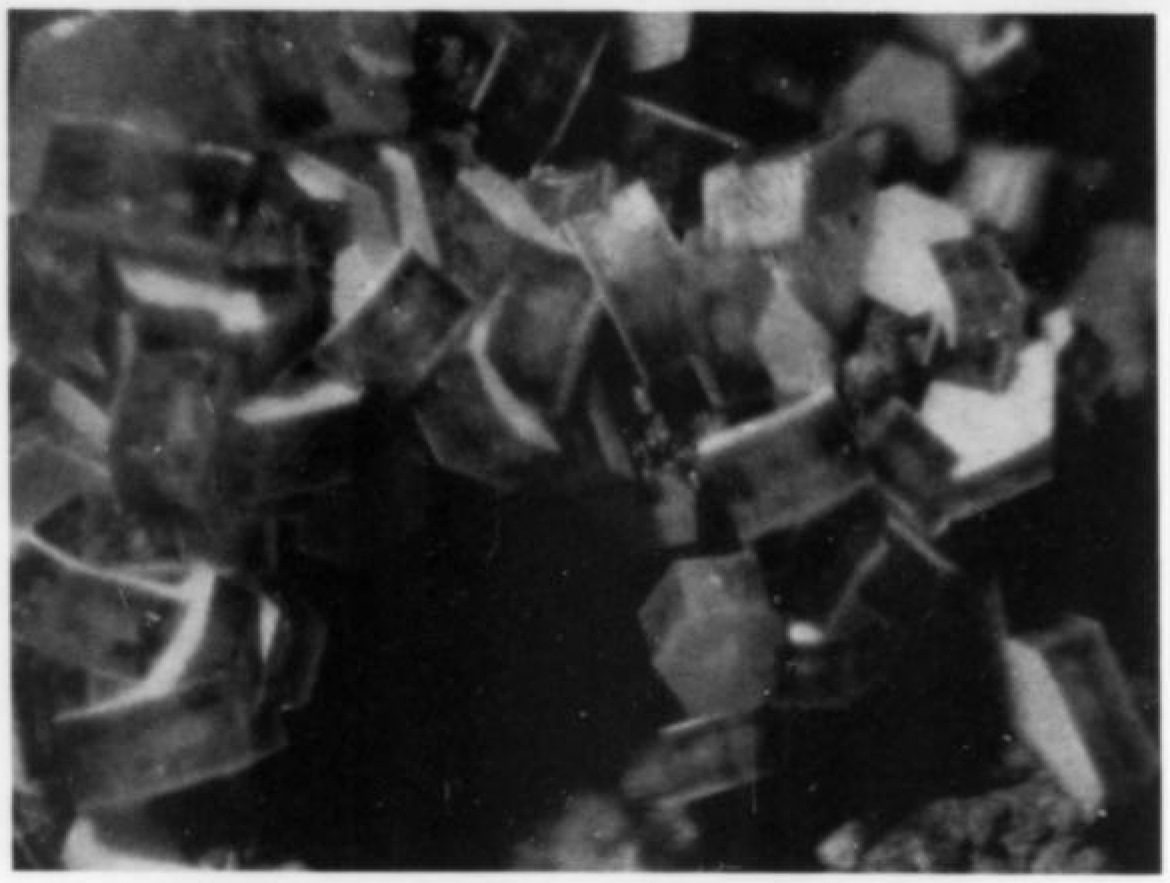


Figure 17. **Tabular, 0.5-mm pyromorphite crystals, greenish yellow with opaque "caps"; Old Central mine, Broken Hill, New South Wales. Photo by Vi Anderson.**

Although I lack the following in my collection, Col Price has written these words about Rum Jungle (Brown's deposit):

"Probably the most beautiful specimen material from Australia to surface in recent years was that recovered in the Northern Territory by teams from a few of our museums, when they opened up a deposit quite close to the surface at Rum Jungle. This was largely cerussite, malachite and pyromorphite with some pseudomalachite and possibly a new species resembling pseudomalachite. This stuff was very handsome indeed and much sought after over here, but unfortunately the deposit was filled in again after the museums had their fill. . . . The fact that this mineral complex contains only common species may turn many collectors off, but in this instance the material is so beautiful that no collector should be without it. The material will not be available again."

(See the article in the September–October 1980 issue of the *Record.*)

Western Australia

I cannot recall a single specimen in my collection from this state, so I will again rely on information from Col Price, as follows:

"Western Australia is a pretty thinly populated place, but there is a vast amount of mineral production going on in the iron ore deposits there. I do not know what types of specimens are available as it's a long way from where I live. Recently, however, I did get a small box from Mount Newman, but the massive iron ore yielded only quartz, hyalite, siderite and what I think is rutile from a number of small vugs.

"From a lone prospect at Milgun Station in the northern part of the state has come hydroxylapatite, montgomeryite, collinsite and natrojarosite in micro crystals. Early in 1978 some rather rare copper minerals and other species were recovered from the Bali Lo Copper mine in Ashburton Downs. Some of the species were caledonite, a species near chenevixite, metazeunerite, and olivenite. A range of unusual species has also been recovered from the Greenbushes tin deposit in the lower part of the state."

(There was an article on the Greenbushes tin deposit in the March–April 1978 issue of the *Record.*)

Swapping

If you wish to exchange for Australian micro minerals, a good way to begin would be to look in the *International Directory of Micromounters* or to write and ask Col Price for his list of

Australian and New Zealand micro collectors. If you do, send him a nice specimen or two to make up for the postage. Better write soon, though, since Col lists only 43 micro collectors in all of Australia and 4 from New Zealand. They may be swamped with mail! Col Price, by the way, appears to be rather at the center of things in Australian micromounting circles in that he has been the most active in promoting the hobby. A one-shot article he wrote on micromounting developed into a regular column in an Australian mineral magazine. From the letters and responses he has received, it is clear that he has attracted a number of collectors to the hobby.

I'm listing the addresses of several of the collectors mentioned in this column. Jim Johnson is a very active trader and has extremely nice material to offer. In addition, he is a tremendous fellow, retired from a varied career as a prospector and miner, and now active as curator of minerals at the South Australian Museum in Adelaide. His letters, filled with local history and anecdotes, are gems. Barry Porter, of course, has those fabulous Iron Monarch phosphates and manganese minerals, as well as other species. Joe Mooney has zeolites from the Flinders area, minyulite and fluellite, and specimens from such out-of-the-way places as Buka and Bouganville Islands (both in the Solomon Islands). Chris Johnston (with a "t") has a large supply of the phosphates from Reaphook Hill and also excellent Tasmanian crocoite and associates.

Mr. James E. Johnson
Mineralogy Department
S. A. Museum
North Terrace
Adelaide, South Australia 5000

Mr. Barry R. Porter
1 Phillips Road
Berri, South Australia 5343

Mr. M. J. Mooney
26 Patapinda Road
Noarlunga, South Australia 5168

Mr. Chris Johnston
5 Malpas Street
Rostrevor, South Australia 5073

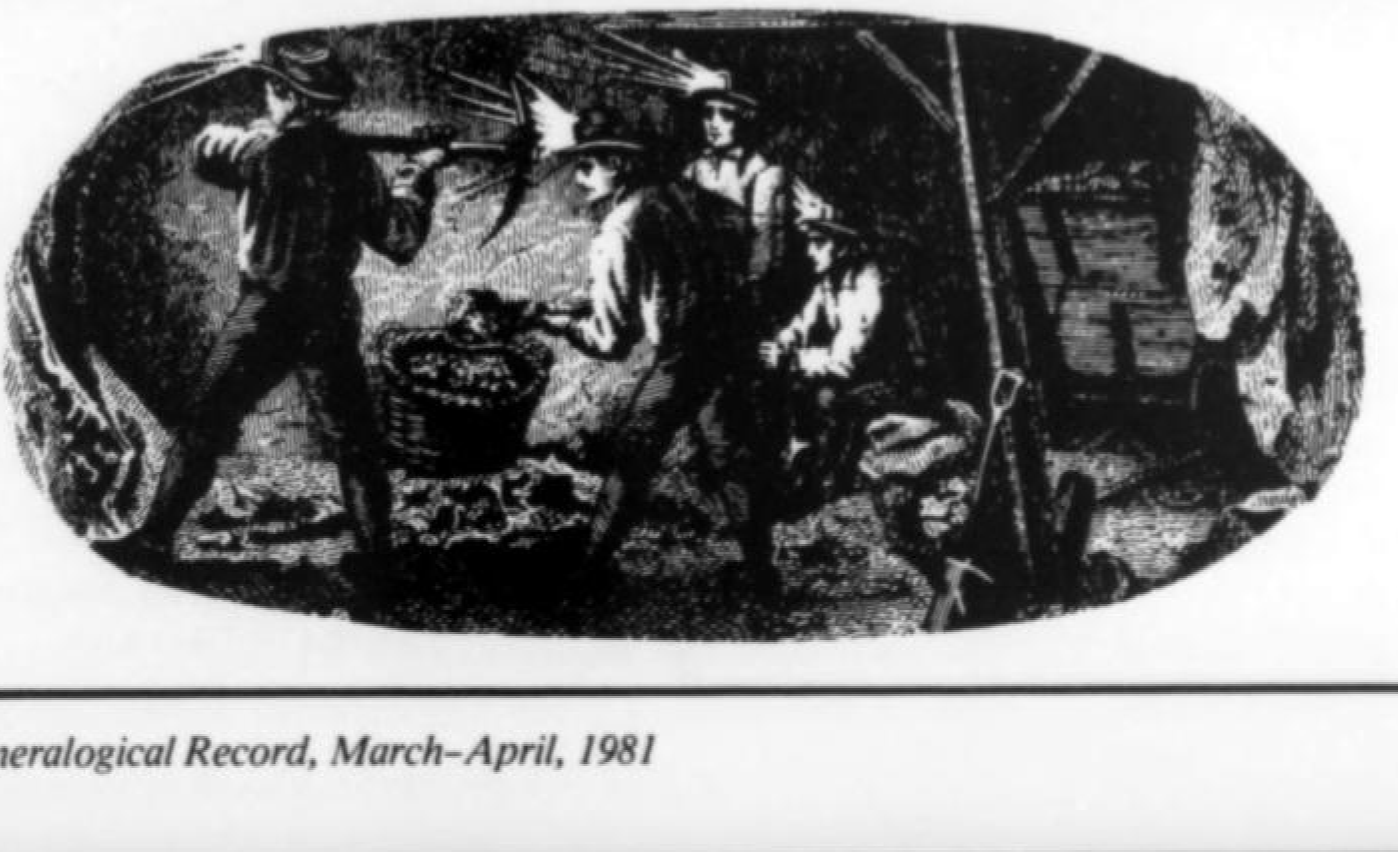
Mr. Col Price
P.O. Box 48
Nowra, New South Wales 2540

ACKNOWLEDGEMENTS

I want especially to thank all the above-named gentlemen who responded copiously, unstintingly and without complaint to my many requests for information about Australian minerals. They are, to use an Australian expression, a "spot-on type of chap." I also thank Norman Colthup for the sketch used in Figure 7. Finally, my thanks to Ross Anderson, who checked optically the identities of some of the minerals described.

Happy hunting!

Wm. A. Henderson, Jr.
174 East Hunting Ridge Road
Stamford, Conn. 06903



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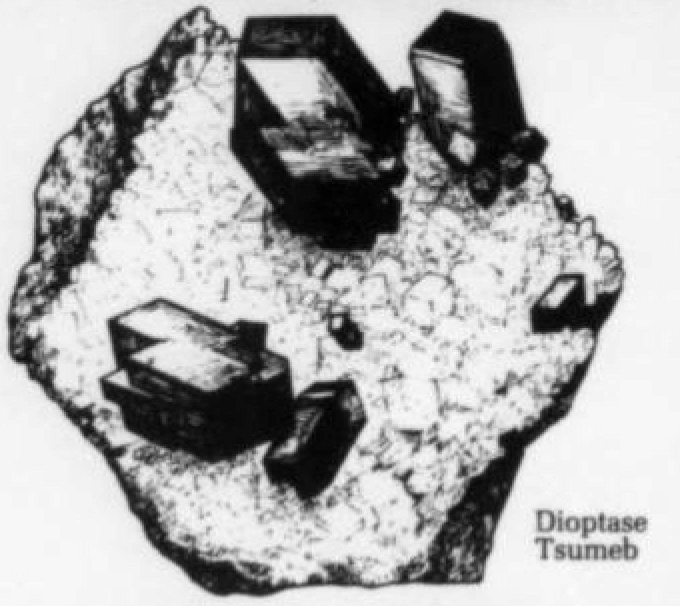

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THE HISTORICAL RECORD

by **Ron Bentley**
1822 S. Carthage Place
Tucson, Arizona 85730

As you see by the above address, I've moved again! And believe me, two moves in less than six months is three moves too many. Whether it was worth having to reorganize all the books, magazines and files in my library a second time remains to be seen. In any case, I expect to stay here for quite some time now.

By the time this column is published, those of you who have been patiently waiting for the duplicate labels I offered many issues back should have them. If not, please let me know; I tried to keep all of the requests together but during two moves anything can happen. So much for loose ends. Now to my main topic for this column:

MINING LORE

Every once in a while one comes across a book or publication which qualifies as a landmark of sorts. Henry Pohs' monograph on miners' lamps (reviewed previously here) is a good example. Another is Wolfgang Paul's 940-page *Mining Lore,* published in 1970 and still in print. This book, like other great classics of historical or mineralogical research, is awe-inspiring for the prodigious amount of time, research and love that must have gone into its compilation. Over 50 pages are devoted to the life and works of Georgius Agricola. Another 50 discuss briefly some 50 famous Freiberg scholars including Werner, Mohs, von Humboldt, Goldschmidt, Lindgren, Breithaupt, Zeuner, Plattner, Pumpelly, Emmons and Naumann. Other sections devote 60 pages to cultural and traditional aspects of mining in the Erzgebirge; theological aspects of mining; a collection of illustrations showing the way mining was carried out in the middle 1800's; 100 pages of German mining stories; descriptions of mining at various worldwide localities; 30 pages of postage stamps depicting mining; and over 120 pages of appendices.

As I said, the book is (thankfully) still in print. The cost is $29.50 plus $1.50 for postage, and orders may be sent to:

Morris Printing Company
1701 S. W. Jefferson
Portland, Oregon 97201

As an added inducement, I have excerpted below (with permission) a few interesting items.

On the Erzgebirge

"*Erzgebirge* means "Ore Mountains." It is a richly mineralized mountain chain stretching in a southwest direction between Saxony and Bohemia . . ."

"St. Joachimsthal is located in the Bohemian part of the Erzgebirge. It is the place where the first dollar, the *Joachimsthaler,* or *Thaler,* for short, was coined in 1519." It is also where Agricola composed the first scientific book on mining and mineralogy, *Bermannus, Sive De Re Metallica* (published in 1530) and his great book on mining, *De Re Metallica Libri XII* (published in 1556 and translated into English by Herbert Hoover).

"Often the view has been expressed that the geologic milieu can be of significance in the development of scientific knowledge. At all times the Upper Saxon area—especially the Erzgebirge—has been a germ-cell for the foundation of the mining sciences in the broadest sense (thus also including geological-mineralogical disciplines). The discovery of ore deposits predestined the Erzgebirge for scientific research and exploration.

"At St. Joachimsthal over 13,000 miners (including mine officers) were actively engaged in 800 mines . . . as early as 1530!

". . . at least 2,200,000 *Thaler* containing 59,773 kilograms of fine silver were coined . . . between 1520 and 1528.

" . . . the Schneeberg mines yielded 3½ million *Gulden (Thaler)* between 1476 and 1485. (At this time one could make a living with 25 *Gulden* per year!)

"The world's oldest academic institution of mining is located in the Erzgebirge—it is the *Bergakademie zu Freiberg in Sachsen.* It was between 1160 and 1170 when great silver-ore deposits were discovered in the Freiberg ("the Free mine") area."

On mineralogists learning from miners

The Russian mineralogist Fersmann once wrote: "You must consider the rock with love and understanding. 'There, look at that!' said the mining workman Lobatschew in the Ilmen mine, showing me a little piece of chiolite, which is extremely rare. 'Here you see the fine pink band which runs between the spar and the "sugar-edge"—this is chiolite, as you call it; without the band it is, correctly speaking, cryolite. If one bites it, it is harder than a piece of ice, but just as slick; in contradistinction, chiolite is more brittle and gnashes between the teeth.'

"So, Andrej Lobatschew taught me, an uneducated mining workman in the Mias, who spent his whole life between the mountains and the rocks. And some years later I found almost all of these particulars of the structure described in the splendid treatise on the Ilmen chiolite by a Danish mineralogist—as a solution of the mystery which surrounds the birth of this ice-stone in the mountains of the southern Urals. This mining workman in his simple and modest nature had made the minutest observations, which would be worthy of the greatest natural scientists.

"'At Kriwaja (the miner said), the schorl, the black tourmaline, is slightly grown on the spar; at Mokruscha it lies deeper and cannot be torn off at all, but the luster . . . at Kriwaja it is as green as stagnant water, but at Mokruscha blue-black as the feather of a raven, yet not as one from the wing but as one from the tail.'

"You authors of stout folios written in your studies (Fersmann concluded) . . . do you understand so to love and to appreciate the stone? Have you developed the mysteries of the beautifully colored fineness of its crystals, the mysterious accord of its colors, of its luster and its forms? If you do not love the rock, if you do not comprehend it there in the mountain itself, in the tunnel, in the ore-mine . . . then all your learned treatises will remain dead, and the rocks will lie in your closets as disfigured and defaced corpses."

Raphael Pumpelly (1837–1923) on his student days at Freiberg

"There was attached to the Academy, a place for the sale of minerals and fossils, superintended by Herr Wappler, where I got a great deal of practical knowledge of minerals; for in buying for my collection, I examined a great number before buying one. I must have spent a half-hour there every day. Breithaupt paid a great deal of attention to paragenesis of minerals and to pseudomorphs. These interested me very much on the hidden story side, and gave me a special interest in chemistry. The optical characteristics of crystals gave me also an interest in the study of physics. All this led to much buying and collecting and outlay. I came to be somewhat of an authority on mineralogy among a small group of student friends, and we formed in time a small 'conference,' meeting once or twice a week at my rooms."

"I remember one excursion in my second year . . . we visited a wonderfully interesting cave. The walls and roof were covered with a mass of great crystals of gypsum instead of stalactites. No torches had blackened them with smoke. As large as one's arm and several feet long, transparent, white with pearly luster and silken texture, these glistening crystals projected out from the intertwined groundmass far into the open, and formed a scene of dream-like beauty.

"One day, I think it was near Ilmenau, I had the good luck to find several specimens of crystals showing an unrecorded law of twinning. They were pseudomorphs after a feldspar. I gave them to Professor Breithaupt, who published them, giving me credit. I imagine that this was the first time my name had appeared in print, except perhaps when I was lost in Corsica and being looked for throughout Europe . . ."

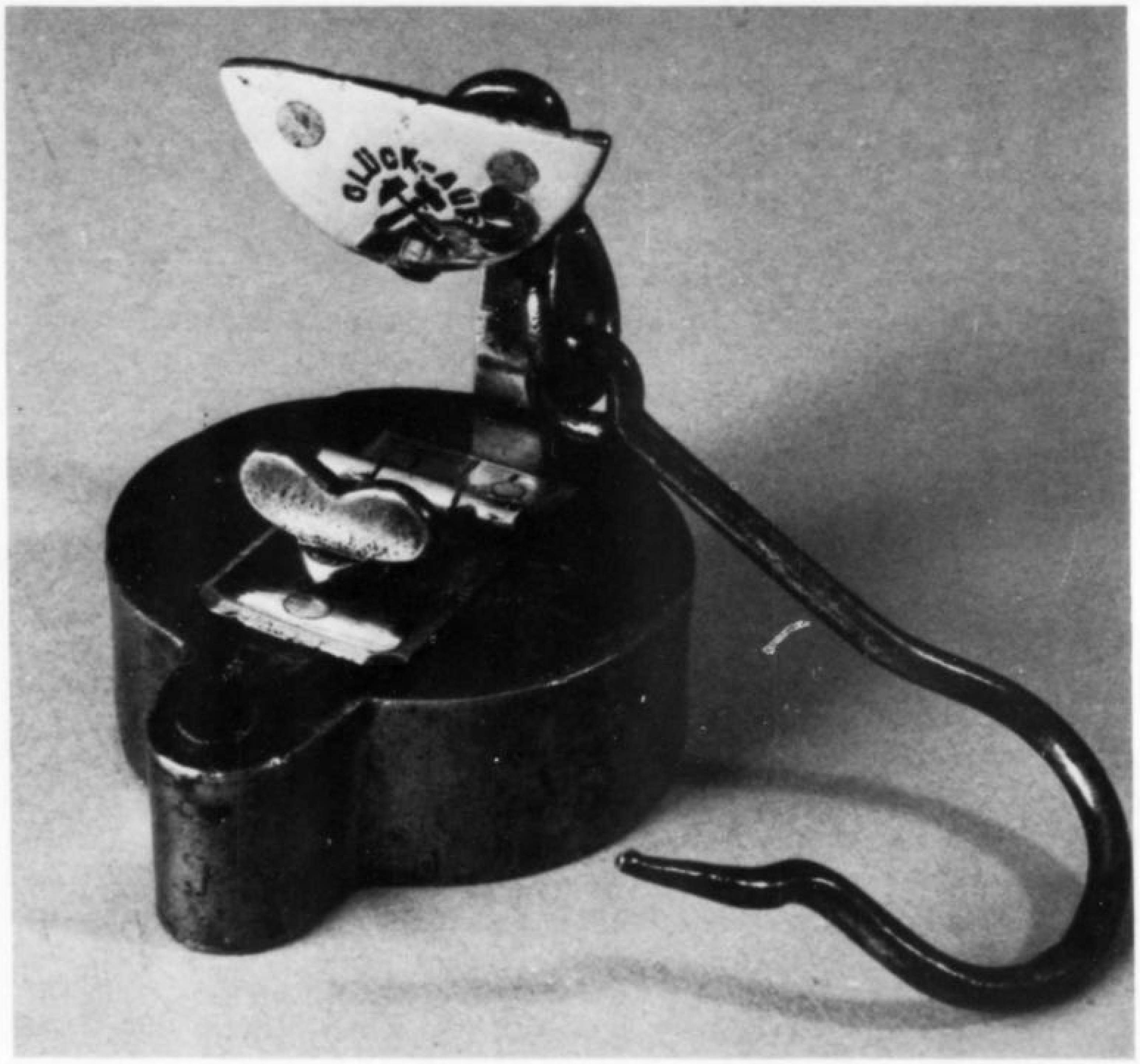


Figure 1. **A German miner's lamp, known as a frog lamp, dated around 1880. Note the "GLÜCK AUF" and the *Schlägel* and *Eisen* (crossed mallet and gad) on the shield. Wendell Wilson collection.**

Glück auf! The miners' greeting

"*Glück auf!* is the German miner's greeting. It cannot be translated exactly, since it has a very particular, poetic flavor or accent. Its meaning is deep. The nearest thing we have for this expression is "good luck" or "God speed you," but there is no real equivalent in English. It may be mentioned that this greeting is not only a traditional, or official miner's greeting, or a formal greeting at the close of corresponding letters, but it also is often used by other people, young and old, farmers, pastors, workmen, physicians, druggists, housewives, poets, musicians . . . living in mining areas. The greeting itself originated in the Saxon-Bohemian Erzgebirge . . . and has been in use for hundreds of years. It was used in a sermon to Erzgebirge miners in 1615, and even Martin Luther (1483–1546), a miner's son, referred to the *Glück* of the miners."

On mining disasters

Everyone is familiar with mine cave-ins, wherein the ceiling collapses and falls down . . . but what about the *floor* giving way and falling *up*? It's known as a "bump," and it only occurs in very deep mines where the pressure of the surrounding rocks is extreme in its tendency to close the openings made by man. "In one instance (in a deep coal mine in England) . . . the swelling underclay broke through and lifted with the force and suddenness of an explosion . . . throwing men and mine cars violently against the roof and producing an air-wave, which smashed the mine doors in the vicinity."

Another disaster, this time a mine explosion, occurred in Virginia in 1845. "Nearly all the internal works of the mine were blown to atoms. Such was the force of the explosion, that a basket then descending, containing three men, was blown back up the shaft and nearly 100 feet in the air. Two fell out and were crushed to death, and the third remained in, and with the basket, was thrown some seventy or eighty feet from the shaft, breaking both his legs and arms. He recovered . . ."

The *Schlägel und Eisen*

"The official emblem of mining in Germany is the *Schlägel und Eisen* (mallet and gad crossed). It is also used in other countries including the United States." The oldest known example of this emblem is found as a design in the Round Chapel of St. Andrew at Kremnitz in the Slovakian Erzgebirge, a famous European mining center. The chapel was built around 1250, though tradition suggests the town was founded by Saxons as early as the 8th century. The emblem occurs again in the seal of the Miner's Relief Association of Zeiring, Austria, a town noted for its ancient silver mines and mint, and the beautiful "Old Miner's Church" built in 1111. The Zeiring mines were abandoned in 1361 because of a "terrible water inrush." Examples abound in the 1500's.

"Since about the second half of the 19th century, the symbol. . . has come into use in geological circles. One repeatedly hears that it represents two geological hammers crossed. But this is wrong.

Work with the mallet and gad was done thus: a miner took the gad with his left hand, placed the sharp edge on the rock, and then with the mallet in his right hand he stroke on the even end of the gad in order to loosen parts of the rock."

"Since it was often incorrectly represented in its form, the form of this symbol was exactly described by the Prussian Mine Inspectorate in a regulation in 1853. According to this communiqué, the emblem has to be so drawn that the mallet lies in top of the gad (its head at top left), because one would first take the mallet with one's right hand, and the gad with one's left hand. The handle of the mallet may not protrude out of the head. On the other hand, the handle of the gad is to protrude out of the head. Moreover, the head of the mallet is slightly bent according to the arc in which one swings the hammer; while the gad forms a straight four-sided wedge (point down)." This design was reconfirmed by German Industry Standards in 1950.

"The exact time when this sign was first used by geologists has not been completely ascertained. It seems as though it was first used by American geologists; however it does deviate somewhat from the official German form described above. Two geological hammers crossed are found much less often as an emblem. When this emblem is found the mallet of the miner does not appear. But a typical geological hammer does appear." This genuine geological symbol has been used with the points of hammers pointing either in or out.

(The emblem used by the *Mineralogical Record* to denote the end of an article is composed of an Estwing-type geologist's hammer and crack-hammer or sledge as used by many mineral collectors.)

Mark Twain on assaying in Humboldt, Nevada (1871)

"The sagacious reader will know now, without being told that the speculative miner, in getting a "fire-assay" made of a piece of rock from his mine (to help him sell the same), was not in the habit of picking out the least valuable fragment of rock on his dump-pile, but quite the contrary. I have seen men hunt over a pile of nearly worthless quartz for an hour, and at last find a little piece as large as a filbert, which was rich in gold and silver—and this was reserved for a fire-assay! Of course the fire-assay would demonstrate that a ton of such rock would yield hundreds of dollars—and on such assays many an utterly worthless mine was sold.

"Assaying was a good business, and so some men engaged in it, occasionally, who were not strictly scientific and capable. One assayer got such rich results out of all specimens brought to him that in time he acquired almost a monopoly of the business. But like all men who achieve success, he became an object of envy and suspicion. The other assayers entered into a conspiracy against him, and let some prominent citizens into the secret in order to show that they meant fairly. Then they broke a little fragment off a carpenter's grindstone and got a stranger to take it to the popular scientist and get it assayed. In the course of an hour the result came—whereby it appeared that a ton of that rock would yield $1,284.40 in silver and $366.36 in gold!

"Due publication of the whole matter was made in the paper, and the popular assayer left town 'between two days.'"

First use of explosives in mining

"It is interesting to note that the black powder has come into use in mining relatively late, even though it was extensively employed in murder and warfare many years before. In 1790, Dr. Baader the Younger wrote: 'Here, too, the abuse preceded the better use, and a great deal was already achieved in the art of smashing human skulls by means of the powder. For more than a century, rocks and masonry were blasted therewith, above and underground in the art of war, before it came to mind whether this force might have the same effect in the mines, and another full century elapsed before improvements were added to the first crude experiments, of which they should have thought of within a few weeks, as it appears to us today.'

"As far as is known, the employment of explosive powder in mines was first introduced in the Hungarian-Slovakian Erzgebirge in 1627. It was Kaspar Weindle who—in the presence of the supervising authority—successfully employed the black powder for drifting at the old mining town of Schemnitz/Banska Stiavnika. According to annual cut marks on the rock of the old tunnels, hardly four or five fathoms of drifting could be accomplished in one year by mallet and gad.

"Subsequently the art of blasting was brought to Bohemia (the Graslitz copper mines), and then to Germany (Harz Mountains, Erzgebirge, etc.). Caspar Morgenstern, a miner from Clausthal, introduced blasting in the Freiberg mines in 1643.

"It is amazing how the ancient miners accomplished so much without the powder's power. Think of the many deep mines and long tunnels driven by hand, with mallet and gad in hard rock! No wonder the miner holds his 'pick more splendid than the sword.'"

Repairs after a mine explosion. *Illustrated London News*, 1866.

What's New in Minerals?

THE NORTHWEST SYMPOSIUM

The Northwest Symposium was held September 26–28, 1980. This was my first opportunity to attend the symposium and I was impressed. Impressed with the quality of the speakers; impressed with the setting; and impressed with the effort that went into sponsoring such an event. The Northwest Chapter of FM deserves compliments for the excellent results. Most of all, I was impressed by the *fun* I had. A symposium is a different breed of mineralogical event, and a highly enjoyable one.

For those of you who have never attended a mineral symposium, let me explain what it is—or isn't. It is different than a mineral show, although there are dealers present. The most stiking difference is the pace. Unlike many shows I have attended, where frenzy runs high, the pace at this symposium was relaxed and friendly. The dealers were selected because of their knowledge and interest in mineralogy, and each dealer brought special material (rare or classic specimens) in keeping with the theme of the meetings, "Native Elements." Most surprising of all, the dealers actually closed down their booths during the lectures so that they, too, could attend. Another good feature of this symposium was that all the proceedings took place in a single large meeting room: displays on one side, dealer booths on two sides, the podium on the fourth wall, and chairs in the center of the room. Between presentations, you could stroll about, get some coffee, look at the displays, or buy a specimen.

More than 125 people attended this symposium; it was the largest group in the five years the Chapter has sponsored the event. This was also the first year the Northwest Chapter broke even on costs, mainly as a result of a mineral auction held Saturday; it was a promising note for the future.

The lectures were in keeping with the symposium topic. Again, the unique character of a symposium was in evidence: the lectures were of more specialized interest than might have been chosen for the general public at a mineral show; yet less "dry" than we might imagine technical papers to be at a professional meeting. Peter Bancroft gave two of the talks, both armchair travelogues: one to Kongsberg (silver) and one to Sicily (sulfur). Vincent Manson, formerly with the American Museum of Natural History and now with the GIA in Los Angeles, presented a wide-ranging talk on diamonds complete with tales of the African diamond fields and the lure of the king of gems. Those who have heard Vince before know how he warms to his subject. Jack Murphy, curator at the Denver Museum, gave a fine lecture on Colorado gold localities, also in the nature of an armchair tour of famous high country locales.

Since the Pacific Northwest is known for its zeolites, a traditional topic at the Symposium has been an update on the latest research into these minerals. Rudy Tschernich, who lives in the area and who is well-known in the field, gave a very informative presentation on recent classification efforts. He was one of two stand-in speakers called on due to last-minute illnesses. With less than 48 hours warning, Rudy pulled up a polished and complete program. The other stand-in was Joe Nagel, curator of the mineral museum at the University of British Columbia and an active FM member. He also gave an interesting lecture on some of the work being done by the research staff at UBC.

While the lectures were the focal point of the Symposium, there was a generous amount of unstructured time planned for looking at displays, visiting with old friends, and examining the dealer stock. In short, this mineralogical symposium was well designed, well planned, and most enjoyable. I highly recommend such an endeavor to other FM groups looking for something worthwhile to do. The Northwest Chapter, and especially Mike Groben and Bob Smith, deserve honors for their efforts.

Barbara L. Muntyan

Figure 1. **A pocket of white cerussite in the Flux mine. The largest crystals are about 15 cm. Photo by David Shannon.**

Figure 2. **A fine group of white cerussite crystals measuring 7 by 9 cm, from the Flux mine. David Shannon photo.**

FLUX MINE CERUSSITE

Two major pockets of cerussite were discovered in October and December, 1980, at the Flux mine in the Patagonia Mountains of Arizona. This is an old locality long known for white, jackstraw-habit cerussite. The pockets were found lined with white jackstraw crystals in impressive clusters and singles to 8 inches each. The

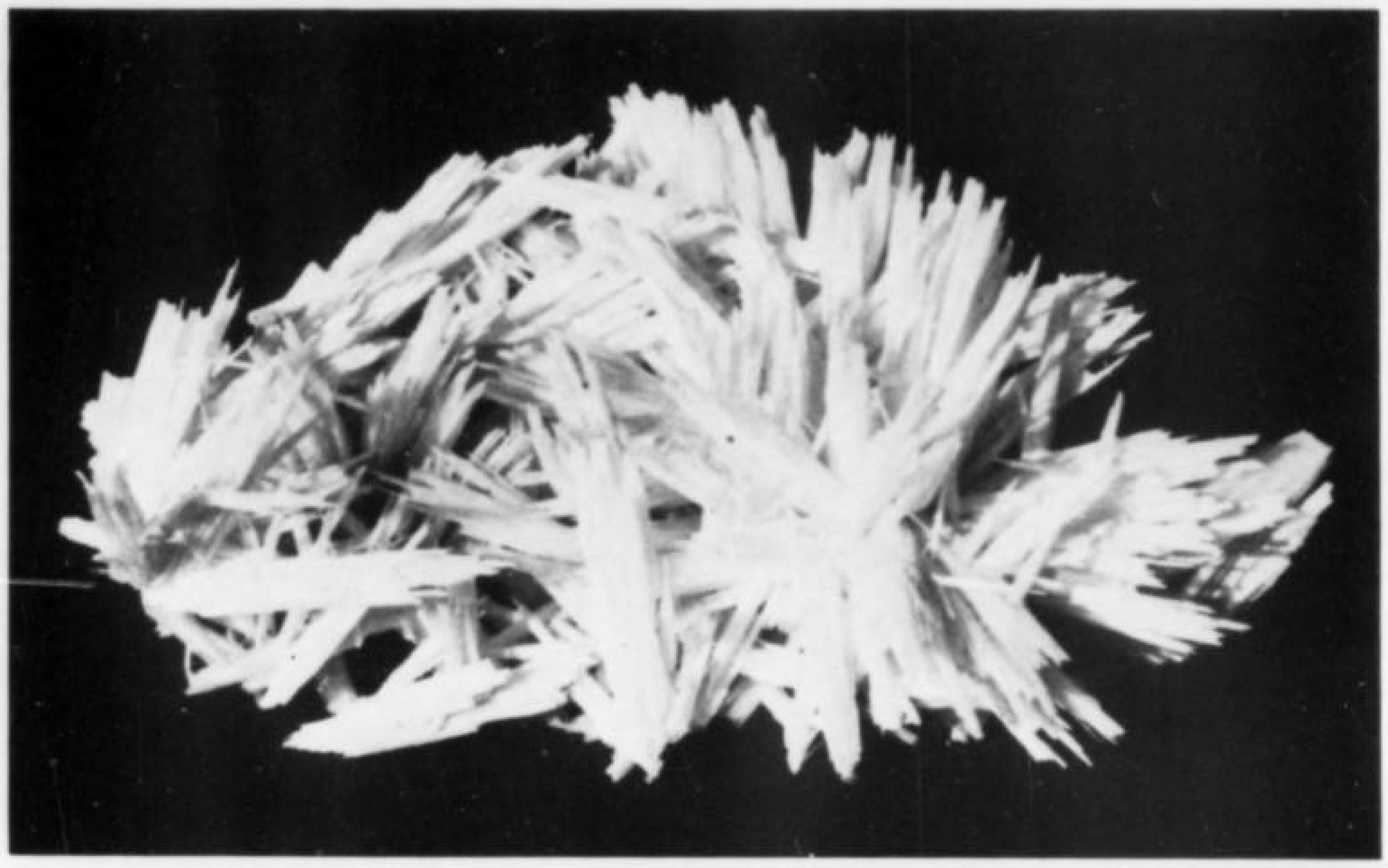


Figure 3. **A large group of white cerussite crystals measuring 8 by 15 cm, from the Flux mine. Photo by David Shannon.**

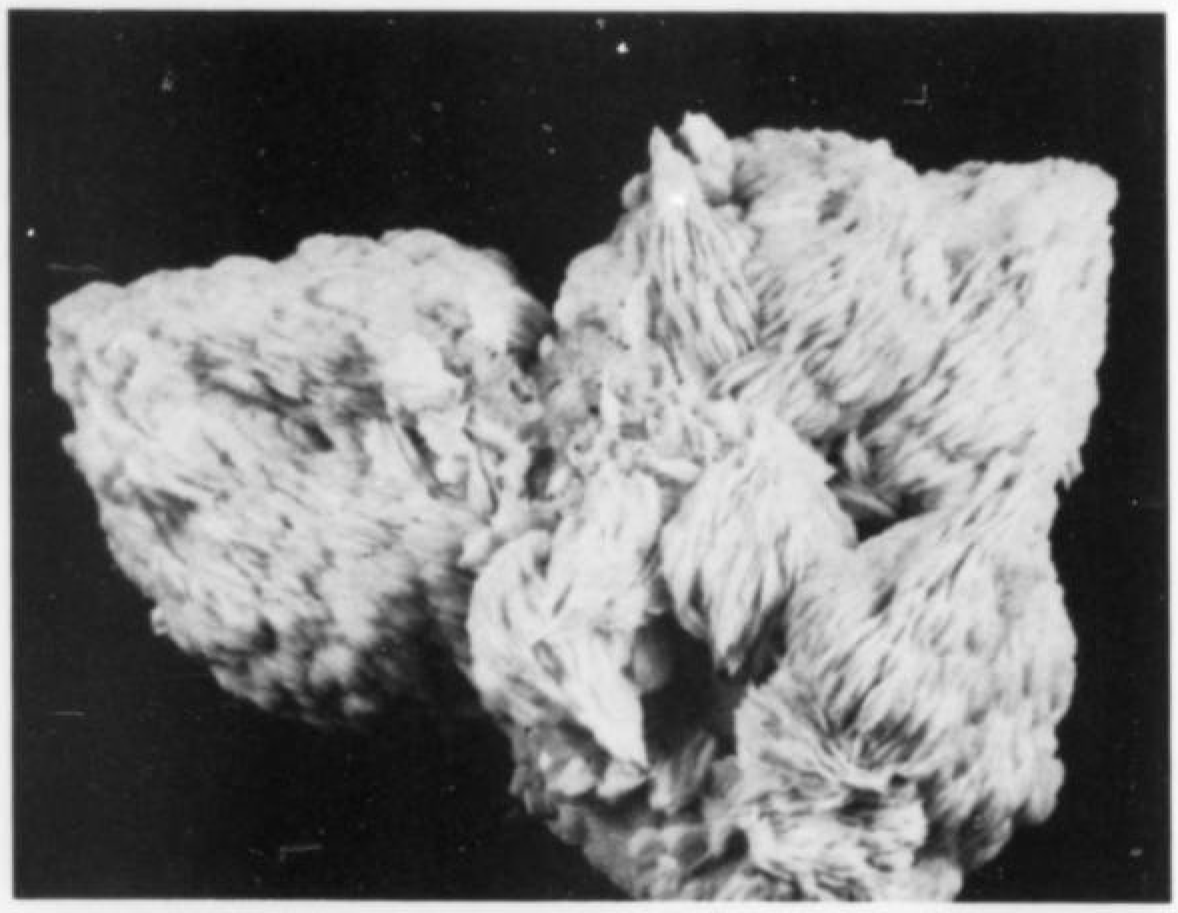
matrix is friable and must be handled very carefully until it can be stabilized; but many very attractive specimens come out free of matrix. The larger of the two pockets measured about 10 by 10 by 2 feet, and yielded thumbnails to 4 by 4-inch cabinet specimens.

A number of major pieces were purchased by Richard Bideaux *(Bideaux Minerals)* who described them as the finest specimens found at the Flux mine in the last 20 or 30 years.

The Flux mine is located in the Harshaw District, in Santa Cruz County, Arizona, about 6 miles southeast of Patagonia. It was first worked in the early 1850's, and intermittently thereafter, for silver in the argentiferous cerussite of the upper oxidized zone. Around 1939 the American Smelting and Refining Company acquired the mine and worked the lower sulfide zone for silver, lead, zinc and copper. Operations ceased in 1963, as evidenced by the 1963 calendar posted above a foreman's desk at the end of the main haulage drift in the sulfide zone.

David M. Shannon

Figure 4. **Pastel-pink barite 9 by 11 cm from the Weldon mine. Photo by David Shannon.**



WELDON MINE BARITE

Over the last couple of years, many beautiful pastel-pink rosettes of barite to nearly 10 inches, associated with calcite on quartz, have been found at the Weldon mine, Pima County, Arizona. This interesting mine, located at the base of a 200-foot cliff halfway up Ben Nevis Mountain, is reached by following a rough, 8-mile jeep trail up the mountain and then hiking the last very steep mile and a half.

The main stope of the mine transects the entire thickness of the mountain, opening on each side. One incline leads to a giant cavern 250 feet long and lined with 2 to 4-inch dogtooth calcite crystals. But the locality is best known (if that can be said of a little-known mine) for barite, which was mentioned by A. L. Flagg in his book *Mineralogical Journeys in Arizona* (1958). Flagg described barite rosettes to 4 inches, and said the locality was "nearly exhausted." But recently collected specimens have ranged up to 10 inches long and 3 inches thick.

The crystal aggregates of barite are football-shaped and sometimes reach the size of footballs as well. The best of the recently collected specimens consist of 2 to 8-inch rosettes of barite scattered across plates of quartz. When collected the specimens are typically covered by a layer of chocolate-brown calcite, which forms a protective cover during removal and transportation of the specimens, and is easily etched off afterward.

The largest and best specimen collected thus far is about 10 by 10 by 8 inches, and is composed of one 9-inch rosette surrounded by nine 3-inch rosettes on a quartz block.

Michael Shannon

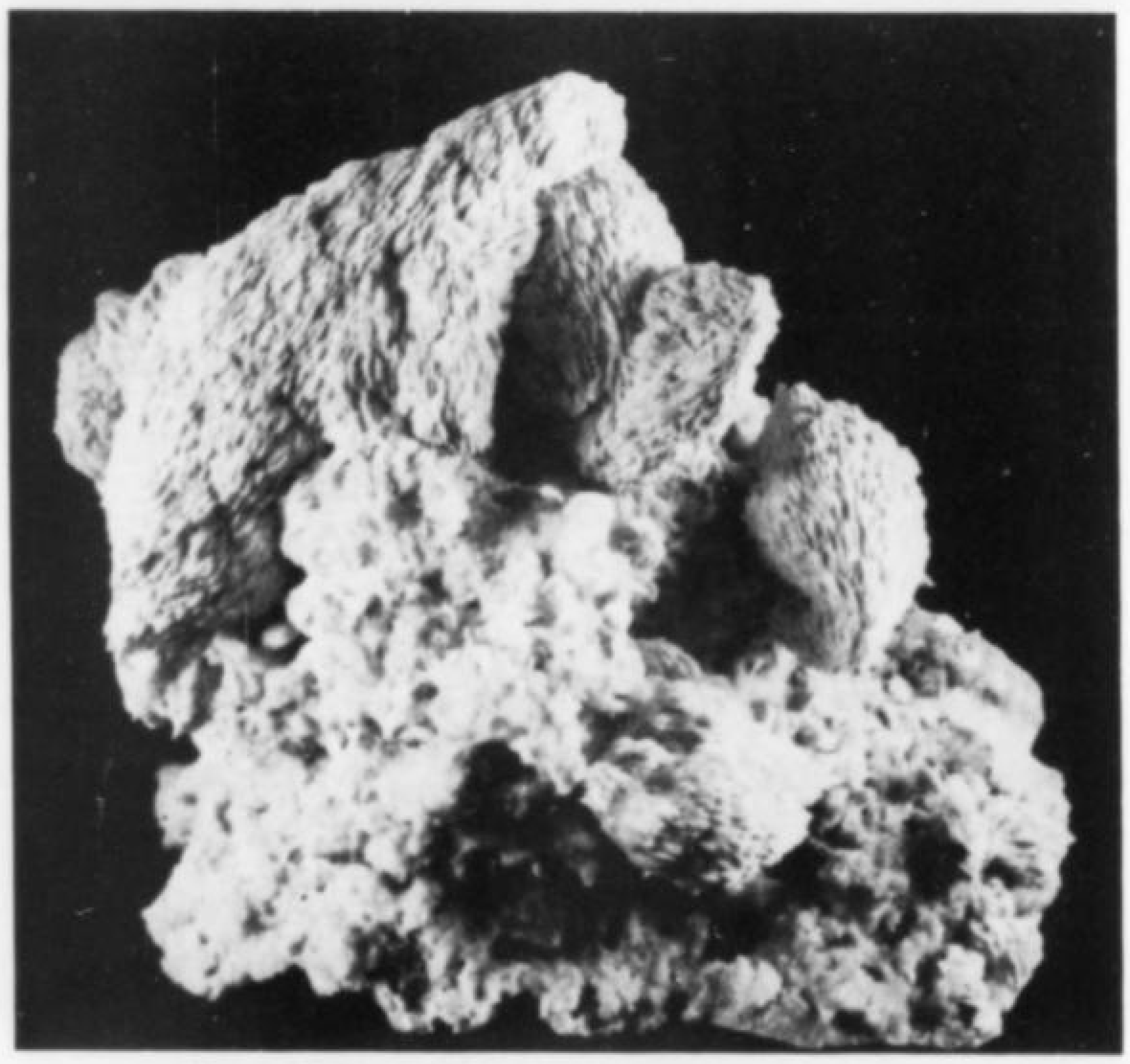


Figure 5. **Pastel-pink barite on a matrix measuring 26 by 30 cm, from the Weldon mine. Photo by David Shannon.**

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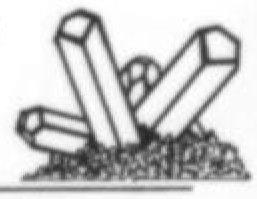

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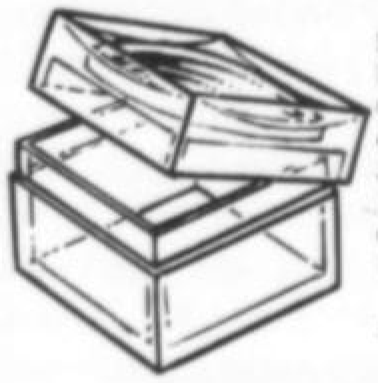

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The Record Bookshelf

Gill's Index to Journals, Articles and Books Relating to Gems and Jewelry, **by Joseph O. Gill. Published (1978) by the Gemological Institute of America, 1660 Stewart Street, Santa Monica, California 90404; 420 pages, 5½ by 8½ inches, hardcover; $24.50.**

A number of well known periodicals dealing with gems have never been indexed, and others have been indexed only poorly. *Gill's Index* attempts to fill this gap by providing a subject index for *Minerals Yearbook* (1882–1975) (chapters on gemstones only), *The Gemmologist* (1931–1962), *Gems & Gemology* (1934–1977), *The Journal of Gemmology* (1947–1978), *Lapidary Journal* (1947–1978), and *The Australian Gemmologist* (1958–1977). Under several subject headings there are also listings entitled *Gem Library Bibliography,* wherein may be found many books (in English only) on the subject dating as far back as 1652. Finally, there is a section listing articles which have comprehensive bibliographies themselves.

The Gem Library Bibliography sections include more than references to books. Specialized geological publications, college theses, museum publications, and articles in other periodicals have been gleaned for inclusion. Gem and jewelry-related articles are included from journals such as *The American Mineralogist, Nature, Scientific Monthly, Science, Mineral Digest, Economic Geology, Mineralogical Record, Life, Harpers, Jewelers' Circular-Keystone, Engineering and Mining Journal, Rock and Gem, The Canadian Mineralogist, Rocks and Minerals, The Mineralogist, American Journal of Science, Journal of the American Chemical Society, Mineralogical Magazine,* and others.

To quote from the author's introduction: "In compiling this index I found some of the article titles to be obscure and sometimes even unrelated to the actual subject of the article. Since it is my objective to create an efficient and useful subject index, not a bibliography, it seemed necessary to use license and to paraphrase these titles in order to clarify the subject content. Many of the articles cover more than one major subject and, in these cases, titles had to be constructed for each subject. Many articles lacked titles completely in which case I provided a brief annotation.

"The authors' names have been eliminated from many articles because I felt them to be unnecessary in a subject index."

The index does not indicate the cases where Gill invented a new title, or where the title is as originally published, so one must look up the actual article to find both the title and the author. At 420 pages, the index is long enough so that one can understand Gill's reasons for not including the original title along with an annotation . . . that addition might have increased the length of the book by 40 percent or more. And it is true that many article titles are totally misleading as to the content of the article itself, so the "new" titles will undoubtedly be a boon to users of the index. Furthermore, the new titles indicated something remarkable: Gill must actually have read all of the articles indexed! For that alone he deserves kudos.

Nearly all gem materials are also minerals, of course, so this index can have great value to mineralogists and mineral collectors as well as gem fanciers. The largest section of the book (211 pages) covers gems alphabetically according to species name (around 135 valid mineral species), and countless interesting articles may be easily found. Tanzanite, for example (the blue gem variety of zoisite), is of acute interest to mineral collectors, and this book may be the only place where one can find a thorough bibliography of sorts. New access is provided to published material on many such topics dear to the mineral collector. In fact, many fine *Mineralogical Record* articles could be launched with a headstart on the literature search provided by *Gill's Index.*

The next large section (118 pages) lists articles and books by country and state (for the U.S.). Though perhaps somewhat less likely to be used than the species index, this section also has its remarkable areas. Under India, for example, the Gem Library Bibliography section lists 21 books dating back as far as 1667 which deal with the gem minerals of India.

The third part lists subjects having to do directly with gemology, such as color, crystals, fluorescence, fraud, inclusions, mining recovery methods, nomenclature, notable people, photography, spectroscopy, and theoretical gemology. The final section (only 22 pages) deals with antique gems and jewelry, jewelry fashions, museum collections and lapidary.

The author has a BS degree in geology/mineralogy, is a certified gemologist (having trained under the Gemological Institute of America), and a fellow of the Gemmological Association of Great Britain. He has amassed one of the largest English-language gemology libraries in the world, efficient utilization of which was the driving force for the compilation of this index.

Gill's Index represents an enormous labor of love requiring years of work, significant funds, and a degree of motivation beyond most authors. (Why has such a comprehensive index not been produced for other important areas of study?) No one can deny that the book will prove extremely useful and much needed. Anyone who likes to read regularly should own a copy.

Wendell E. Wilson

OTHER TITLES RECEIVED

Inventaire Mineralogique de la France no. 9: 56—Morbihan, **by R. Pierrot, L. Chauris, C. LaForet and F. Pillard. Published (1980? undated) by the Bureau de Recherches Geologiques et Minieres (B.R.G.M.), Service Editions et Vente, B.P. 6009, 45060 Orleans Cedex, France; 315 pages, 7 by 9½ inches, softcover, $22.35 (95.00F).**

This is the most recent in a series of French publications inventorying the mineralogy of various provinces, Morbihan in this case. Many locality maps are included for the 58 localities in Morbihan which are discussed. Other publications in the series are as follows: (no. 1) Cantal, (no. 2) Hautes-Alpes, (no. 3) Finistere, (no. 4) Alpes-Maritimes, (no. 5) Cotes-du-Nord, (no. 6) Tarn, (no. 7) Aveyron, and (no. 8) Haute-Garonne.

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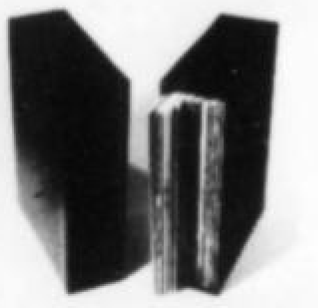

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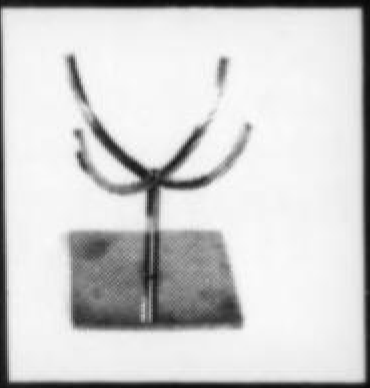

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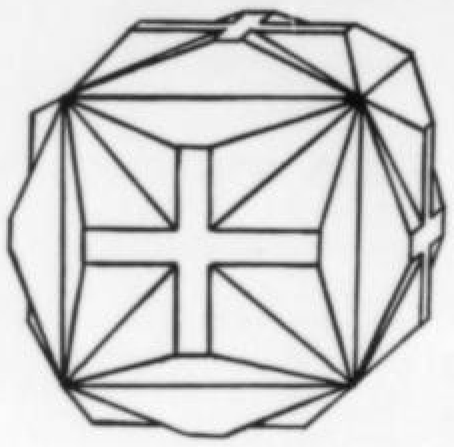

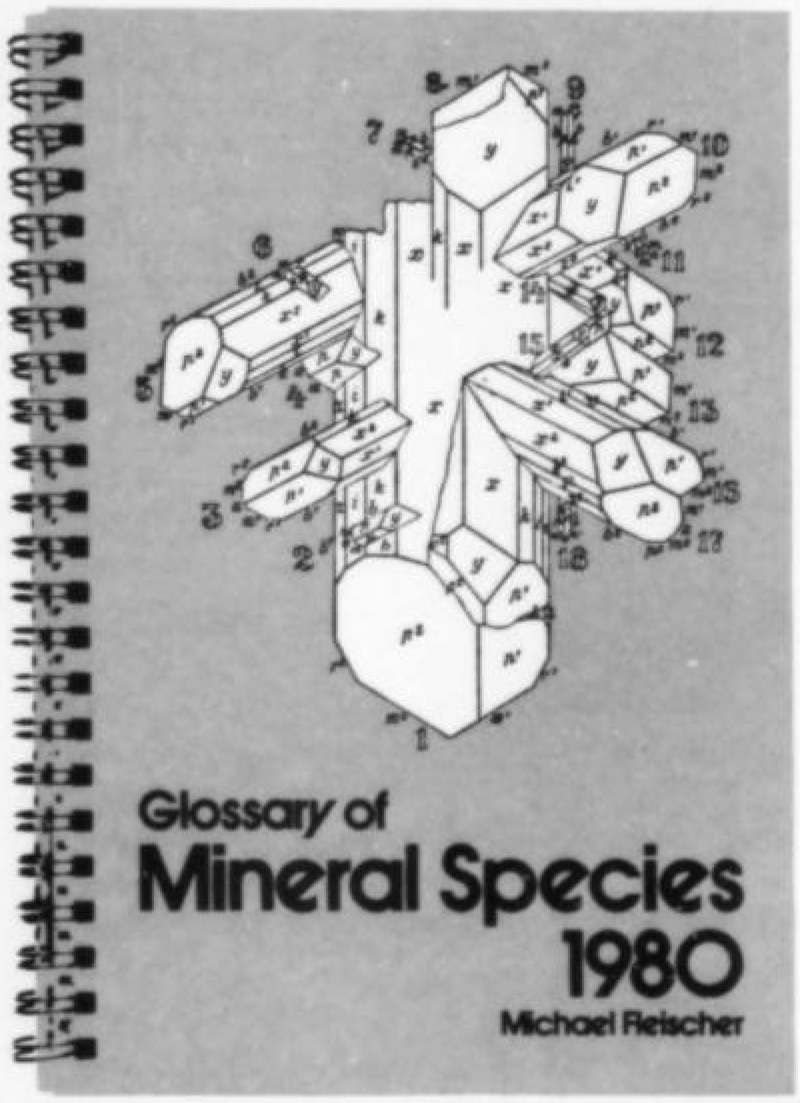
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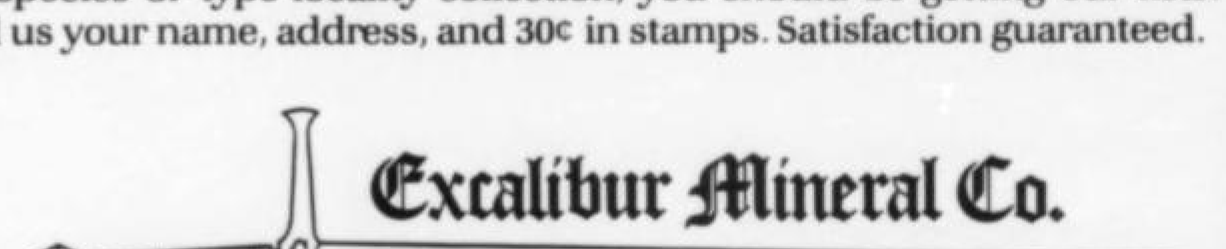

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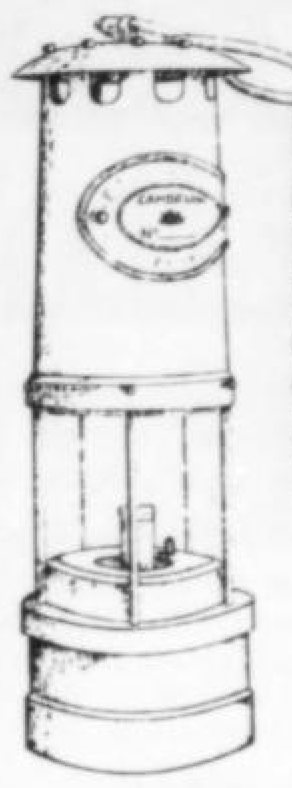

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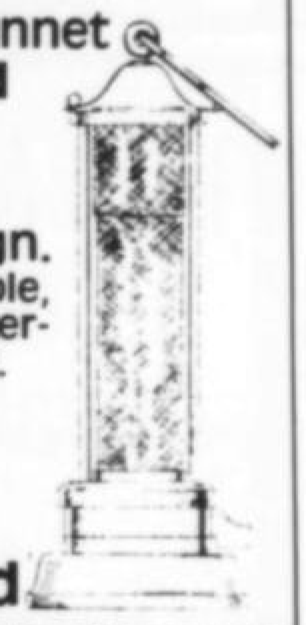

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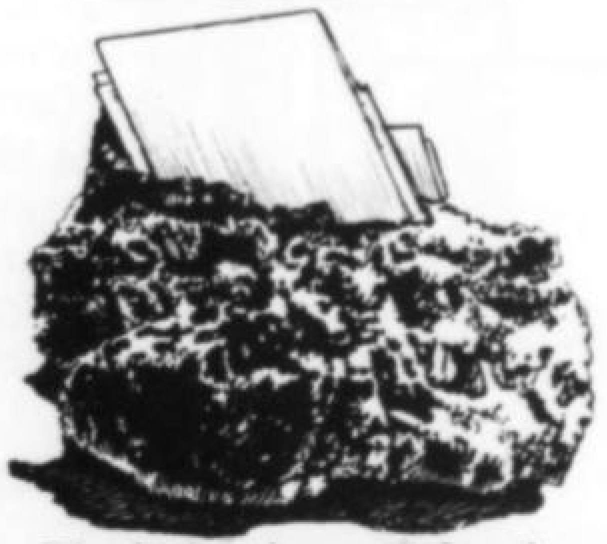

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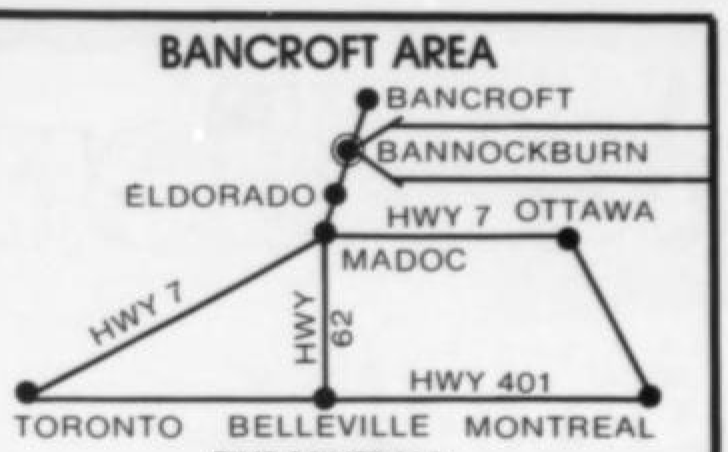

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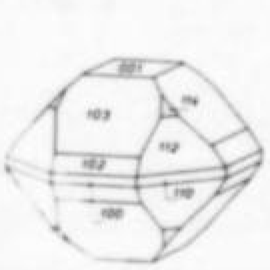

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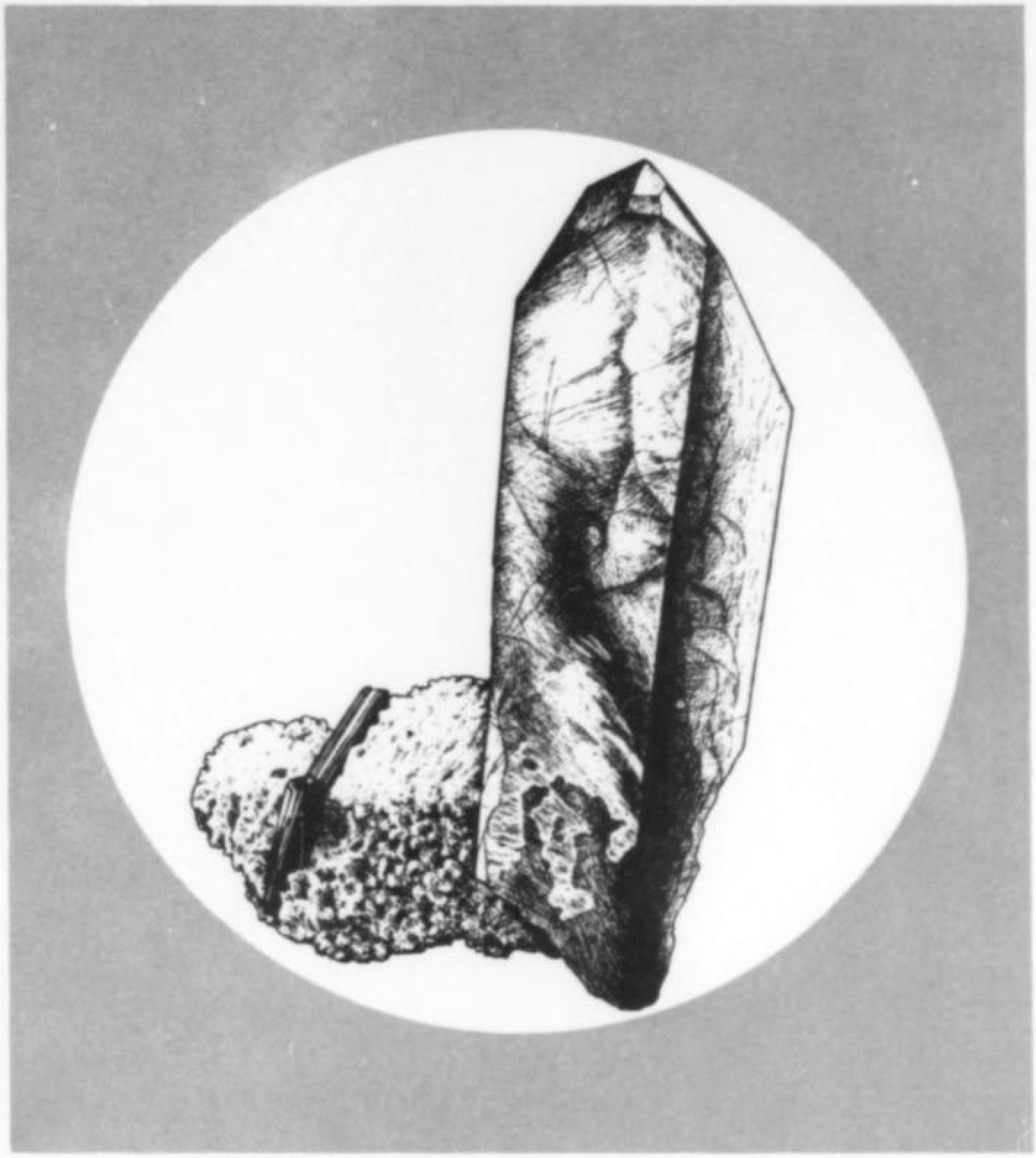

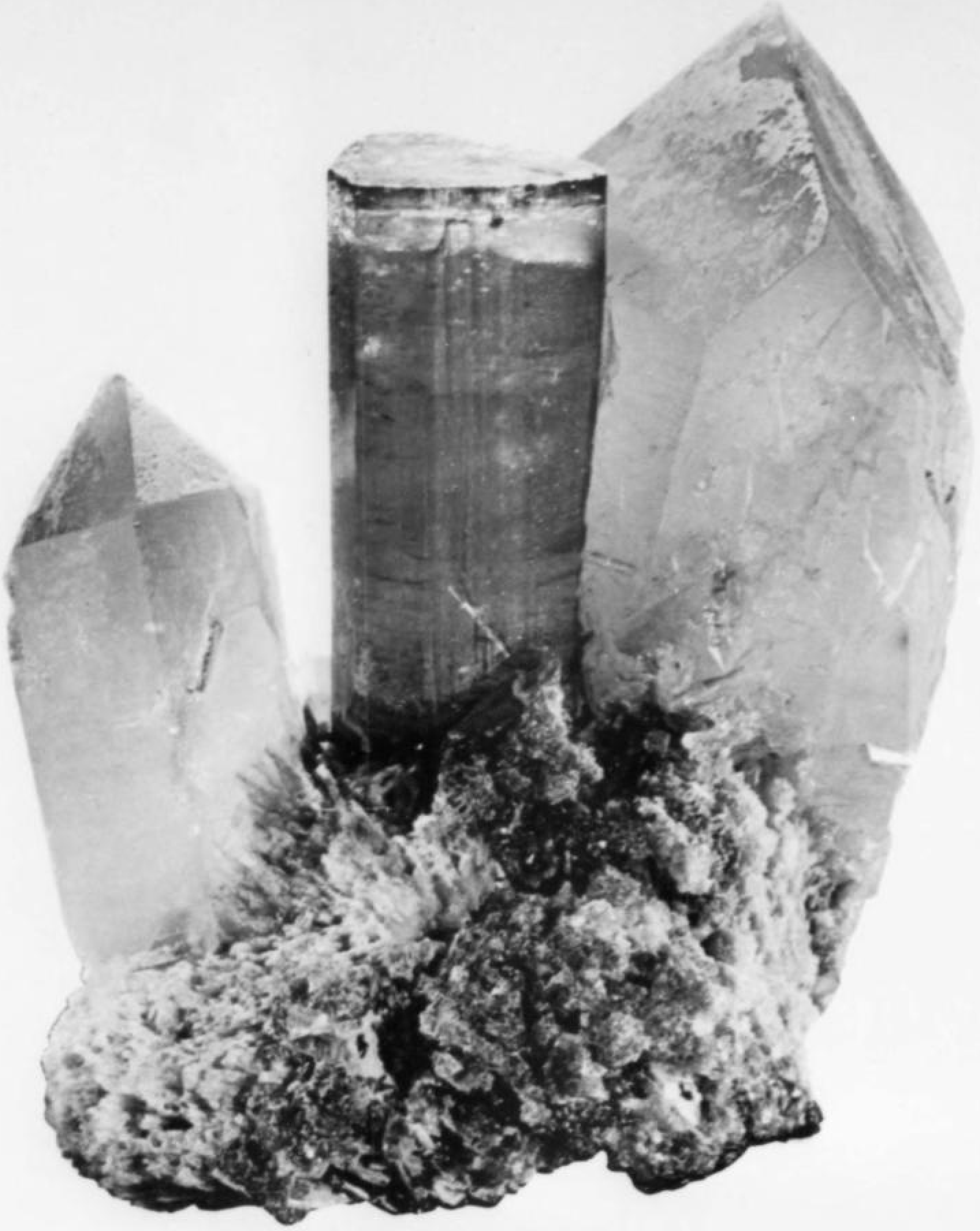

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