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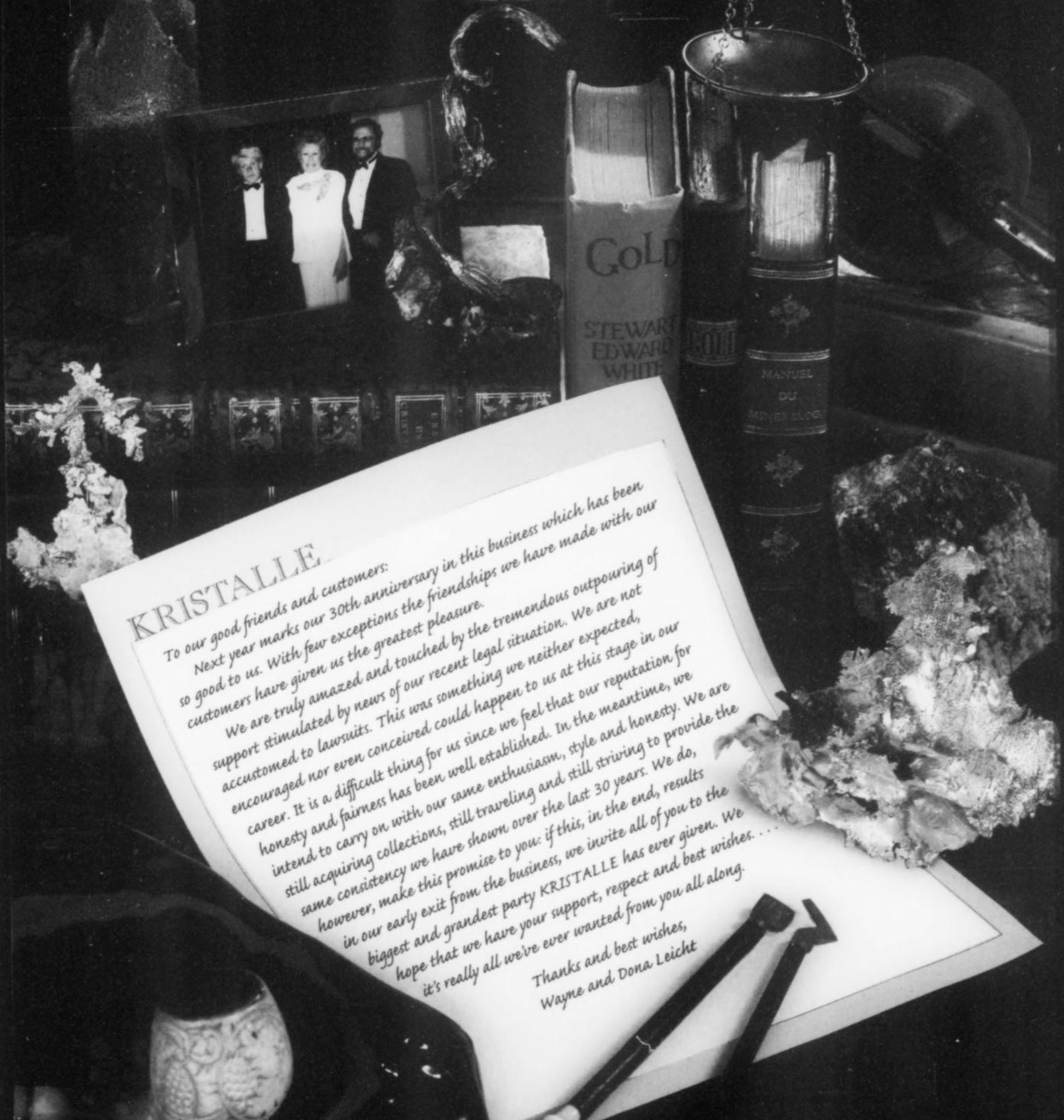

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THE
MINERALOGICAL
RECORD

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Articles

Columns

COVER: AMAZONITE and SMOKY QUARTZ, 7.3 cm, from the "Tree Root Pocket," Pikes Peak, Colorado. Bryan Lees specimen; photo by Harold and Erica Van Pelt.

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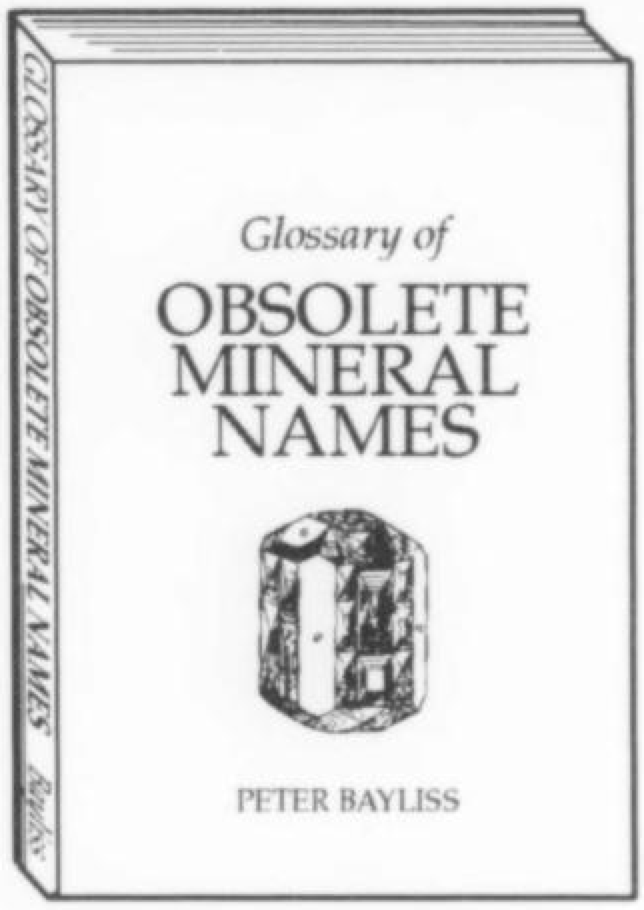
notes from the EDITOR



New Glossary Companion!

After many years of preparation we are pleased to announce a new book ready for publication: a companion to *Fleischer's Glossary of Mineral Species*, which will be titled *The Glossary of Obsolete Mineral Names* by Peter Bayliss. Here is where you will find all of those old mineral names that have mutated into something else over the years and are no longer considered valid (thus are no longer in *Fleischer's Glossary*).

Approximately 30,000 mineral names are listed, along with the currently-accepted IMA-approved mineral name *and* a reference to the discreditation, original source, redefinition or other nomenclatural key. (This reference feature is lacking in a recently published, more expensive work on mineral synonyms). We think that anyone who uses *Fleischer's Glossary* will want to have this book around as a back-up. And, of course, it has one big advantage over *Fleischer's Glossary*: it is unlikely to become obsolete very soon, since all of the names in it are *already* obsolete! And, in any case, we will be publishing periodic updates (as we do for *Fleischer's*) listing recent nomenclatural changes.

We expect to have this book ready in time for the Tucson Show or before. It will run about 244 pages (8½ x 11 inches, twice the page size of *Fleischer's Glossary*), hardcover, and sell for $32. Advance orders can be placed through the Circulation Manager (P.O. Box 35565, Tucson, AZ 85740). Orders (excl. wholesale orders) received prior to February 1 will be shipped postage-free when the books are ready; thereafter a shipping fee of $3 per book will apply.

New *Minerals of California*

The California Department of Conservation has announced plans to produce a new, revised and updated edition of *Minerals of California*. They are asking for the assistance of mineralogists and collectors in gathering new data on California minerals and mineral occurrences.

The new book will be published as an update of *Minerals of California*, Bulletin 189 (last published in 1966), but will also include the data from Pemberton's *Minerals of California*, published independently by Van Nostrand Reinhold in 1983.

Information about mineral occurrences not in the above-mentioned previous works should include data such as crystal size, habit, color, associations, a precise location, and a note on how the minerals were identified.

Plans also call for the use of some color mineral photography, although there is not yet a budget established to pay photographer's fees. Museums and collectors having photos on file that could be used without fee are encouraged to contact the Department.

Information will be collected through December 2000; send to:

Department of Conservation
Division of Mines and Geology
801 K Street, MS 08-38
Sacramento, CA 95814-3531
Attn: John Clinkenbeard
Tel: 916-323-7696
e-mail: jclinken@conserv.ca.gov

French Postcards, Monsieur?

Louis Dominique Bayle, editor of the French mineral magazine *Le Règne Minéral*, has informed me of a beautiful set of mineral postcards currently available from the magazine. A set of 18 different cards sells for 50 French francs (about $8.50 U.S.), plus an additional 20 Ff for airmail. They do accept Visa, Mastercard and Eurocard. Contact:

Le Règne Minéral
Editions du Piat
1 bis, rue du Piat
F-43120 Monistrol-sur-Loire
Tel/Fax: 33-471-66-5467

The magazine, by the way, is excellent: large format, full-color, beautifully illustrated and very informative. A one-year, seven-issue subscription is 400 Ff.

Back Issues

In this issue you will find a complete roster of the back issues we still have in stock, showing covers. We usually only do this once a year, so have a look and see what you need. Or pick out some special issues to use as Christmas presents, perhaps along with a gift subscription. Remember that sales of these back issues directly support the production of current issues, so each issue you buy improves the next issue you'll receive on your subscription. You win double, and protect yourself against the time when we become sold out of issues you still need to complete your set. You can fax a Visa/Mastercard order directly to the Circulation Manager at 520-544-0815, and get prompt delivery while supplies last.

Notices

Died, Henry A. Pohs, 70, in Denver, Colorado. Henry Pohs was well known to every serious collector of mining antiques and memorabilia in the U.S. In the late 1960's he began publishing a collector's newsletter, *The Underground Lamp Post*, which he distributed free to the small number of collectors operating at that time; over the years his circulation grew to more than 500 readers around the world. In 1974 he published the first book on the subject: *Early Underground Mine Lamps*; it became the "bible" of lamp collecting for many years. Finally, in 1995, he self-published a massively enlarged compendium (867 pages), *The Miner's Flame Light Book*, which brought together a lifetime of learning and research on all types of antique mine lamps. He was truly a pioneer in his field.

BARIUM SILICATE MINERALS FROM TRUMBULL PEAK, MARIPOSA COUNTY, CALIFORNIA

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First discovered before 1930, the Trumbull Peak barium silicate site is the type locality for sanbornite and is known for several rare minerals including alforsite, celsian, gillespite, macdonaldite, pellyite, titantaramellite and witherite. Additional minerals recently identified from the Ba-lenses include benitoite, fresnoite, kinoshitalite, krauskopfite, walstromite, and three new Ba minerals currently under study.

INTRODUCTION

Trumbull Peak is one of several barium silicate occurrences located along the western margin of North America; it hosts such minerals as alforsite, celsian, gillespite, macdonaldite, pellyite, titantaramellite and witherite, and is the type locality for sanbornite. Additional minerals discovered during this study include benitoite, fresnoite, kinoshitalite, krauskopfite and walstromite. Four new species, provisionally referred to as Mineral 10, Mineral 21, Minerals 27 and Mineral TPUK-1, have also been identified from specimens collected during the study.

Other noteworthy Ba-silicate occurrences include Dry Delta, Alaska Range, Alaska (Schaller, 1922, 1929); the Ross River–Pelly River area, Yukon Territory, Canada (Montgomery, 1960); the Big Creek–Rush Creek area, Fresno County, California (Alfors *et al.*, 1965); Chickencoop Canyon, Tulare County, California (Franke, 1930; Hinthorne, 1974), and the La Madrelena mine, Baja California, Mexico (Hinthorne, 1974).

The first description of the Trumbull Peak Ba-silicate locality was published by Rogers in 1932 when the new barium silicate sanbornite was described, in addition to new localities for celsian and gillespite. Since then, reference has been made to the area's mineralogy by Alfors *et al.* (1965) and Alfors and Pabst (1984).

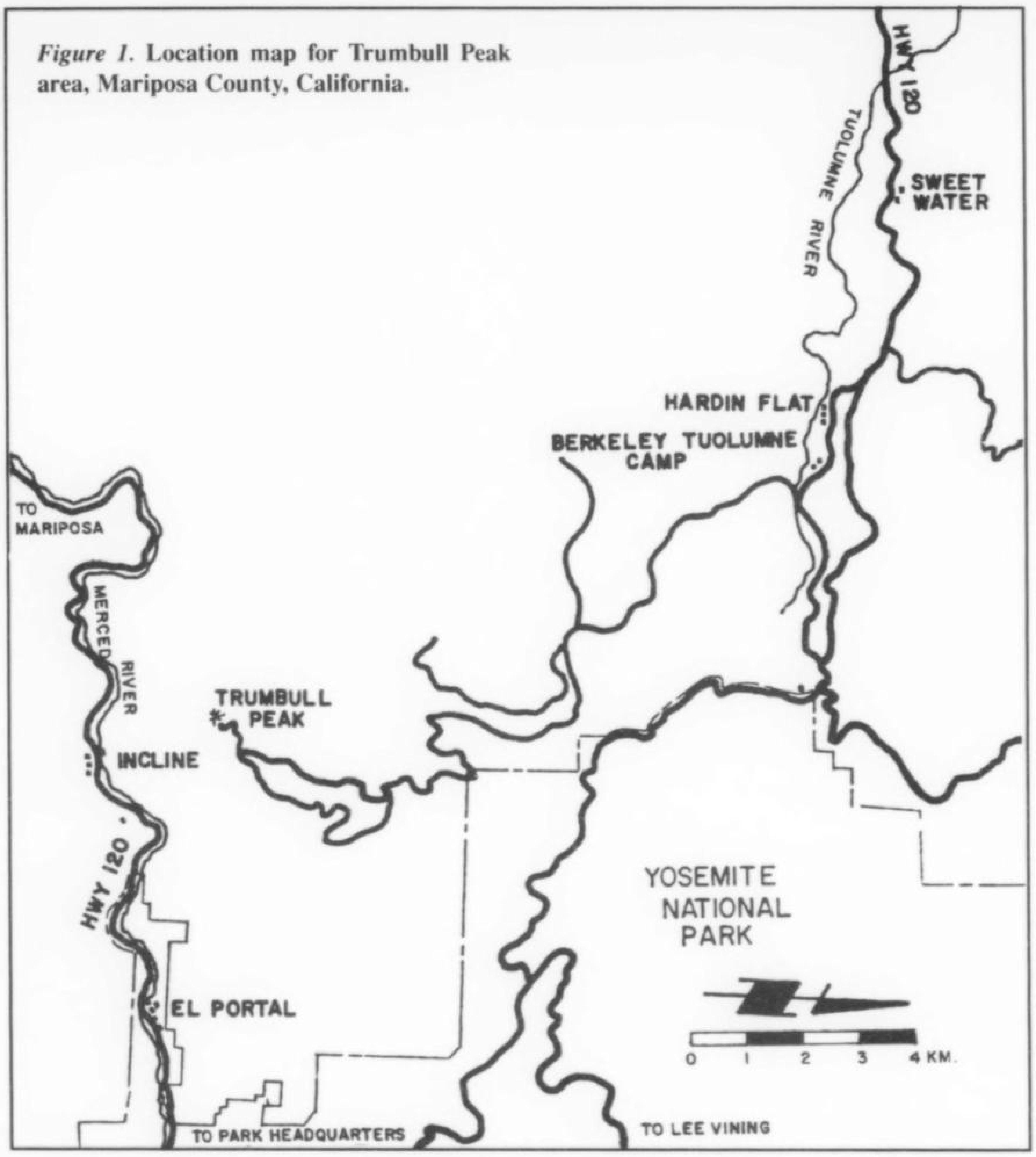

Figure 1. **Location map for Trumbull Peak area, Mariposa County, California.**

LOCATION

Trumbull Peak is located on the western slope of the Sierra Nevada Range in NE¼ Sec. 9, T3S, R19E, Mount Diablo Meridian, about 67 km northeast of Merced and 8 km west of El Portal, the gateway to the Yosemite National Park. To reach Trumbull Peak, travel east on State Highway 120 to Berkeley Toulumne camp and then southeast on U.S. Forest Service road 1S12 for about 20 km, following the old logging railroad grade. About 5 km before reaching the area, Forest Service road 1S20 branches to the right and terminates atop Trumbull Peak. Because of the abundance of roads in the area, a Forest Service map is quite useful.

About 400 meters up the Trumbull Peak road there is a sharp left bend as the road heads south. At this corner there is a small parking area large enough for two vehicles. The general collecting area is located about 200 meters down the steep slope to the northwest. There are no physical landmarks identifying the location of the Ba-silicate lenses, and much searching may be required unless the area has been explored previously.

The collecting localities consist of three elongated shallow pits that have been excavated by collectors over the years. None exceed 2 meters in length and 50 cm in width, with a maximum depth of 50 cm. Collecting at the site is made very difficult by the steep terrain and by the unfortunate fact that most of the barium silicate material has already been removed from the area. Indiscriminate blasting has scattered material down the steep hillside, and this material now constitutes the best collecting. The barium silicate-bearing rock weathers to a fine-grained white material which is visible at a distance.

In 1987 a large forest fire affected much of the area from State Highway 120 to Trumbull Peak, including the western slope of the peak. The area has changed in appearance over the 25 years since we first visited it in 1963. Several trees which were standing near the largest lens have since been destroyed.

Because the slope is quite steep, averaging 45° or more in places, precautions should be taken while climbing in the area. A long rope is useful in descending and ascending the slope because of the loose rock and soft soil. There is very little shade in the area, and collecting can be quite exhausting during the summer months.

HISTORY

Rogers (1932) states that the locality was discovered by Anthony Marsh of Incline, Mariposa County, sometime before 1930 (the exact date is not given). Samples collected by Marsh were submitted to the California Division of Mines for identification because of the presence of a rose-red mineral in addition to a white to colorless, cleavable mineral with a pearly luster. The rose-red mineral was identified as gillespite by Division of Mines person-

Figure 2. **Typical barium silicate-bearing area on the west slope of Trumbull Peak. G. Dunning photo.**

nel. At that time gillespite was known only from Dry Delta, Alaska Range (Schaller, 1922).

The pearly white mineral was not immediately identified at the Division because of its unusual properties. Instead, it was forwarded by Frank Sanborn of the Division of Mines to Austin F. Rogers at Stanford University for description. Rogers performed an analysis of the mineral and determined it to be a new layered barium silicate; he named it sanbornite after Frank Sanborn, in recognition of his faithful work as a determinative mineralogist. Since that time, sanbornite has been identified from a number of localities, the best being the barium silicate veins in the Big Creek–Rush Creek area of Fresno County, California (Alfors *et al.*, 1965).

Several other minerals were also noted by Dr. Rogers from the Trumbull Peak samples, including celsian, witherite, diopside, schorl, pyrrhotite and three (?) unidentified minerals, one of which was later identified as titantaramellite by Alfors and Pabst (1984).

During the period from 1920 until the late 1930's there was considerable logging activity in the woods both north and west of Trumbull Peak. An inclined railroad was constructed west of the camp at Incline, up the steep eastern slope of Trumbull Peak, to harvest the rich stands of sugar pine. A total of 21 logging camps were in existence during this time, with over 200 men working. Johnson (1963) described this logging operation in his history of the Yosemite Valley Railroad.

Rogers was able to visit the Trumbull Peak area and collect additional samples of the barium silicates with the aid of Anthony Marsh and Jim Law, logging foreman. Marsh may have worked for the railroad or logging company, because the entire area was under control of the logging company and special passes were required to enter the logging areas. The only way up to the timber area was by means of the inclined railroad, which attained a grade of nearly 78% near the summit.

Since its discovery by Marsh in the early 1930's, the area has been visited by a number of mineral collectors who have obtained samples of the barium silicate minerals, including sanbornite, gillespite, celsian, pellyite, macdonaldite, titantaramellite, and the recently described barium analog of chlorapatite, alforsite.

Our field collecting experience at Trumbull Peak began in 1963, when we located one of the three reported lenses. We found a number of broken specimens which contained rich patches of gillespite in sanbornite and a few "taramellite" grains (not known as titantaramellite then). A few specimens containing macdonaldite were also noted in the weathered sanbornite. Some of the gillespite-sanbornite specimens were noted as having a clear, fine-grained quartz patch containing small titantaramellite crystals, and, as we later determined in 1984, abundant minute grains of alforsite. It was at this time that we were involved in the mineralogy of the Kalkar quarry in Santa Cruz, California, where some of the largest titantaramellite specimens were being recovered, as well as pabstite, celsian and witherite (Dunning and Cooper, 1986).

A second trip to Trumbull Peak was planned in the summer of 1988 to obtain site photographs and additional material for study. We were, however, unable to relocate the lens we had found in 1963. While exploring the steep slope, we found a second, smaller lens beneath several small trees and dense brush above a rocky ravine; it contained several white float samples of sanbornite-quartz rock. This material was found to be higher in quartz content than the previous lens visited in 1963. Smaller amounts of sanbornite and gillespite make up the general vein content, with abundant, small titantaramellite crystals. A pale, massive brownish yellow mineral was also noted which was suspected of being pellyite.

GEOLOGY

Trumbull Peak is located within a region known as the western metamorphic belt (Bateman and Wahrhaftig, 1966) of the Sierra Nevada, a strongly asymmetric mountain range with a long, gentle western slope and a high, steep eastern escarpment. The rugged peaks and surrounding ridges west of Incline are composed of Paleozoic metasedimentary rocks, principally quartzite and hornfels. The age of the sediments is not known more precisely than Paleozoic, and the granite composing the Sierra Nevada Batholith several kilometers to the east is supposedly late Jurassic. The sedimentary beds are isoclinally folded and have suffered a low-grade dynamic metamorphism. The general geology of the region has been studied by Macdonald (1941) and Krauskopf (1953). Brief descriptions have also been written by Fitch (1931), Rogers (1932), and Alfors and Pabst (1984).

Along the northwestern slope of Trumbull Peak several lenses occur, each less than a meter wide, which are rich in barium silicates and are surrounded by a hard, dense quartzite. These lenses have a steep dip, near 80°, and show a fine-grained texture similar to that seen in the surrounding quartzite. A narrow alpine dike, less than a meter wide, occurs about 50 meters away from the largest lens but according to Alfors and Pabst (1984) appears to have no connection with the barium silicate lenses.

MINERALOGY

The mineral specimens collected during 1988 from the quartz-rich lens were later broken into specimens 4 cm or smaller and examined under a binocular microscope using white light and

Table 1. **Minerals identified from Trumbull Peak.**

Mineral	*Composition*	*Rarity*
Barium Minerals		
Alforsite	$Ba_5(PO_4)_3Cl$	Very rare
Barite	$BaSO_4$	Rare
Benitoite	$BaTi(Si_3O_9)$	Rare
Celsian	$Ba(Al_2Si_2O_8)$	Uncommon
Fresnoite	$Ba_2TiO(Si_2O_7)$	Very rare
Gillespite	$BaFeSi_4O_{10}$	Common
Kinoshitalite	$(Ba,K)(Mg,Mn,Al)_3Si_2Al_2$-$O_{10}(OH)_2$	Rare
Kruaskopfite	$H_4Ba_2[Si_4O_{12}]\cdot 4H_2O$	Very rare
Macdonaldite	$H_2Ca_4Ba[Si_8O_{19}]_2\cdot 8H_2O$	Rare
Pellyite	$Ba_2Ca(Fe,Mg)_2[Si_6O_{17}]$	Uncommon
Sanbornite	$BaSi_2O_5$	Common
Titantaramellite	$Ba_4(Ti,Fe,Mg)_4[B_2Si_8O_{27}]O_2Cl_x$	Common
Walstromite	$BaCa_2[Si_3O_9]$	Very rare
Witherite	$BaCO_3$	Common
Mineral 10	Ba-Fe-Al-Cl Silicate	Rare
Mineral 27	Ba-(Fe,Mn,Ca)-Silicate-Phosphate	Very rare
Mineral TPUK-1	Ba-Fe Silicate	Rare
Associated Minerals		
Biotite, barian	$(K,Ba)(Mg,Fe)_3[(Al,Si)$-$Si_3O_{10}](OH,F)_2$	Uncommon
Diopside	$CaMgSi_2O_8$	Uncommon
Fluorapatite	$Ca_5(PO_4)_3F$	Rare
Pyrrhotite	$Fe_{1-x}S$	Common
Quartz	SiO_2	Common
Schorl	$NaFe_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$	Uncommon
Vesuvianite	$Ca_{10}Mg_2Al_4(SiO_4)_5(Si_2O_7)_2(OH)_4$	Uncommon
Mineral 21	$SiO_2\cdot nH_2O$ (?)	Rare

shortwave ultraviolet light. Those specimens which exhibited physical properties (color, habit, fluorescence) which could not be immediately matched with known minerals reported from Trumbull Peak were set aside for additional tests. Each of the questionable minerals was subjected to a scanning electron microscope examination using backscattered electron imaging (BSE) and energy dispersive spectrometry (EDS). This data was compared with spectra from barium silicate minerals of known composition obtained from the Big Creek–Rush Creek deposits described by Alfors *et al.* (1965). Three of the questionable minerals were identified by their characteristic fluorescence under shortwave ultraviolet light, EDS spectra and color; these were benitoite, fresnoite and walstromite. A fourth mineral, krauskopfite, was later identified by X-ray diffraction (XRD) and EDS. A fifth mineral (an unnamed blue-green Ba-Fe-Cl silicate), because of its characteristic powder pattern and EDS spectrum, was found to be identical to Mineral 10, one of the several unknown barium silicates found at the Big Creek–Rush Creek barium deposits. A pale brown mica was also separated from the quartz-sanbornite rock which shows a high concentration of barium. This mineral was later identified as kinoshitalite by its XRD pattern and EDS spectrum. On some of the weathered sanbornite from the second lens, a radiating, pearly white mineral was isolated which was determined by its habit and EDS spectrum to be identical with Mineral 21, a hydrated form of silica first isolated from the Rush Creek area. A single specimen containing a brownish black layered mineral was subsequently identified by XRD as Mineral 27, first noted at Big Creek, Fresno County. Small masses of a granular black mineral were discovered in material rich in sanbornite, gillespite and pyrrhotite which has been proven by XRD to be a new species and is currently under study.

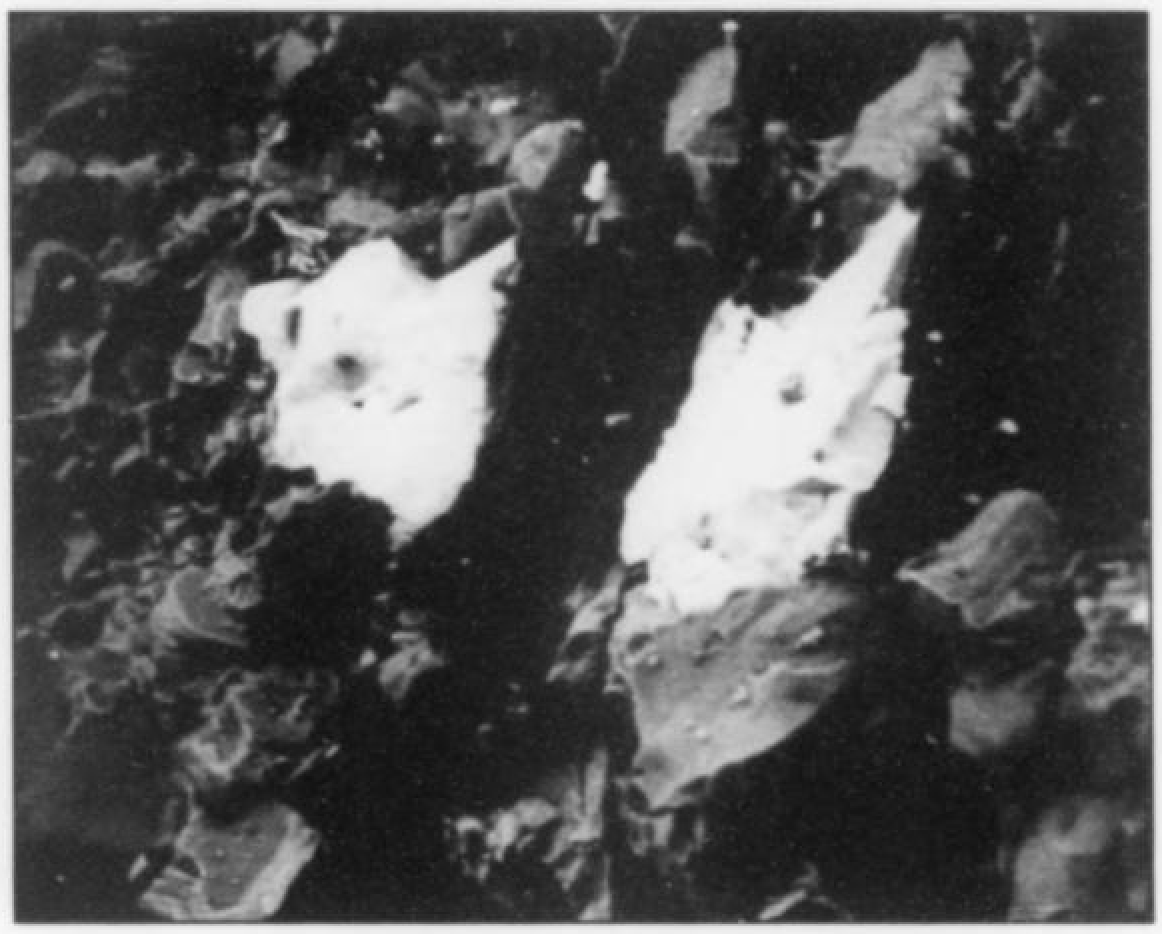

***Figure 3.* Anhedral grains of alforsite in quartz, 0.04 mm in diameter. G. Dunning specimen and SEM-BSE photo.**

Barium Minerals

Alforsite $Ba_5(PO_4)_3Cl$

Alforsite, the barium analog of chlorapatite, was described as a new mineral by Newberry *et al.* (1981) from the metamorphic sanbornite-quartz rocks along Big Creek, Fresno County, California, about 90 km southeast of Trumbull Peak. They also noted this mineral in samples of quartz containing sanbornite and gillespite from Trumbull Peak which were obtained from the University of Michigan Mineralogical Collection. Stinson (1982) has recorded its presence in the Rush Creek deposit, Fresno County, and at the La Madrelena mine, Baja California, Mexico.

At all the known localities, alforsite grains are generally less than 0.2 mm in size and are embedded in quartz. They are colorless and resemble typical fluorapatite exhibiting low birefringence and high relief. These features make it difficult to distinguish alforsite from fluorapatite and the many high-relief barium minerals except by electron microprobe. Alforsite has a distinctive reddish violet cathodoluminescence in the 10 to 15 Kev electron beam. Using the SEM with a BSE detector, alforsite is relatively easy to identify if there are not other barium minerals in high concentration, such as celsian. The EDS spectrum is quite distinctive and cannot be confused with associated celsian and witherite, which are often found in grains of comparable size.

The Trumbull Peak alforsite is usually associated with titantaramellite in a fine-grained quartz which is easily recognized in the field. Alforsite has been identified from both lenses and is about equal in abundance in the specimens examined. A typical specimen of about 1 square centimeter in size will contain around 6 to 30 grains of alforsite.

Barite $BaSO_4$

Small anhedral grains of barite associated with sanbornite, gillespite and quartz were identified in the samples collected in 1988.

Benitoite $BaTi(Si_3O_9)$

Benitoite was identified in quartz-rich samples from the lens material collected during 1988 and also in several of the sanbornite-gillespite specimens collected in 1963. The anhedral grains are colorless and generally less than 0.01 mm in size. They have a distinctive blue-white fluorescence under shortwave ultraviolet light. No zirconium or tin was noted in the EDS spectra obtained from several grains examined.

Celsian $Ba(Al_2Si_2O_8)$

Celsian, the barium feldspar, occurs as inconspicuous colorless grains, generally 0.1 mm or smaller in fine-grained quartz. Rogers (1932) noted this mineral in the samples containing sanbornite and gillespite; at that time it was the first mention of celsian in the United States.

Fresnoite $Ba_2TiO(Si_2O_7)$

Fresnoite occurs as anhedral grains, less than 0.1 mm in size, with a pale lemon color. It was first suspected because of its pale yellow fluorescence under shortwave ultraviolet light. Most of the fresnoite grains are associated with dark brown titantaramellite and colorless benitoite in the quartz-rich rock.

Gillespite $BaFe^{2+}(Si_4O_{10})$

Because of its beautiful rose-red color and perfect cleavage, gillespite (described by Schaller in 1922 and later studied by Pabst in 1943) is the most interesting of the barium silicate minerals occurring at Trumbull Peak. When associated with white to colorless sanbornite, it makes a very attractive specimen. In thin section Schaller (1922) noted its striking pleochroism under the microscope. At the larger lens site, gillespite was found to compose about half of the barium silicate rock composition.

Kinoshitalite $(Ba,K)(Mg,Mn,Al)_3[(Si,Al)_4O_{10}](OH)_2$

This rather rare barium mica of the brittle mica family was identified in the samples obtained from the lens located in 1988. Kinoshitalite is pale brown in color with a micaceous habit, and occurs in isolated flakes in the quartzite associated with sanbornite, gillespite, pyrrhotite and titantaramellite. It was identified by XRD and EDS using a comparison sample obtained from the type locality, the Noda-Tamagawa mine, Iwate Prefecture, Japan, described by Yoshii *et al.* (1973). About ten small samples are known from the lens material.

Kruaskopfite $H_4Ba_2[Si_4O_{12}]\cdot 4H_2O$

Krauskopfite was identified by its powder pattern and EDS spectrum as a constituent of a thin white vein traversing fresh quartz-rich samples containing sanbornite and walstromite. When this thin vein was broken open, the long, colorless grains showed a subvitrous luster and two perfect cleavages at 90°. The type locality for this mineral is the Esquire #1 claim at Rush Creek, Fresno County, California (Alfors *et al.*, 1965).

Macdonaldite $H_2Ca_4Ba[Si_8O_{19}]_2\cdot 8H_2O$

Macdonaldite was recorded from specimens collected at Trumbull Peak by Alfors *et al.* (1965). It forms small radiating crystal aggregates up to 0.5 mm in diameter and individual crystals as much as 2 mm long. Macdonaldite was found on our specimens collected in 1963 from the larger lens but not in the material from the small, quartz-rich lens examined in 1988.

Pellyite $Ba_2Ca(Fe,Mg)_2[Si_6O_{17}]$

Pellyite was recognized and described as a new mineral by Montgomery (1960) and Montgomery *et al.* (1972) from near the headwaters of the Ross and Pelly Rivers, Yukon Territory, Canada. Its presence at Trumbull Peak was established by Pabst and Harris (1984) as yellow-brown anhedral grains and masses less than 3 mm in size. They also give additional data and localities for pellyite. It is typically found in quartz from at least one of the three lenses on the northwest slope of Trumbull Peak. Only a few specimens were recovered during our 1988 trip. Pellyite also has been identified from the Esquire #7 claim at Big Creek, Fresno County, California, by Montgomery *et al.* (1972). The crystal structure of pellyite has been solved by Meagher (1976).

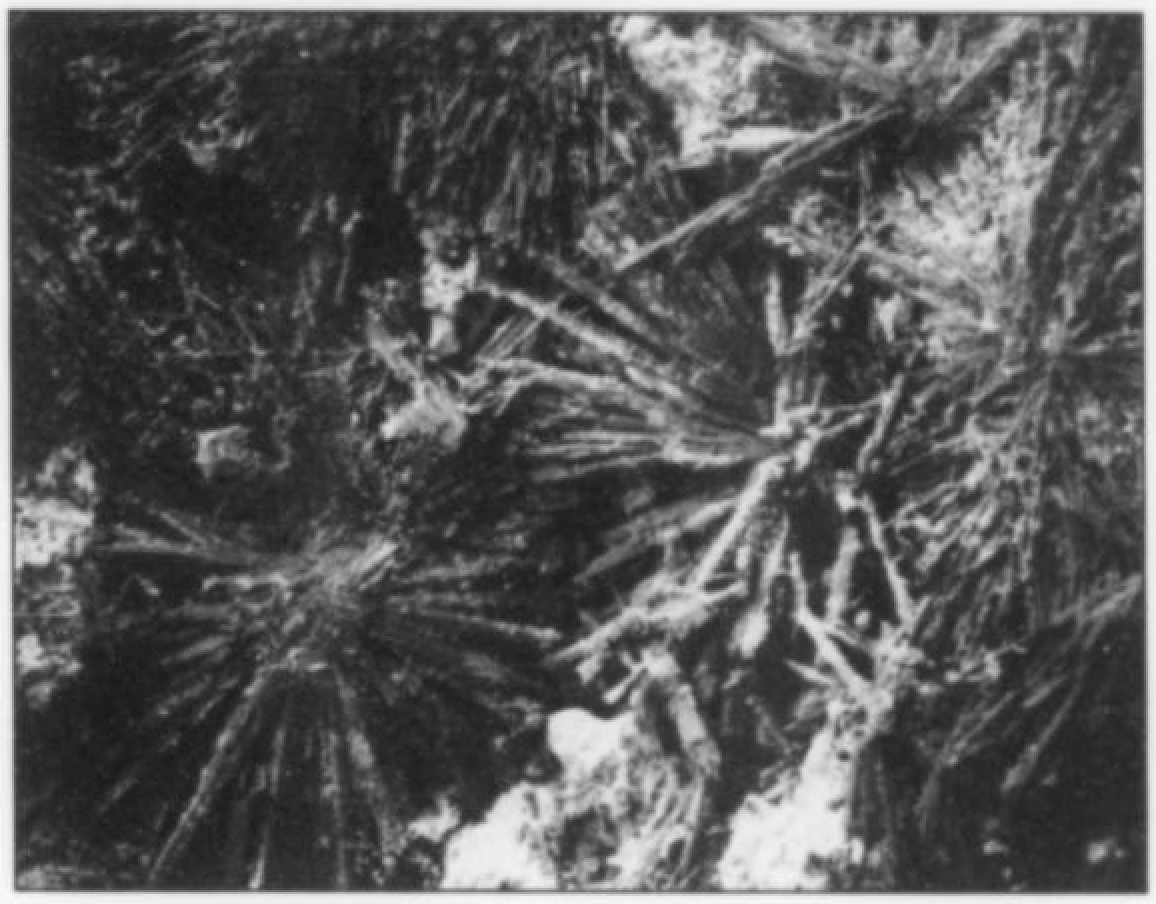

***Figure 4.* Radiating sprays of macdonaldite, 3 mm in diameter. G. Dunning specimen and photo.**

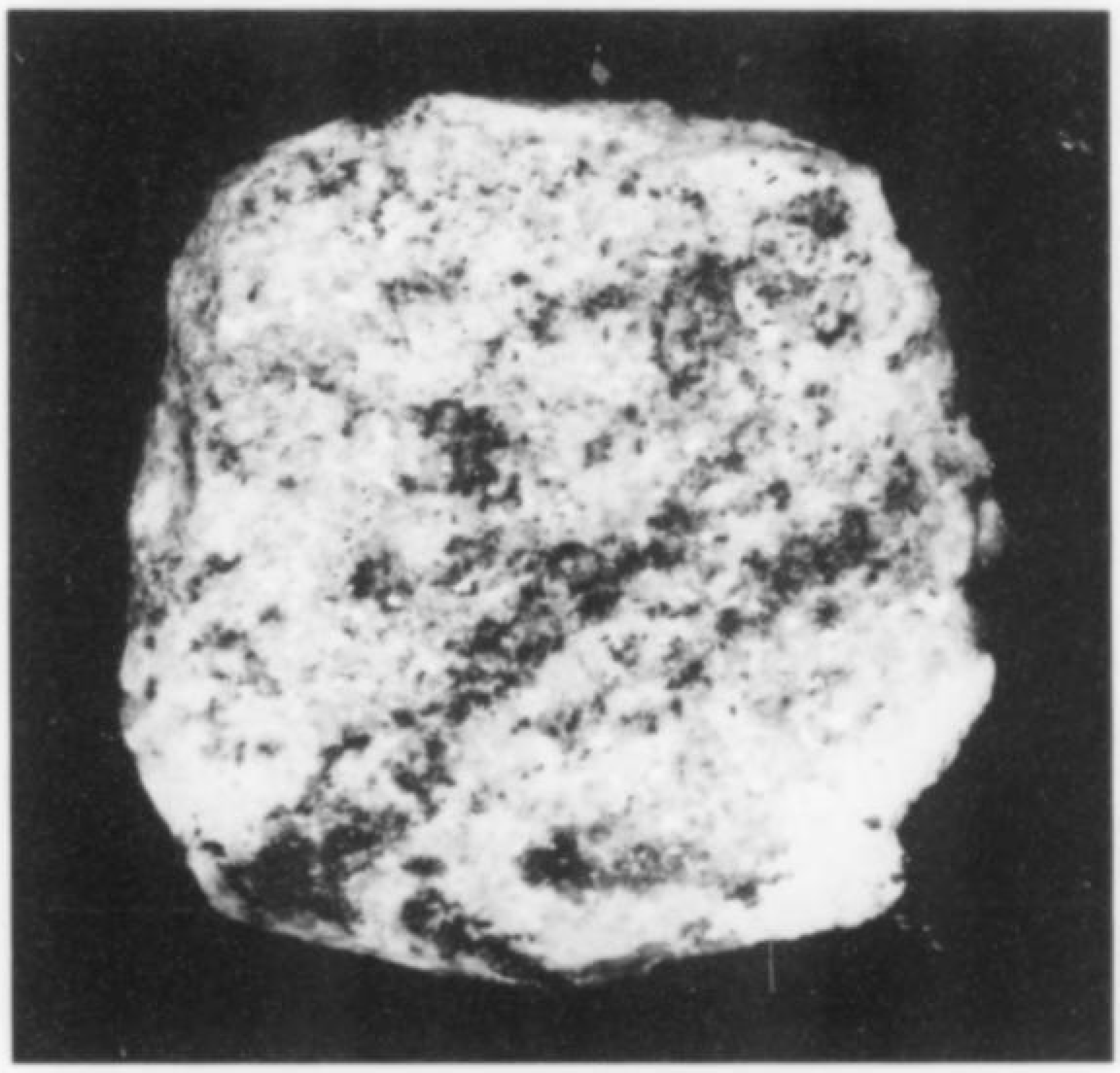

***Figure 5.* Typical specimen of sanbornite in quartz containing gillespite veins (dark); 6 cm. G. Dunning specimen and photo.**

Sanbornite $Ba[Si_2O_5]$

Sanbornite was first noted as a new mineral from Trumbull Peak by Rogers (1932), and its crystal structure was solved by Douglass in 1958. It occurs in white to colorless, subtransparent plates up to 3 cm in size and about 4 mm thick; it is easily recognized in the field by its perfect cleavage. Weathering of sanbornite results in an opaque white coating rich in silica and rarely also in Mineral 21, an undescribed hydrous silica mineral. Sanbornite is usually associated with rose-red gillespite and dark brown titantaramellite in the quartzite lens material.

Titantaramellite $Ba_4(Ti,Fe,Mg)_4[B_2Si_8O_{27}]O_2Cl_x$

Rogers (1932) noted in his study of the barium minerals at Trumbull Peak an unknown mineral, dark brown in color, with a very high relief and strong absorption. This mineral was later identified as taramellite and referenced by Alfors *et al.* (1965); it has been found at nearly all of the important barium silicate localities in North America. Pabst (1978) and Alfors and Pabst (1984) have described the mineral and its associations in detail. As a result of their work, the Ti-dominant taramellites found in California are now known as titantaramellite. Taramellite, the Fe-dominant member, occurs at Candoglina, Italy; the V-dominant member, nagashimalite, occurs at the Mogurazawa mine, Japan.

Titantaramellite is present in moderate amounts in most of the samples found at Trumbull Peak. It is especially abundant, although in small, broken crystals, in the specimens collected from the smaller lens during 1988. Alfors and Pabst (1984) list a number of crystallographic forms for the Trumbull Peak titantaramellite including the {010}, {001}, {110} and {011}. Less commonly observed forms include the {101}, {310}, {012} and {021}.

Walstromite $BaCa_2[Si_3O_9]$

Walstromite was identified by its dull pink fluorescence under shortwave ultraviolet light and by its EDS spectrum which was compared to material from the type locality, Big Creek, Fresno County. It has only been observed from the quartz-rich material collected during 1988, and then, only about a dozen small samples were found. It shows a good cleavage and the average grains are generally less than 0.5 mm in size.

Witherite $BaCO_3$

Minute grains of witherite occur throughout the sanbornite-gillespite-quartz rock and are usually less than 1 mm in size.

Mineral 10 Ba-Fe-Al-Cl silicate

Small masses and veins of a dark blue-green mineral with elongated grains were observed in the quartz-rich rock collected in 1988. An EDS spectrum was found to match a mineral of similar color and habit noted both in material from the Yukon Territory, Canada, and the Big Creek–Rush Creek area, Fresno County, California (Alfors *et al.*, 1965). This material has been provisionally designated as *Mineral 10* and has been under study for many years. Recently, a single quartz specimen was discovered which hosts two small groups of radiating bluish green crystals with deep grooves parallel to the long axis. This is the first known example of crystals of this mineral.

Mineral 27 Ba-(Fe,Mn,Ca)-silicate/phosphate

This mineral has been known from the Big Creek locality, Fresno County, for several years and is currently under study. It occurs as brownish-black radiating crystals surrounded by quartz, sanbornite and gillespite. Only a single specimen has been recovered from the material examined.

Mineral TPUK-1 Ba-Fe silicate

A jet-black, fine-grained mineral was isolated from specimens rich in sanbornite, gillespite, titantaramellite, pyrrhotite and quartz. It forms rounded masses about 2 mm in diameter. An X-ray diffraction pattern does not match any known phase. About 30 specimens containing this mineral are known.

Associated Minerals

The Ba-silicate lenses host several minerals which do not contain barium. Rogers (1932) observed small amounts of diopside, pyrrhotite, schorl and vesuvianite in the samples he studied in thin section. Newberry *et al.* (1981) noted small amounts of fluorapatite associated with the alforsite at Trumbull Peak. Also identified in the suite of minerals collected in 1988 is another unknown phase designated as *Mineral 21* from the Rush Creek area, Fresno County. This mineral is essentially a hydrous form of silica and is the result of sanbornite weathering.

Table 2. **Possible paragenetic timeline for the Trumbull Peak barium silicate locality.**

Mineral	*Early*			*Late*
Alforsite	——			
Barite	——			
Benitoite	——			
Celsian	——			
Fresnoite	——			
Gillespite	——			
Kinoshitalite		——		
Krauskopfite			——	
Macdonaldite				——
Pellyite	——			
Sanbornite		——		
Titantaramellite	——			
Walstromite		——		
Witherite			——?	
Mineral 10		——		
Biotite, barian		——		
Diopside	——			
Fluorapatite	——			
Pyrrhotite	——			
Quartz	——			
Schorl	——			
Vesuvianite	——			
Mineral 21				——

Biotite samples recovered from the quartzite margin of the lens examined in 1988 contain small amounts of barium replacing potassium.

PARAGENESIS

The quartz-rich Ba-silicate lenses exposed along the northwestern slope of Trumbull Peak probably originated from Paleozoic sediments which were metamorphosed prior to being uplifted to their present position. Fitch (1931) has described a barite-witherite deposit about 8 km east of Trumbull Peak which formed by replacement of a limestone bed by barium solutions related to the Sierra Nevada Batholith. Of the three reported lenses at Trumbull Peak, only two have been sampled by the authors; the third has not been relocated.

The most northerly lens is composed of a mixture of quartz, sanbornite, gillespite and titantaramellite. From textures observed in these specimens, titantaramellite, gillespite and quartz formed first, followed by sanbornite. Pyrrhotite appears contemporaneous with the gillespite. Within fine-grained quartz are equigranular grains of alforsite and celsian. Weathering of the rocks at this lens site has resulted in crusts of silica, radiating crystals of macdonaldite, isolated crystals of Mineral 21 and secondary witherite. The rare barium mica, kinoshitalite, occurs within the sanbornite-gillespite-quartz veins. Along the contact margins of the barium lens with the quartzite, barium-rich biotite is common.

The second lens is located to the south of the first lens and is quartz-rich with very little gillespite or sanbornite. Within the quartz are isolated crystal sections of titantaramellite, masses of pellyite, rounded grains of benitoite, fresnoite, walstromite, celsian, Mineral 10 and pyrrhotite. Thin veins of krauskopfite cut this quartz. The mineral assemblages of the two lenses examined are probably related to the initial bulk chemistry of the sediments prior to metamorphism. Hinthorne (1974) suggests that sanbornite was formed by the reaction of witherite with quartz. His results place a lower temperature limit of about 440°C and a probable upper limit of 600°C on the formation of the sanbornite-quartz rocks. The conditions for the formation of gillespite and its associations were not investigated in his studies. Gillespite has yet to be synthesized in the laboratory. Figure 3 illustrates a possible sequence for the various minerals identified at Trumbull Peak.

CONCLUSIONS

The Ba-silicate lenses at Trumbull Peak may still have the potential for producing additional minerals, although diligent searching will be required. Alfors and Pabst (1984) state that the lenses have been nearly exploited to exhaustion; however, a few samples of the sanbornite-rich rock can still be found on the steep slope below the outcrops. The lighter colored Ba-silicate rock is easily visible against the contrasting darker quartzite and hornfels.

Access to the area is still possible and the roads are generally in good condition. Collecting should be confined to either the spring or fall months, as the region can be quite hot during the summer.

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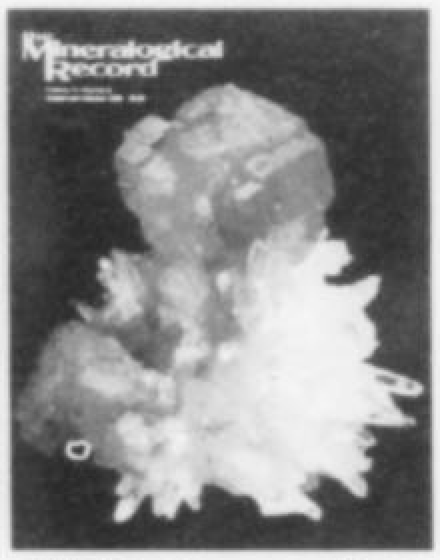

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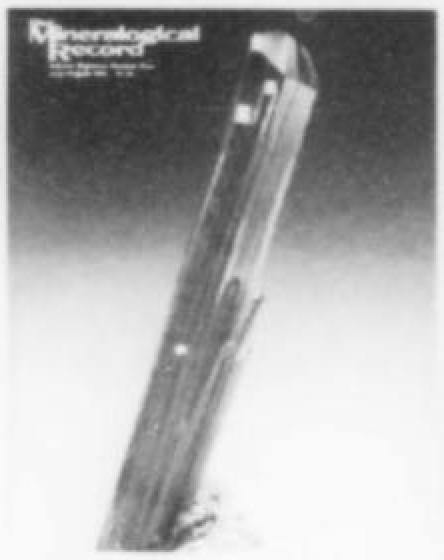

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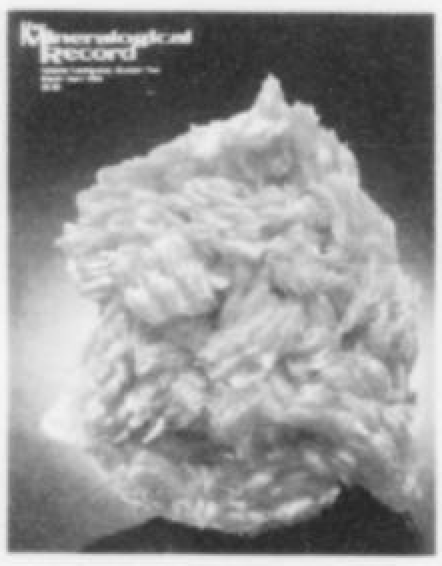

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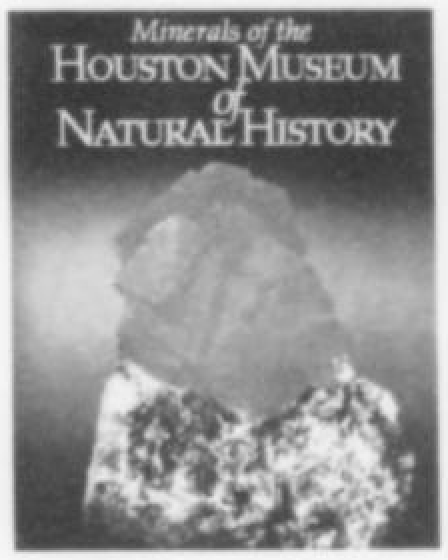
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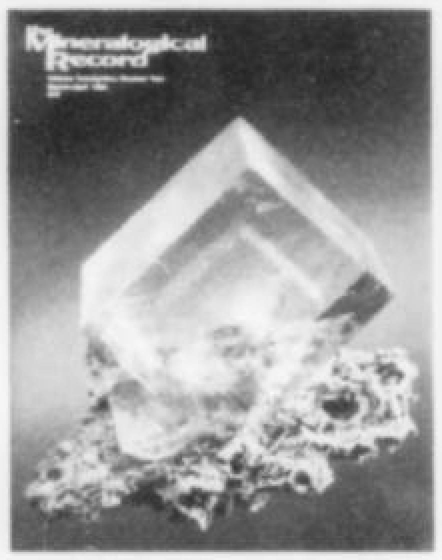

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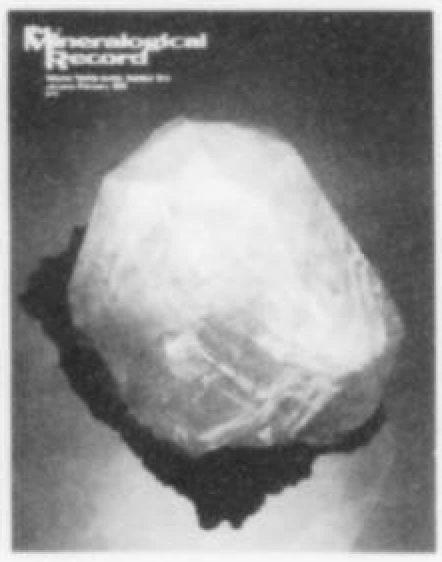

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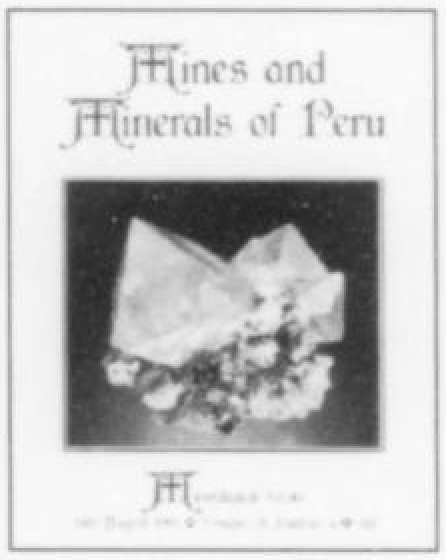

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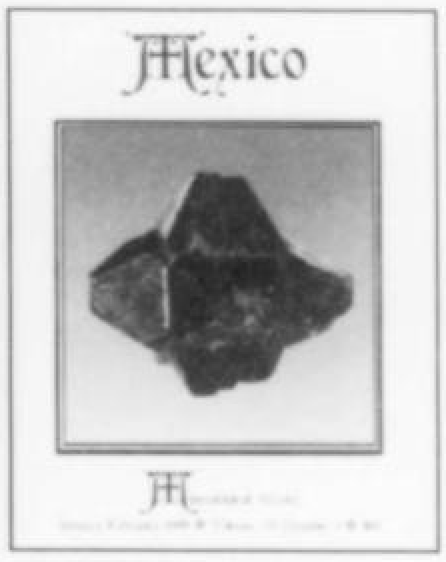

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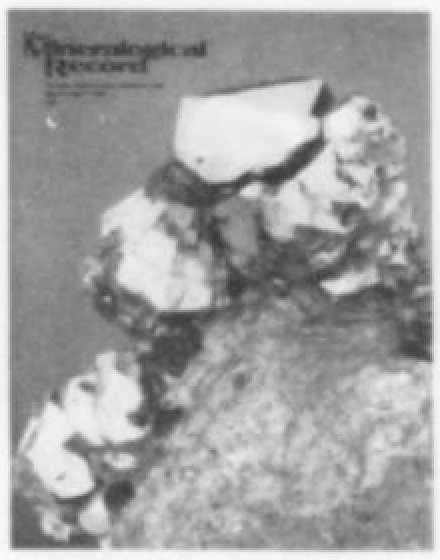

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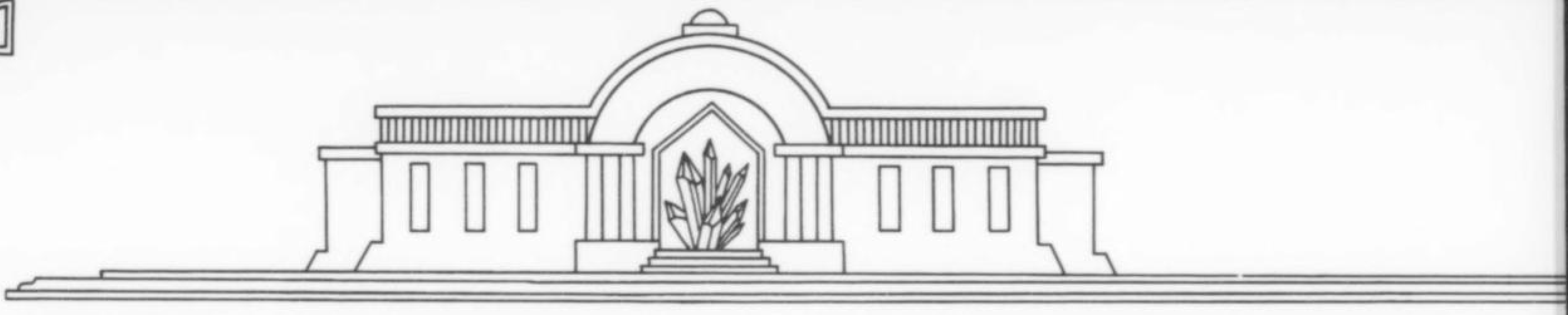

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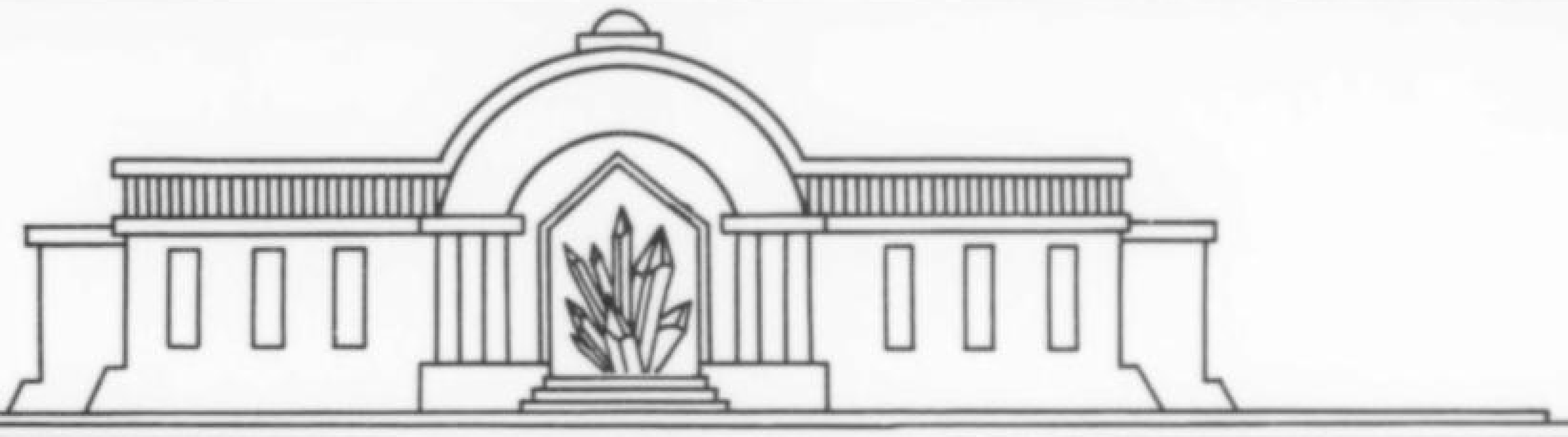

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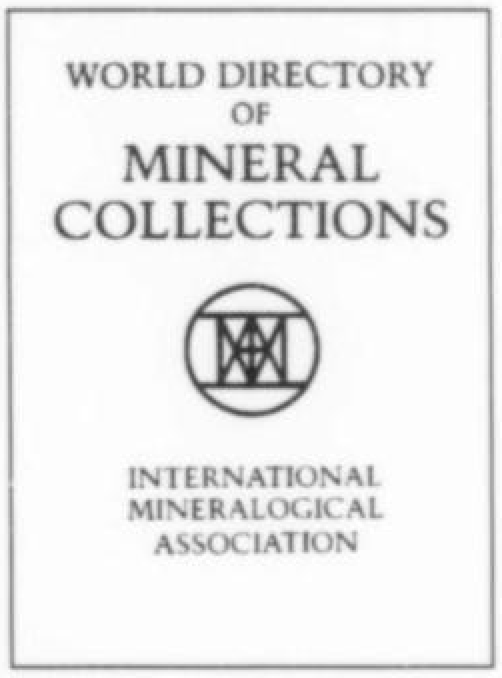

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THE DODO DEPOSIT
SUBPOLAR URALS, RUSSIA

Evgeni V. Burlakov*
Urals Geological Museum
39 Kuibyshev Street
620219 Ekaterinburg, Russia

The Dodo mine in the Subpolar Ural Mountains is an extraordinary Alpine Cleft deposit famous for large and beautiful smoky quartz gwindels, fine titanite twins, water-clear apatite crystals, gemmy brookite, and a range of other species.

INTRODUCTION

Fine specimens of quartz, titanite, brookite and other minerals from the Dodo mine have been reaching the Western mineral market more or less since the end of the Cold War period; the Fersman Mineralogical Museum in Moscow brought a selection of specimens to the Munich Show in 1989. But the occurrence has been known in Russia since the 1920's. The locality itself is situated in a remote area of Tyumen Oblast, near the crest of the Ural Mountains in a portion of that range known as the Subpolar Urals (Pripolyarnyy Ural). The Subpolar Urals are a high section of the mountains dominated by Mount Narodnaya (1894 meters) and Mount Neroika (1646 meters), and connecting with the Polar Urals to the north and the Northern Urals to the south.

The Dodo mine site is about 3 km northwest of the village of Neroika and 6 km northeast of Mount Neroika; the town of Saranpaul lies about 100 km to the east-southeast, and is sometimes loosely cited as the locality name (or as "near Saranpaul").

Neroika village is the headquarters of the Neroisk Exploration and Development Company, the most important sponsor of Polar and Subpolar Urals exploration and the agency in charge of mining at the Dodo site.

The Dodo deposit extends across a series of ridgetops ranging from 600 to 850 meters in elevation. The region is known for its severe polar climate, where the winter snows often do not begin melting until June.

HISTORY

The first discovery of large quartz crystals in the Subpolar Urals took place in 1927, along the upper reaches of the Lyapni River. The find was made by an expedition sponsored by the USSR Academy of Science, and headed by A. N. Aleshkov. Shortly thereafter, in that same year, Aleshkov discovered the Dodo deposit. During the following seven years the expedition studied the geology of the Subpolar Urals.

In 1935 the Polar Urals Expedition, also under the direction of Aleshkov, was sponsored by the Russian Gemstone Trust for the purpose of exploiting the quartz crystals. The Saranpaul settlement was chosen as the base of operations where mining supplies, food

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*Formerly geological engineer at the Dodo deposit, and part of the Polar Urals Exploration Program under the firm Severkvarzsamozvety.

Figure 1. View of the settlement of Neroika, beneath the peak of the same name, near which is the Dodo deposit. E. Burlakov photo.

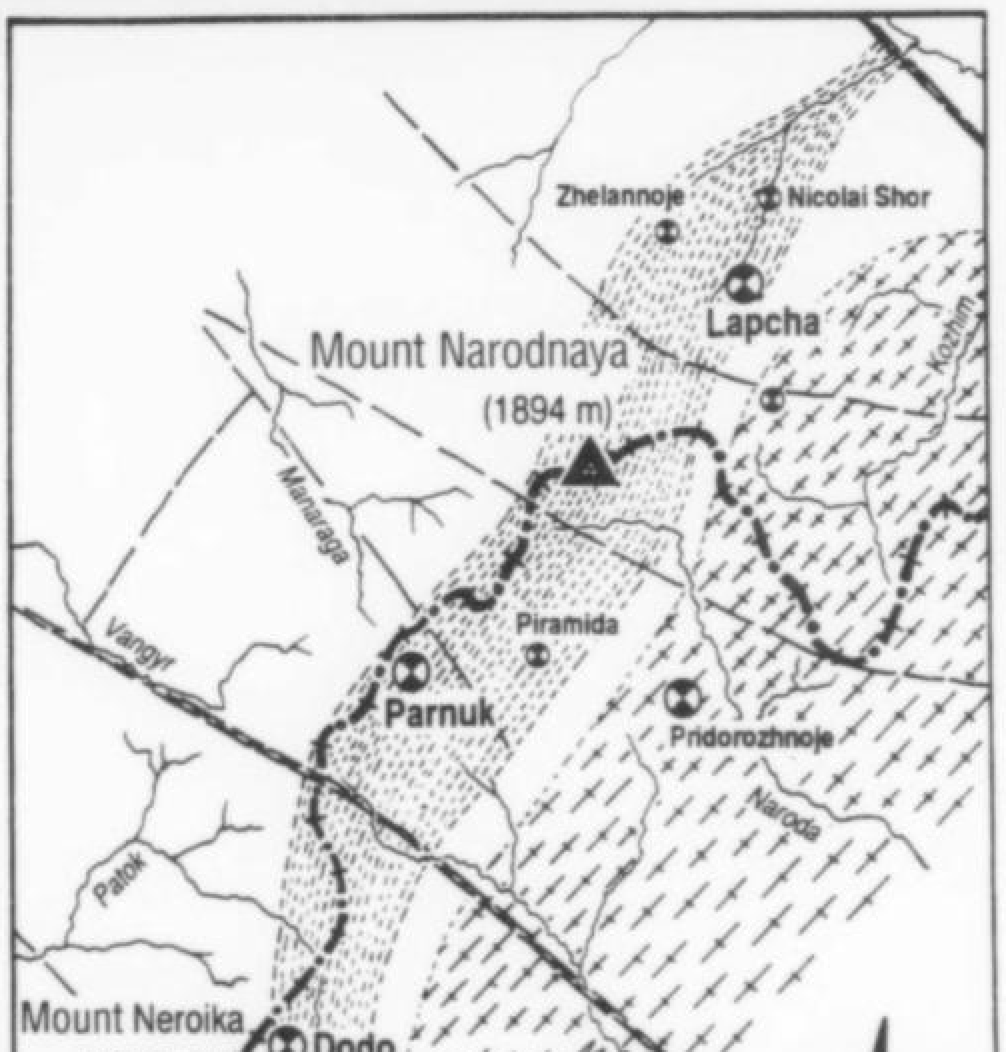


Figure 2. General geology of the Alpine-type quartz deposits in the Subpolar Urals (after Bukanov, 1995). (1) Granite gneiss dome—Proterozoic, (2) Central schist/greenstone zone, (3) Large shear zone—the Ural Transverse Faults, (4) Local thrust fault structures, (5) Ural Divide (watershed).

Figure 3. Location map.

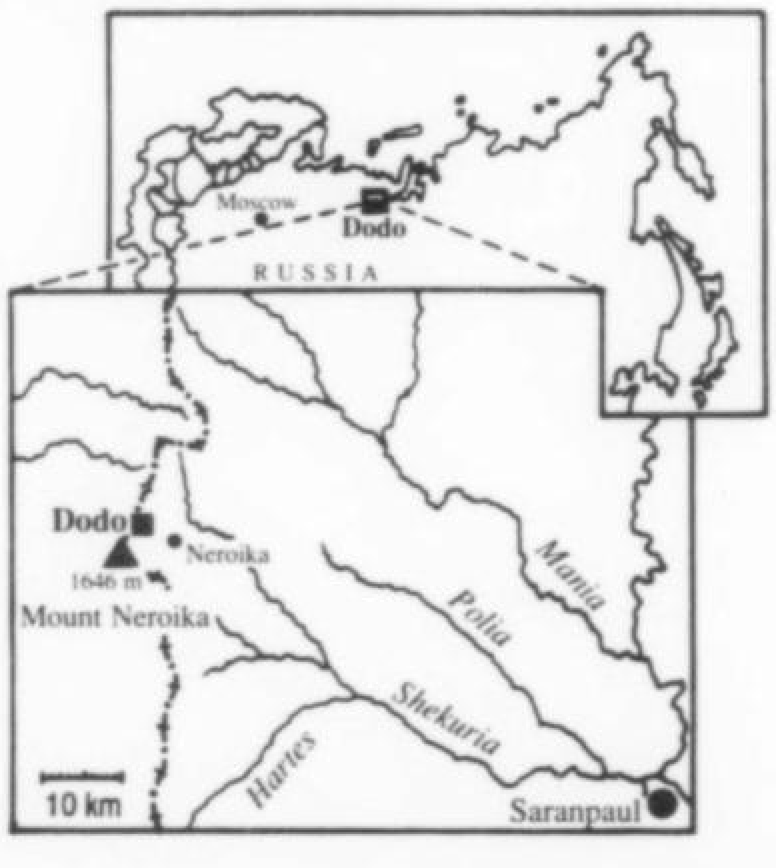


Figure 4. **A Russian geologist documenting an ice-filled quartz crystal cleft in the Dodo mine. E. Burlakov photo.**

and manpower were organized. At that time the transportation of workers, equipment and supplies to the mine site was by horse-drawn (and deer-drawn) vehicles along trails through the taiga and along the rivers. In some cases boats were pulled upriver by ropes and poles almost the entire distance to the mine. Each boat could carry six to ten people and 500 to 1000 kg of cargo. The trip from Saranpaul took 10 to 15 days.

Mining, geological work and exploration were carried out at the mine site every summer from 1935 to 1941. During this time, all major placer deposits of quartz crystals and some quartz veins with crystal-lined pockets were worked out from the surface.

Up until 1958 the production from the Dodo deposit was relatively undistinguished, but in that year a new stage of development was begun. This revitalization was inspired by a sharp increase in the demand for industrial-grade quartz, and was facilitated by the modernization and mechanization of the workings. Year-round underground mining and exploratory drilling soon encountered large, crystal-lined cavities, and the Dodo mine rose in prominence to become one of the largest quartz-mining operations in Russia.

In 1973 the recovery of industrial-grade vein quartz began to replace pocket quartz. Detailed exploration has identified reserves (approved by the State Reserve Commission in 1983 and 1990) sufficient to sustain mining operations for several dozen years.

The Dodo deposit has now been studied to a depth of over 200 meters, with no diminution of crystals at depth. Based on the author's research on the structure of mineralized zones in cleft deposits of the Polar Urals, exploitable mineralization should extend at least 150 to 250 meters deeper, which is deeper than any currently operating mines in the region (Burlakov, 1987, 1989, 1990). Each year the Dodo deposit yields dozens of tons of quartz crystals, with reserves estimated at several hundred tons more.

GEOLOGY

The Dodo deposit is located in the central part of the crystal-bearing Neroika Belt, situated near the axis of the Lyapni anticlinorium (a second-order structure related to the Urals mega-anticlinorium). Rocks of the area consist of volcanogenic-sedimentary deposits of Middle Riphean age (the Puiva Series) which have been subjected to repeated faulting and greenschist-facies metamorphism. The predominant rock types include quartz-sericite schist, quartz-sericite-chlorite phyllite-like schist, and pure quartzite. The schist terrane is intruded by numerous dikes ranging from felsic to mafic composition.

The major structure related to the deposit is the Dodo anticline, restricted to the footwall of the Neroika-Patok granitoid massif. In plan view the anticline forms a horseshoe-like fold dipping northward; the flanks are schist of the upper schist sequence of the Puiva Series, surrounding a core of phyllite-like schist of the lower schist sequence.

Surface prospecting and exploratory mining have revealed over 800 quartz veins in the Dodo mine area. These veins can be categorized into six major structural-morphological types:

(1) Quartz veins consisting of lenticular to plate-like bodies filling steeply dipping (50°–80°) rupture joints. Such veins are generally not crystal-bearing but are an important source of industrial-grade vein quartz.

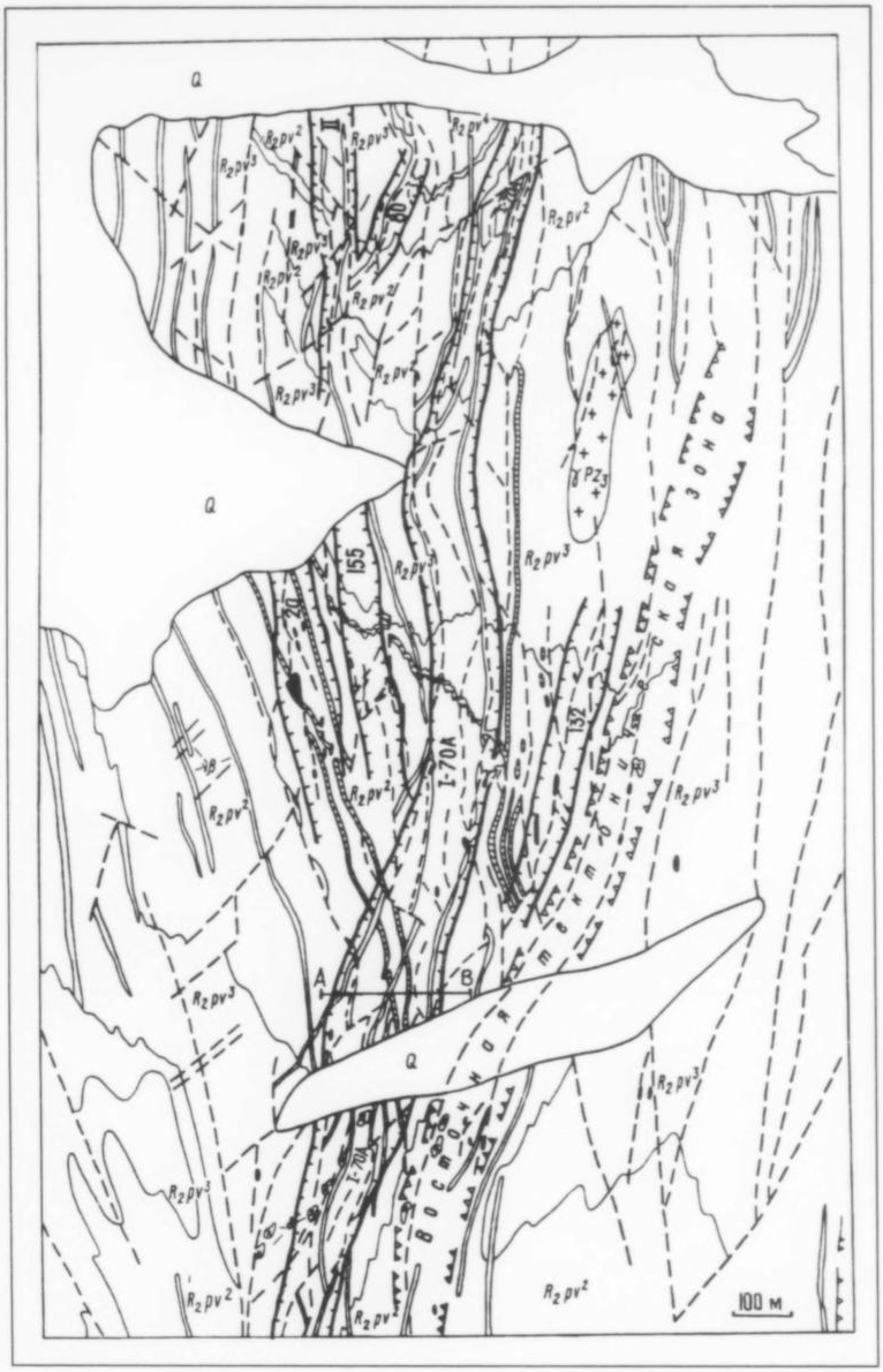


Figure 5. **Geological map of the Dodo area. (1) Quaternary deposits, (2–4) Schists of the Puiva Series, (5) Granite, (6) Dikes of diabase and albitophyre, (7) Diorite, (8) Contacts, (9) Faults, (10) Quartz veins, (11–12) Quartz-crystal-bearing zones.**

(2) Quartz veins emplaced along gently dipping benches of shear-thrust faults and shear-overthrust (0° to 5°) faults. In shape the veins are plate-like with abundant apophyses and with many xenoliths from the host rock. Such veins are generally not crystal-bearing.

(3) Quartz veins filling shear fissures which feather out from the overthrusts and thrust faults at a dip of 20° to 60°. In form they are lenticular to wedge-shaped. Veins of this type are known to contain crystal-bearing open pockets.

(4) Quartz veins in fracture zones within the diabase dikes; generally not crystal-bearing.

(5) Quartz veins of tubular shape invading diabase and albitophyre dikes; generally not crystal-bearing.

(6) Quartz veins of complex and combined forms incorporating features of vein types 1 and 3, or vein types 2 and 3. The veins occupy rupture joints and feathering fissures from shear joints. As a rule, such veins contain crystal-bearing pockets. Larger veins of this type have been known to yield several tens of thousands of tons of vein quartz and several dozen tons of quartz crystals.

Six crystal-bearing tectonic zones with distinguishing fissure structures have been identified. In plan view and in cross-section they can be seen to intersect, resulting in the lenticular conformation of the cleft zones. The largest of the crystal-bearing clefts are associated with thrust faults. The crystal-bearing tectonic zones are accompanied by numerous diabase dikes which themselves are often controlling structures for the crystal clefts. The largest and most productive of the crystal-bearing zones in the region has been designated Zone 1-70A, and has been under exploitation for several decades.

The tectonic fractures in the area have been subdivided into three groups with respect to quartz vein and crystal formation:

(1) Pre-quartz fractures, represented by local crumpling zones and zones of intense schistosity.

(2) Quartz-controlling fractures, represented by faults, thrust

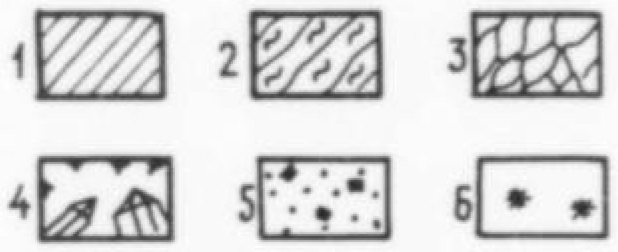


Figure 6. **Diagram of a typical quartz pocket at the Dodo mine: (1) sericite schist, (2) hydrothermally altered schist, (3) quartz lens, (4) quartz crystals, (5) chlorite, apatite, titanite, etc., (6) ice. (Drawing by E. Burlakov)**

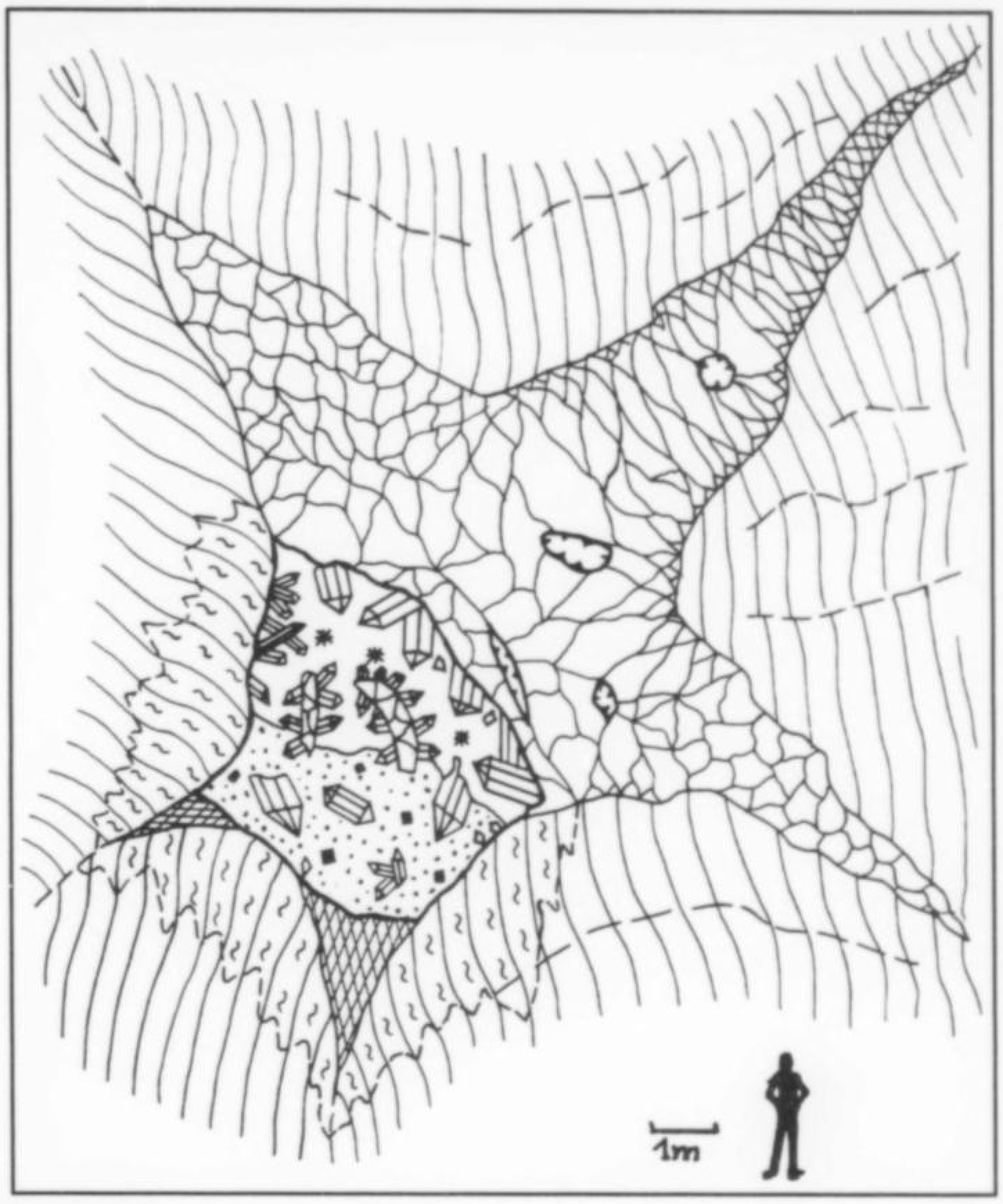
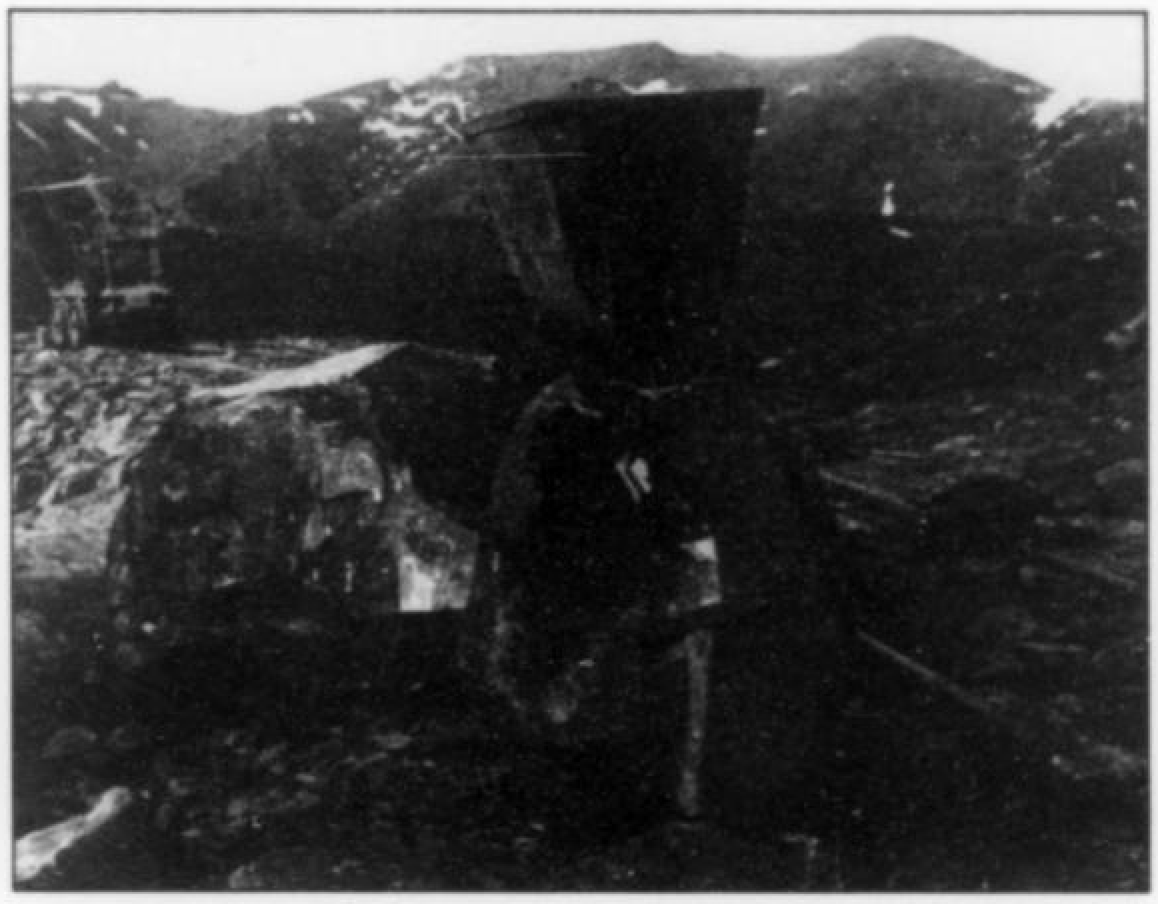


Figure 7. **Meter-high pieces of huge quartz crystals mined in 1950 from Cleft #151. Archives of E. Burlakov.**



faults and overthrusts. The largest crystal-bearing clefts are located in the overthrusts.

(3) Post-quartz fractures, represented by secondary faults and diagonal shears.

The quartz crystal cavities in the Dodo deposit have been subdivided into three types as well:

(1) Cavities connected with quartz lenses. These include not only the cavities within quartz lenses but also those which have formed along the contact with country rock. These cavities are of a piece with the quartz lenses and are controlled by the same fissures. The crystal-bearing cavities are most common in the lowermost parts of the quartz lenses.

(2) Mineralized clefts in country rock. These are characterized by the absence of quartz lenses, with quartz crystals growing directly on the cleft walls. As a rule, these clefts are associated with well-developed aureoles (leached zones) of hydrothermally altered rock.

(3) Mineralized fault zones. In this case the quartz crystal cavities have formed within brecciated fault zones, localized directly on fault planes and step-dislocations. They have irregular contours and show inclusions of country rock.

The shapes that can be taken by the crystal-bearing cavities range from wedge-shaped to lenticular, tubular, and blocky or equidimensional. The sizes can be huge, ranging from 1 to 40 meters long, up to 16 meters high, and 30 cm to 5 meters wide. Cavities are considered to be "small" if they yield less than 5 tons of quartz crystals! Large pockets produce 20 to 50 tons, and very large cavities can produce well over 50 tons of quartz crystals. The single largest crystal-bearing cleft encountered so far (designated no. 6/28) was found in connection with adit no. 28, and yielded no less than 300 tons of quartz crystals!

A typical crystal cleft of the first type (one connected with a quartz lens) carries first-generation calcite, usually massive; 5% to 30% of the cavity is filled by chlorite sand containing fragments of country rock and of the quartz lens, and also containing detached quartz crystals and crystal clusters. Other quartz crystals remain attached to the cavity walls. The remaining open space is filled with ice or water.

PARAGENESIS

Many years of geological, geochemical and mineralogical study have led to a general understanding of the special geological/structural and mineralogical/geochemical factors unique to the Dodo deposit. Three essential factors have been revealed:

Figure 8. **Quartz lens in a crystal-bearing fissure at the Dodo mine open pit, 1950. Archives of E. Burlakov.**

Figure 9. **Workers opening a crystal vug in a prospect pit at the Dodo mine, summer of 1937. Archives of E. Burlakov.**

(1) The Dodo deposit formed at greater depths than other deposits of the Subpolar Urals. This great depth resulted in a particular geochemical environment (fractionation of heavy and light rare-earth elements, of elements differing in ionic radius, and of isotopes) during mineral deposition.

(2) The peculiar geological and structural setting resulted in the formation of a fluid regime which influenced the multi-stage, polygenic, polycyclic processes of mineral formation.

(3) Concurrently with the formation of typical alpine-type clefts in the deposit, there was an influx of chemical components that had originated from deep-seated sources: potassium, fluorine, chlorine, boron, mercury, arsenic, antimony, uranium and thorium. Consequently the quartz crystal cavities in the deformation zone contain as many as 30 additional accessory species. In addition, there are commonly two or three generations of minerals such as titanite, rutile, monazite, anatase, and brookite. These multiple generations reflect repeated leaching and solution processes taking place at intervals between paragenetic phases.

In those clefts located outside of the deformation zone, only a simple mineral assemblage is typically present, reflecting the general composition of the local country rock. Usually only 5 to 8 mineral species comprise the assemblage, and as a rule are all of one depositional generation.

It can be concluded, therefore, that the large number of crystal clefts in the Dodo deposit are intermediate in genesis between hydrothermal quartz veins and true alpine-type clefts mineralized solely by lateral secretion from the local country rock.

MINERALOGY

Almost since their first discovery, the Dodo clefts and their mineralogy have been investigated by many researchers: Lemlein (1936, 1937, 1954 etc.), Schafranowsky (1937, 1944), Bukanov (1961–1974), Malyshev *et al.* (1974), Kolbin (1977), and Juchtanov (1981). All of the more recent data on the mineralogy of the deposit—from 1984 to the present—are to be found in the scientific papers and production reports of the author of the present article.

The Dodo deposit exceeds all other deposits of the Polar Urals in the richness and variety of its mineralogy. At this writing, 62 different mineral species directly associated with alpine-type cleft formation are known from Dodo. These species have been identified by various analytical methods, including chemical analysis and X-ray and infrared spectroscopy. Below, only minerals of the

Figure 10. **Anatase crystals to 7 mm on schist from the Dodo mine. E. Burlakov collection; Stefan Weiss photo.**

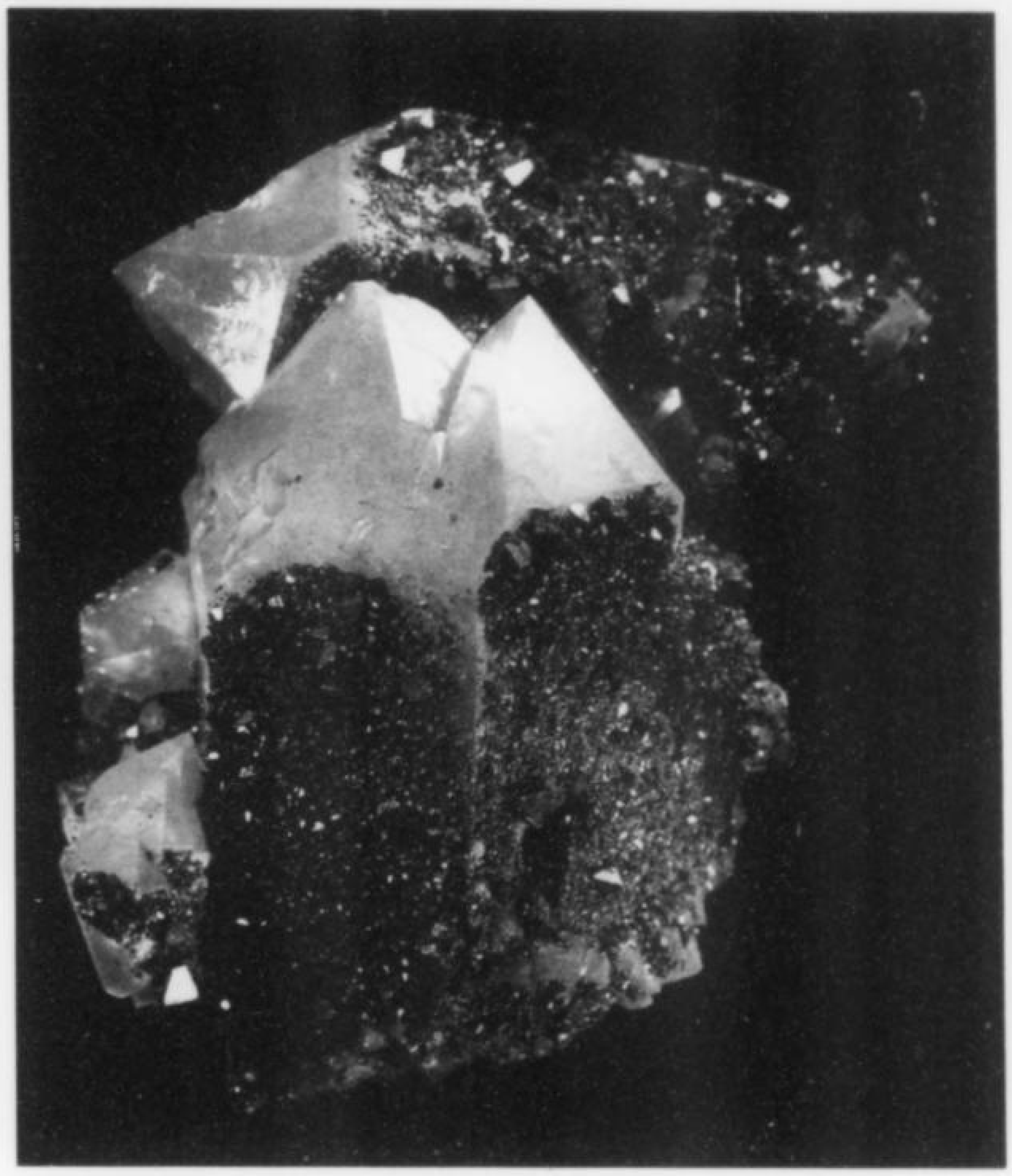


Figure 11. **Anatase crystals to 4 mm partially covering a milky quartz crystal. Andreas Weerth collection; Stefan Weiss photo.**

crystal-bearing parageneses—i.e., true cleft minerals—are described; of the minerals of the country rock, only those which recrystallized within the cavities (e.g., garnets, zircon) are listed.

The paragenetic status of corundum and moissanite is questionable; these were discovered by different authors as xenoliths in the country rock, but later also listed among the cleft minerals (e.g., by Burlakov, 1989). Corundum is rare, being found intergrown with the cleft minerals as 0.1 to 0.2-mm grains, pink to blue or green. Hexagonal moissanite—a high temperature/high pressure silicon carbide known primarily as synthetic "carborundum," a grinding abrasive—was first found in 1974 by the mineralogist Soochoovoy in dressed, pulverized quartz crystal samples (grain size 0.1–0.5 mm) and identified by X-ray analysis. It appears as green to pale blue tabular crystals 0.1 to 0.3 mm in diameter. However, the author as of this writing has identified moissanite neither in the country rock nor as crystals, nor with quartz crystals. Thus it is not to be ruled out that the 1974 moissanite formed or was introduced during sample preparation.

A series of secondary minerals (hemimorphite, cerussite, malachite and others) formed either during the last phase of cleft mineralization or as weathering/oxidation products (Burlakov, 1989).

Below, all cleft minerals of the Dodo deposit are described in alphabetical order.

Actinolite $Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$

Actinolite has not often been found in the Dodo deposit. It is seen as pale green acicular crystals included in quartz, and as aggregates of tangled filaments in birds-nest shapes (see also tremolite).

Albite $NaAlSi_3O_8$

Albite forms water-clear crystals twinned on the Albite Law, in sizes to 7 mm. These crystals are often found on the walls of mineralized fissures, in association with apatite, anatase, chlorite and adularia.

Allanite-(Ce) $(Ce,Ca,Y)_2(Al,Fe^{2+},Fe^{3+})_3(SiO_4)_3(OH)$

Allanite-(Ce) is rare in the deposit. It is found in cleft fillings as dark brown, tabular crystals between 0.5 and 1 mm.

Almandine $(Fe^{2+},Ca,Mn^{2+})_3(Al,Fe^{3+})_2(SiO_4)_3$

Garnet from the alpine-type clefts of the Dodo deposit is compositionally a mixture of almandine and grossular: 58.3% almandine, 37.4% grossular, 4.3% spessartine, corresponding to the general formula $(Fe^{2+}_{1.8}Ca_{1.1}Mn^{2+}_{0.1})_3(Al_{1.4}Fe^{3+}_{0.1})_2(SiO_4)_3$. In the schists and quartzites of the deposit one finds chloritized garnets as 0.5–2 mm crystals in the fissures. Garnets which have crystallized in the clefts are much larger and fresher. Here are found well-developed, transparent crystals in sizes to 7 mm, with smooth, lustrous faces showing growth figures.

Anatase TiO_2

Anatase is widespread in the deposit. It is found as nest-shaped aggregates on the walls of mineralized fissures, as inclusions in quartz crystals, and as overgrowths on quartz faces. The average crystal size is 2.5 mm; the maximum size is 1.2 cm. Most anatase crystals are of typical dipyramidal habit, although pinacoidal crystals are also found. The color ranges from yellow-green to pale blue and black; the luster is adamantine to metallic.

Ancylite-(Ce) $SrCe(CO_3)_2(OH)\cdot H_2O$

Ancylite-(Ce) was first discovered and described from Dodo in 1974 by V. V. Bukanov. This ancylite always contains some Ca substituting for Sr, and La and Nd substituting for Ce. It forms dipyramidal crystals to 2 mm. The color is pale pink, pale yellow or cream, sometimes with a waxy white overgrowth on the faces. Ancylite-(Ce) is found as crystal aggregates and as sprinklings on the faces of quartz crystals; associated species include anatase, fluorapatite and chlorite. A thus-far unnamed lanthanum and neodymium-containing cerium calcium carbonate occurs intergrown with the ancylite; this may be the Ca analog of ancylite-(Ce).

Anglesite $PbSO_4$

Anglesite overlies galena as rough crystal aggregates and crusts.

Ankerite $Ca(Fe^{2+},Mg,Mn)(CO_3)_2$

Ankerite is rare, occurring as small (to 5 mm) crystals grown on the faces of quartz crystals.

Arsenopyrite FeAsS

Arsenopyrite is rare at Dodo, forming 0.5 to 0.8-mm crystals intergrown with chalcopyrite.

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

Azurite is found as microcrystal aggregates and radial spherules. It forms inclusions in massive quartz near the clefts, and in quartz crystals, apparently as an alteration product of tetrahedrite and chalcopyrite.

Biotite $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$

Biotite is found in the clefts as 0.5 to 1-mm inclusions in quartz crystals.

Figure 12. **Quartz crystals to 2.3 cm, with acicular gray boulangerite and acicular, pale yellow rutile inclusions. E. Burlakov collection; Stefan Weiss photo.**

Boulangerite $Pb_5Sb_4S_{11}$

Boulangerite forms inclusions in the outer zones of quartz crystals, as aggregates of tangled, threadlike crystals and as oriented bundles of needles. The needles average 0.01 to 1 mm thick, and may be 5 cm long. The color is steel-gray to blue-gray, with a metallic luster. Associations include rutile, anatase, ancylite-(Ce), chlorite and brookite.

Brookite TiO_2

Brookite is found as inclusions in quartz crystals, as overgrowths on their faces, and as fillings in the clefts, with calcite and anatase. The transparent crystals show a typical "alpine" hourglass-shaped dark zone, the colors varying from dark brown to honey-yellow; the luster is brilliant and adamantine to metallic. These very brittle crystals have an average size of 0.5 mm thick and 1 x 2 cm across, but the largest one known to the author is 12 cm along the *c* axis! Such giant crystals are usually found already broken in the clefts, as a result of recent tectonic movements, frost action, or blasting by the miners. Brookite also occurs, not uncommonly, as a secondary overgrowth on rutile.

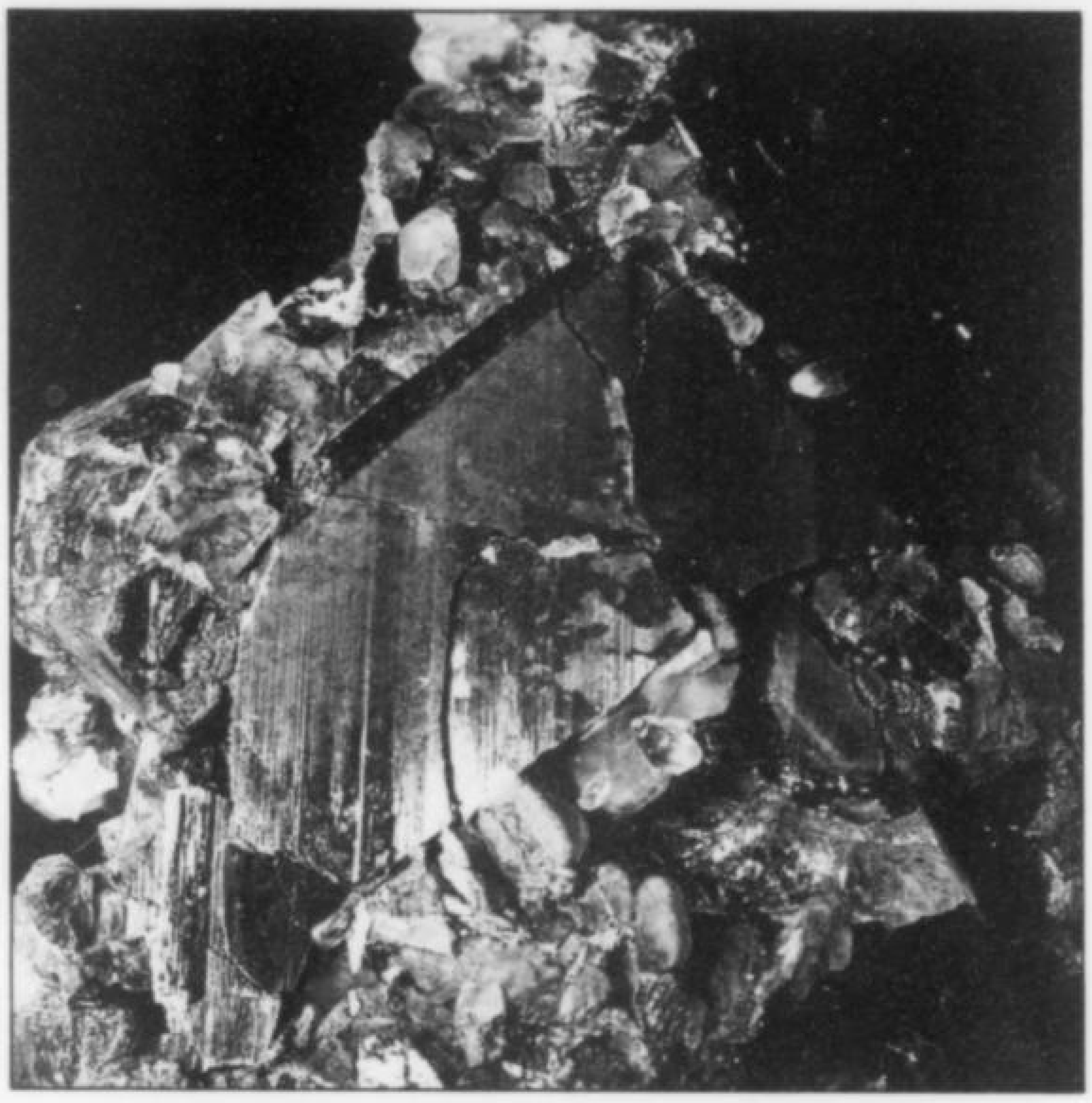


Figure 13. **Large brookite crystal, 4 cm, fractured by tectonic movements, on calcite-covered matrix from the Dodo mine. Collection and photo: E. Burlakov.**

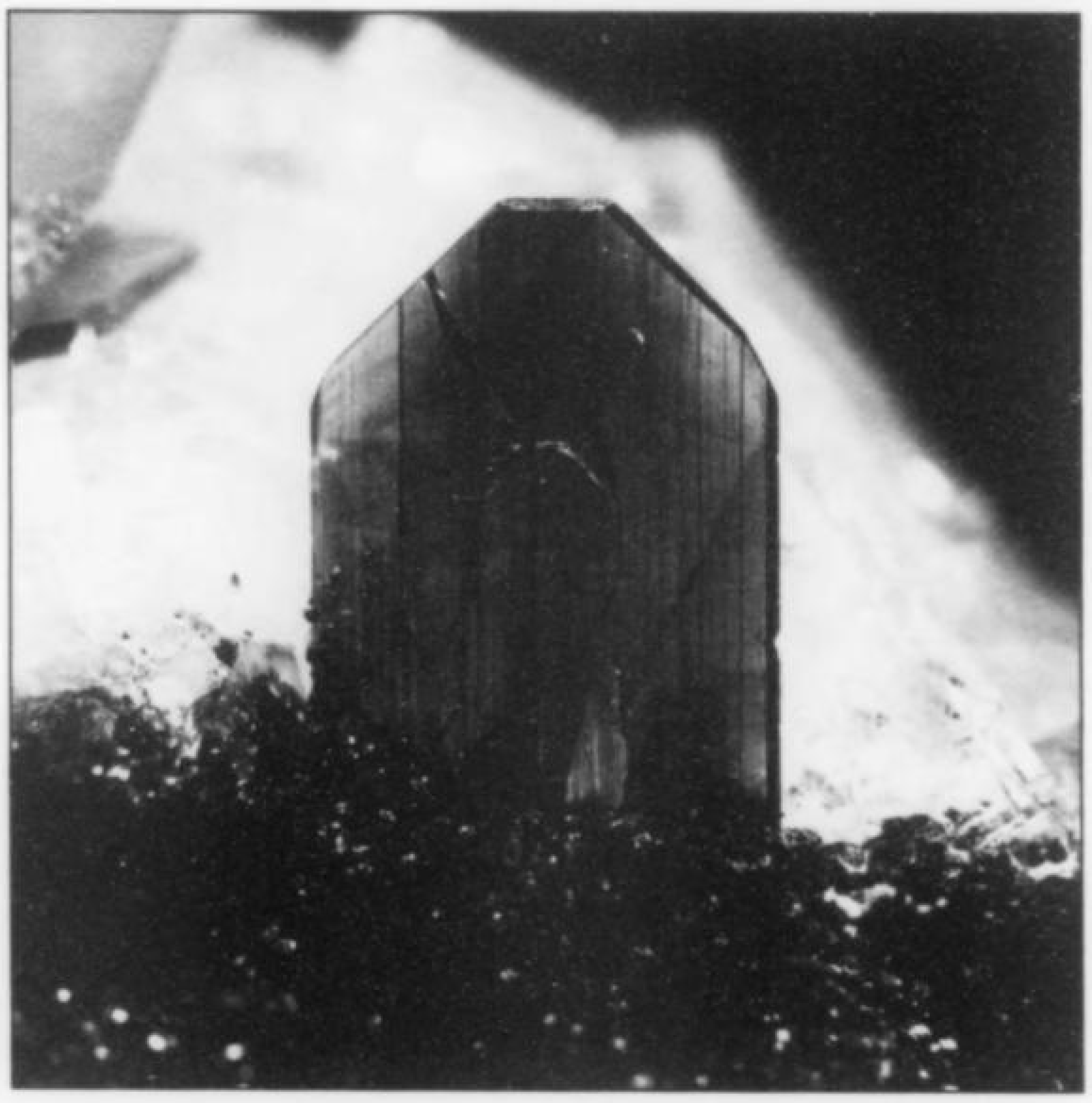


Figure 14. **Transparent brookite crystal, 2 cm, with "hourglass" inclusions, on chlorite and quartz from the Dodo mine. Private collection; Max Glas photo.**

Calcite $CaCO_3$

Calcite is found in practically every cleft. In the Dodo deposit, four calcite generations have been distinguished. The first genera-

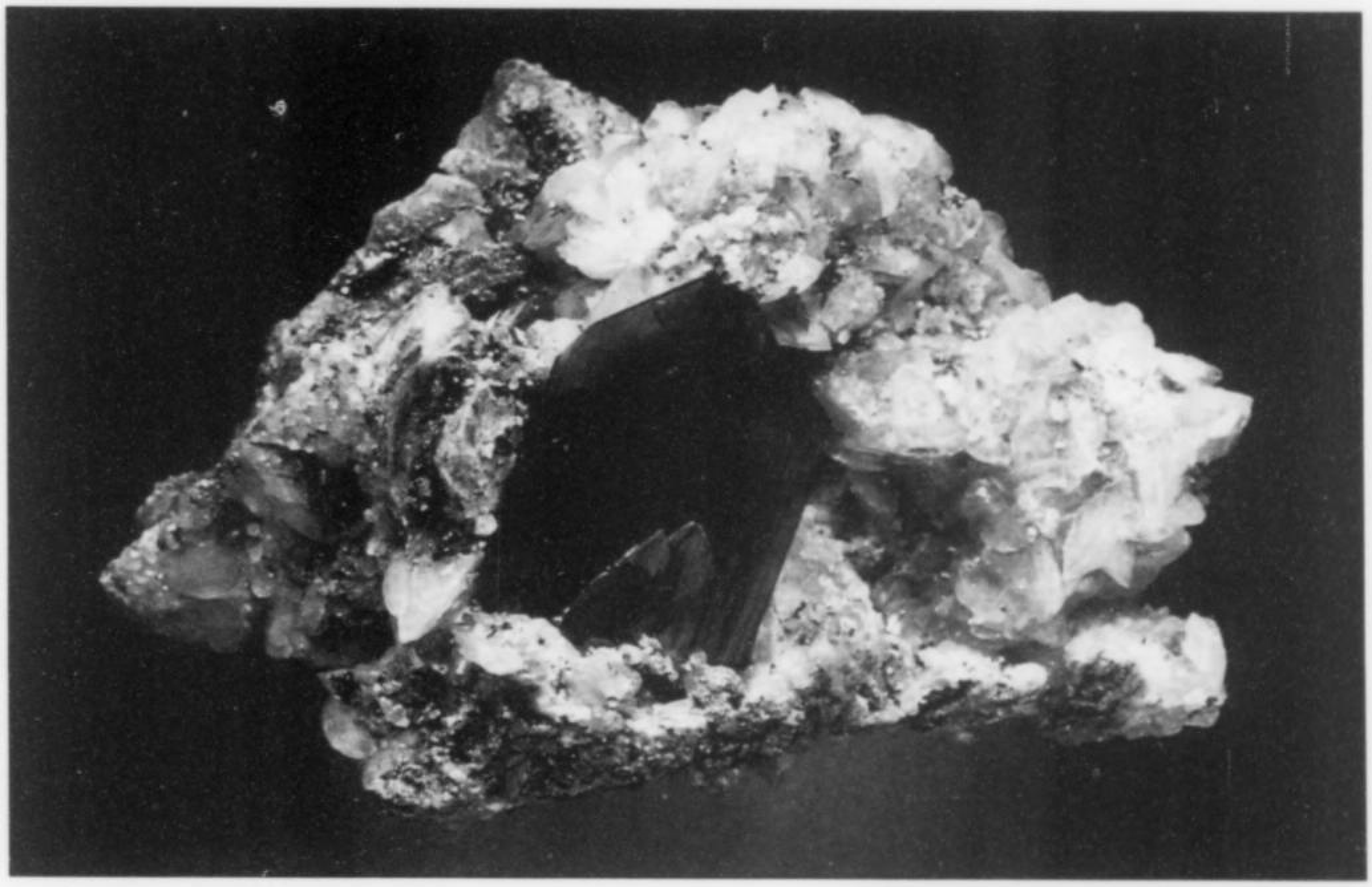


Figure 15. **Brookite crystal on matrix, 8.6 cm, from the Dodo mine. Van Scriver specimen; Jeff Scovil photo.**

tion, forming before the beginning of quartz crystal growth, appears as massive grains or pinacoidal crystals; it is opaque, and very dark brown to medium brown and yellowish.

The second calcite generation forms simultaneously with quartz crystals and grows in parallel with them. After later partial dissolution of the calcite, "sawtooth" crystals remain on the quartz faces. The second calcite generation can also grow on the first without essential changes in crystal form; however, contamination by chemical impurities here is less by an order of magnitude. The color of these calcites is generally white.

The third calcite generation crystallizes during and after the final stages of quartz crystallization. These calcite crystals are rhombohedrons sometimes weighing 100–200 kg, of white, lilac or lemon-yellow color, and to varying degrees transparent. Weakly colored or wholly colorless, clean "Iceland-spar" crystals of optical quality are not uncommon.

The fourth calcite generation crystallizes during the last phase of cleft formation. These crystals are of scalenohedral habit and are at

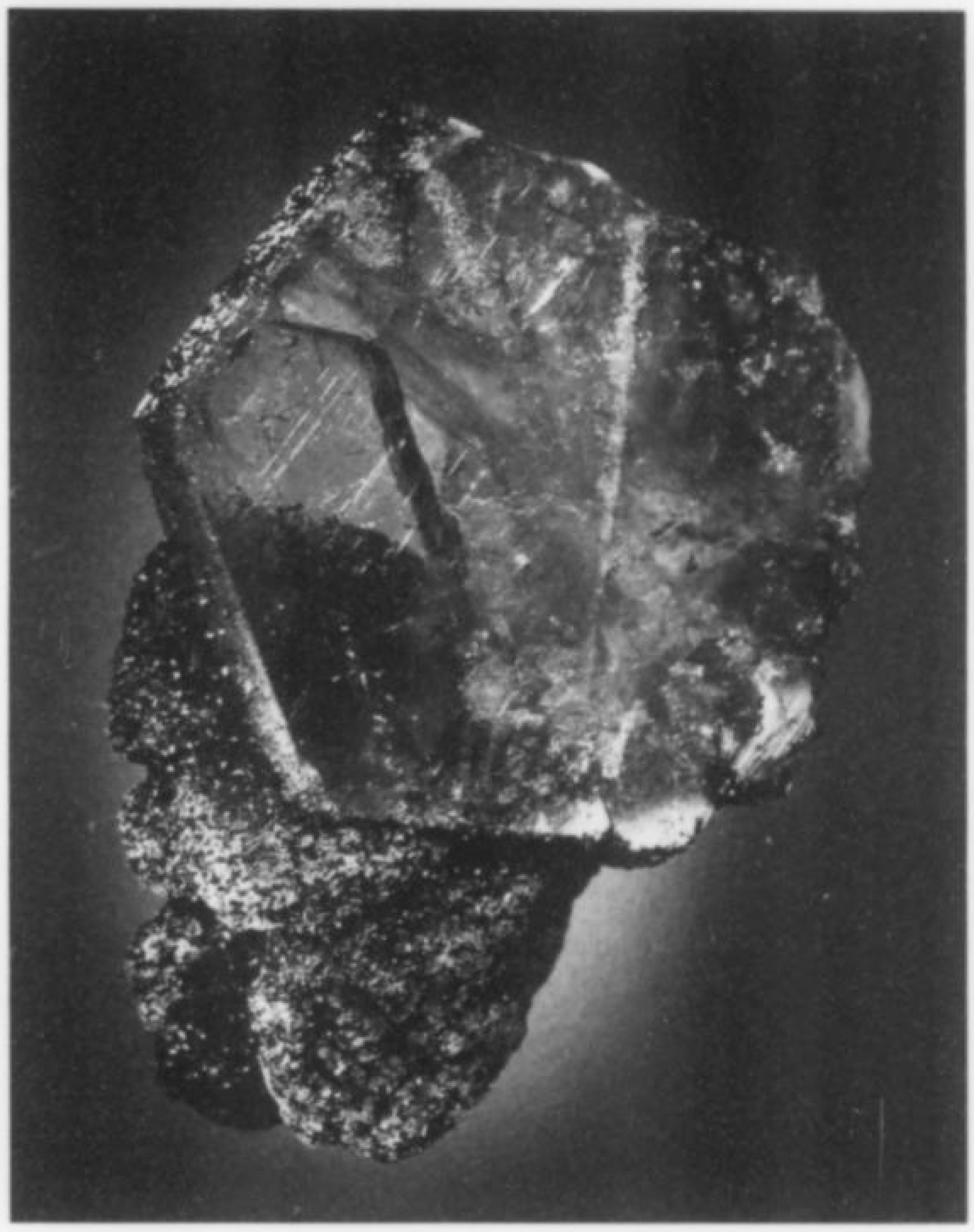


Figure 16. **Fluorapatite crystal, 4.5 cm, on chlorite schist matrix. This is among the largest apatites yet found at the Dodo mine. E. Burlakov collection; Stefan Weiss photo.**

Figure 17. **Fluorapatite crystals, 4.6 cm, with chlorite from the Dodo mine. Richard Kosnar collection; Jeff Scovil photo.**

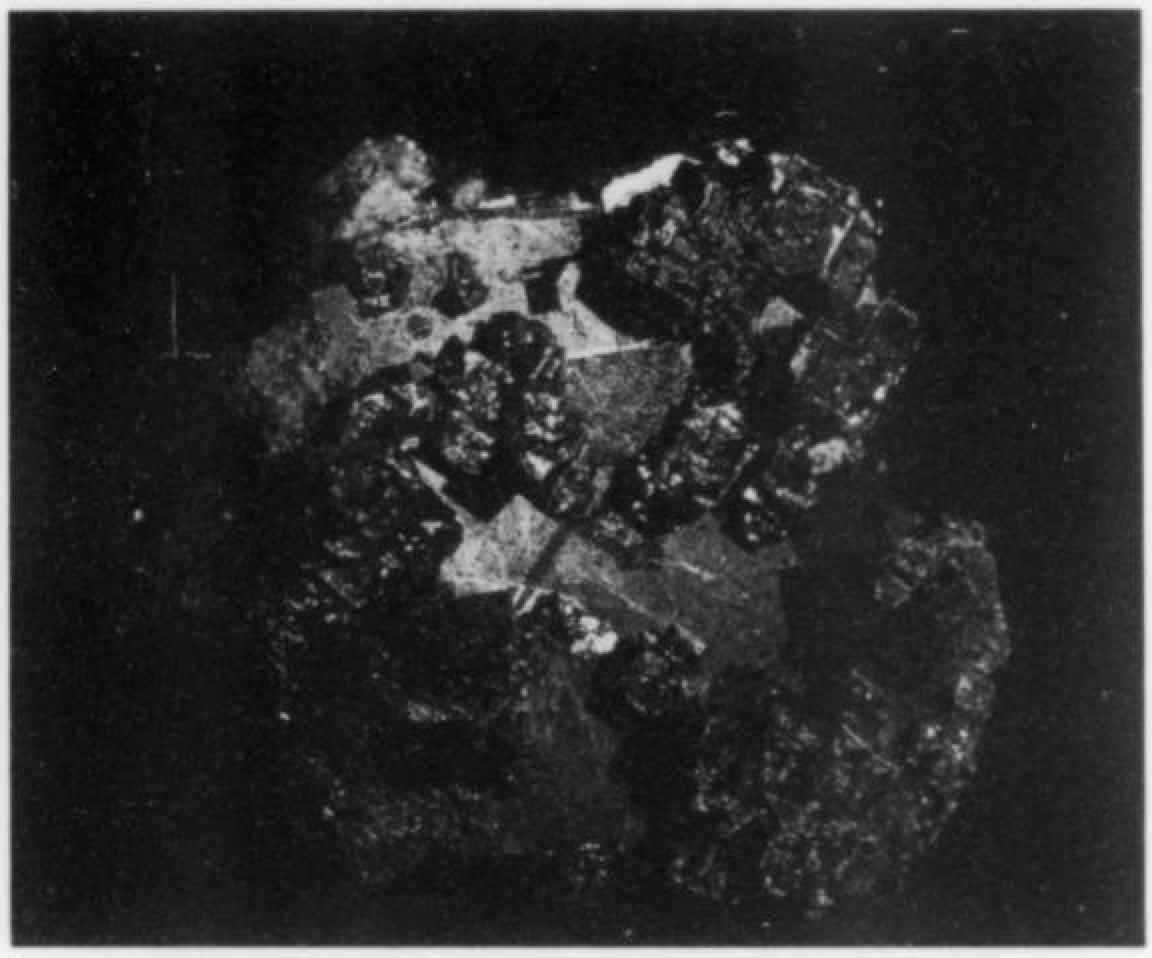


Figure 18. **Bismuthian galena crystals (octahedral overgrowths) epitaxial on galena, 3 cm, from the Dodo mine. E. Burlakov collection; Stefan Weiss photo.**

most 5 cm in size. They are transparent and colorless, sometimes weakly amethyst-colored, and contain goethite inclusions.

Cerussite $PbCO_3$

Cerussite forms red-orange needles to 2 mm long, resting on crystal faces of galena, calcite, quartz and other minerals.

Chalcopyrite $CuFeS_2$

Chalcopyrite is precipitated onto quartz crystals in irregular habits to a few centimeters, and as small, complex crystals to a maximum size of 1.2 mm. It is associated with sphalerite, galena and adularia.

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

Chrysocolla is found as bluish green spherules of radiating, rough crystals encrusting chalcopyrite and tetrahedrite.

Cobaltite CoAsS

Cobaltite occurs rarely in the cleft fillings with pyrite and chlorite, as crystals of octahedral, cuboctahedral and tetrahedral habits. Crystal sizes range between 0.1 and 0.5 mm; the color varies from black to medium-gray, sometimes with a pink patina.

Cosalite $Pb_2Bi_2S_5$

Cosalite, like boulangerite, is found as inclusions in quartz crystals, in tangled bundles of acicular crystals commonly intergrown with small, equant crystals of bismuthian galena, as well as with anatase, apatite and chlorite. The cosalite needles are between 0.005 and 1.5 mm thick, and reach 7 cm long. The luster is brightly metallic, and the color is steel-gray with a bluish sheen.

Chlorite Group

Chlorite from Dodo varies chemically from an iron-rich clinochlore to chamosite, and is one of the most widespread mineral groups in the alpine-type Dodo clefts. Its crystallization began before and ended after the phase of quartz crystal growth; the late chlorite is found both as inclusions within quartz crystals and as encrustations on their faces. Granular chlorite can fill up to 50% of the volume of the crystal clefts; this "sand" is an agglomeration of wormlike, elongated chlorite crystals from 2 to 15 mm long, which break easily along cleavage planes to form loose hexagonal platelets.

Clinozoisite $Ca_2Al_3(SiO_4)_3(OH)$

Clinozoisite occurs as inclusions in quartz crystals. The length of the transparent prisms can reach 1.5 cm; the color is gray-green to swamp-green. In some cases clinozoisite is partly or wholly replaced by sericite.

Epidote $Ca_2(Fe^{3+},Al)_3(SiO_4)_3(OH)$

Epidote is included in quartz crystals. It forms dull, long-columnar gray-green crystals. Small crystals of 1–5 mm are more or less transparent; larger ones are usually strongly fractured and opaque.

Fluorapatite $Ca_5(PO_4)_3F$

Fluorapatite is found in almost every crystal cleft. Most commonly it forms single crystals in chlorite sand, or crystals growing in the fissures, in crystal-bearing vugs. Associations include quartz crystals, titanite, adularia, anatase and calcite. The tabular or thin-platy crystals are greenish to pale blue. To be sure, fluorapatite does not occur in the Dodo deposit in such large crystals as are found at Puiva, where it may reach 10 cm in size. The average size of Dodo apatite crystals is 1–2 cm, the maximum size being around 4 cm.

Fluorite CaF_2

Fluorite is rare in the deposit. It is found in the chlorite sand as irregular grains to 2 cm, usually colorless, sometimes with a weak violet tinge.

Galena PbS

Galena is commonly found in association with bismuthian galena in the crystal clefts. Normal galena usually crystallizes in a

Figure 19. **Orange monazite with tabular brookite and calcite, 2 cm, from the Dodo mine. E. Burlakov collection; Stefan Weiss photo.**

cubic habit, as a first generation, on quartz, essentially before the beginning stages of the growth of quartz crystals. Bismuthian galena, with an octahedral habit, forms in the final stages of quartz crystal growth. It makes equant skeletal crystals, often hoppered, to 5 cm, and is often encrusted with anglesite.

Goethite $FeO(OH)$

Goethite is an alteration product of sphalerite, pyrite, pyrrhotite or chlorite, and forms partial or total pseudomorphs after these.

Gold Au

Gold is seen very rarely as flat to equant grains to 1 mm in the outer zones of quartz crystals.

Gypsum $CaSO_4 \cdot 2H_2O$

Gypsum is found in clefts having abundant sulfide mineralization, as transparent, pale blue, curved, filiform crystals to 1 cm long.

Graphite C

Graphite forms finely foliated crusts on quartz and calcite crystal aggregates in clefts in carbonaceous phyllites.

Hematite Fe_2O_3

Hematite occurs in peripheral zones of the deposit, as thin, hexagonal tablets to 5 mm.

Hemimorphite $Zn_4Si_2O_7(OH)_2 \cdot H_2O$

Hemimorphite forms white to yellow-white radiating aggregates and mammillary crusts occurring as inclusions in the quartz lenses near the clefts and in quartz crystals accompanied by sphalerite.

Ilmenite $Fe^{2+}TiO_3$

Ilmenite is one of the most widely distributed minerals of the deposit. It is found both in the chlorite sand and as inclusions in quartz, calcite and apatite crystals. It is deposited as thin tabular crystals to 4 cm, black and lustrous, with faint striations on the faces. Ilmenite commonly replaces brookite, anatase and rutile.

Kainosite-(Y) $Ca_2(Y,Ce)_2Si_4O_{12}(CO_3) \cdot H_2O$

Kainosite-(Y) occurs in leached-out cavities once filled with first or second-generation calcite; it is associated with albite, titanite and chlorite. The crystal habit shows a combination of rhombic prisms and dipyramids. Color is yellowish brown; the average crystal size is around 0.5 mm, to a maximum of around 2 mm.

Magnetite Fe_3O_4

Magnetite occurs in the cleft fillings with anatase, albite, titanite and chalcopyrite. It forms brilliant octahedral crystals to 3 mm, whose faces show sharp growth figures.

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

Malachite is seen as radial aggregates and mammillary crusts to 5 mm thick. It is an alteration product of chalcopyrite and tetrahedrite, but occurs also as inclusions in quartz crystals and in massive quartz near the clefts.

Melanterite $Fe^{2+}SO_4 \cdot 7H_2O$

Melanterite is uncommon. It is always of the magnesian variety, forming opaque white mammillary crusts and radial aggregates to 1.5 cm, associated with gypsum, calcite and pyrite.

Meneghinite $Pb_{13}CuSb_7S_{24}$

Meneghinite occurs in the galena-quartz crystal paragenesis. It forms six-sided, stepped, parallel-growth aggregates of thin acicular to filiform crystals; the longest individual needles reach 2 cm, with a thickness of up to 1 mm. The color is dull blue-gray.

Monazite-(Ce) $(Ce,La,Nd,Th)PO_4$

Monazite-(Ce) is a characteristic mineral in the neighborhood of clefts in metasomatically altered rocks. In the quartz crystal zones at Dodo it is found growing on quartz faces, and in the chlorite sand. Associated species include brookite, anatase, fluorapatite, titanite and boulangerite. The equant crystals, up to 1 mm, are bounded by pinacoids; their color varies from pale yellow through orange.

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

Montmorillonite is found in the cleft filling in the form of compact gray-white masses. The clay mineral is also found as oriented inclusions in growth zones in many quartz crystals.

Muscovite $KAl_2AlSi_3O_{10}(OH)_2$

Muscovite rarely forms leafy crystals 1 to 1.5 cm across. The dominant variety in the deposit is the finely divided *sericite*, which is found included in many growth zones of quartz crystals.

Orthoclase $KAlSi_3O_8$

Orthoclase is common in the Dodo deposit as the transparent variety *adularia*, especially in the crystal clefts inside diabase bodies. The crystal habit is recognizable as a combination of the rhombic prism and the pinacoid. Average crystal size is about 3 cm. Translucent through milky white adularia crystals are associated with titanite, fluorapatite, chlorite, sphalerite and quartz.

Parisite, Sr-analog

In the Dodo deposit a type of parisite occurs as a cleft mineral, but it may well correspond to a hitherto unnamed strontium analog of parisite-(Ce), formula $(Sr_{0.7}Ca_{0.3})(Ce_{1.0}La_{0.6}Nd_{0.3}Pr_{0.1})_2[F_2|(CO_3)_3]$. The parisite analog forms tabular hexagonal prisms, frequently with corroded edges, having a strong cleavage along {0001}, and varying in color from pale brown to yellow-brown. The mineral crystallized during the final growth phase of the quartz crystals, and is to be found on their outer faces. It is also found in fissures in hydrothermally decomposed schist, associated with ancylite, anatase, fluorapatite and boulangerite. The crystal sizes reach only 0.5–1 mm.

Piemontite $Ca_2(Al,Mn^{3+},Fe^{3+})_3(SiO_4)_3(OH)$

Piemontite is rare. In the filling of one crystal cleft, tiny prisms to 0.6 mm were observed.

Prehnite $Ca_2Al_2Si_3O_{10}(OH)_2$

Prehnite was found in a cleft as transparent, pale green, rounded

***Figure 20.* Flawless chunks of industrial-grade quartz are carefully cobbed out by a technician. E. Burlakov photo.**

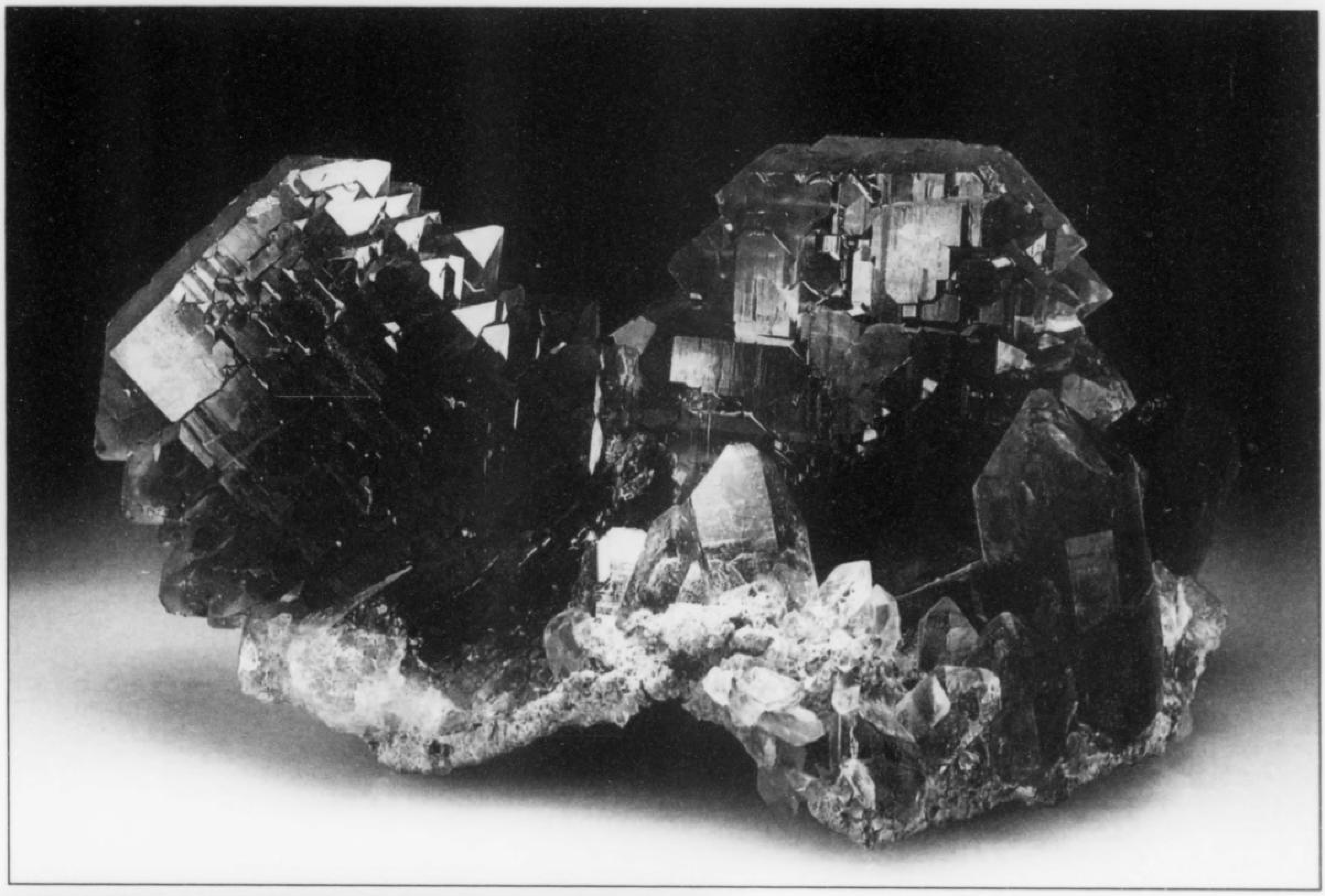


Figure 21. **Smoky quartz gwindel cluster, 18.5 cm, found at the Dodo mine in 1974. Van Scriver collection; Jeff Scovil photo.**

Figure 22. **Quartz gwindel, 7 cm, from the Dodo mine. Private collection; Stefan Weiss photo.**

Figure 23. **Quartz gwindel, 5.8 cm, from the Dodo mine. Van Scriver collection; Jeff Scovil photo.**

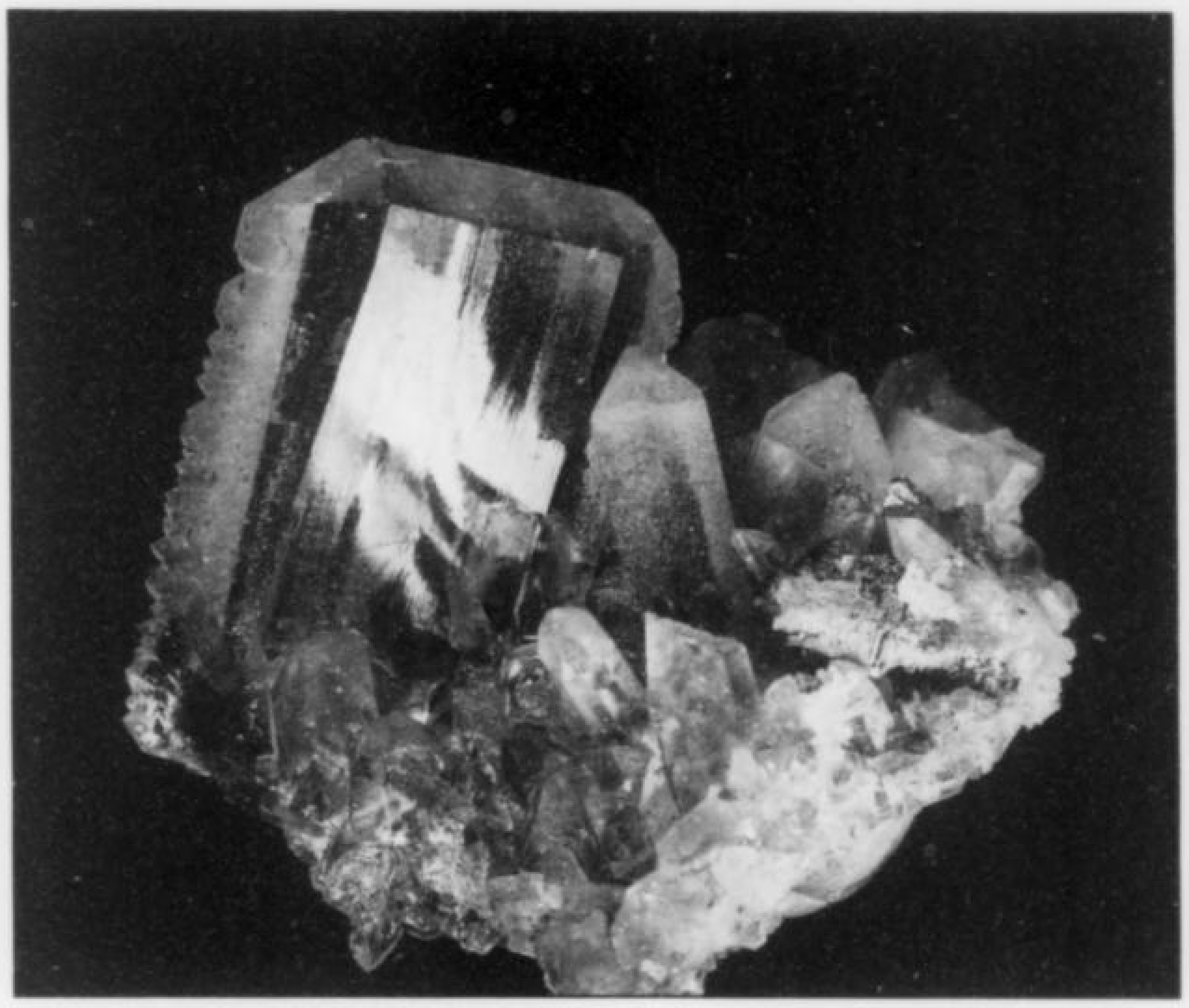


Figure 24. **A beautiful "closed" gwindel of quartz, 4.5 cm, from the Dodo mine. E. Burlakov collection; Stefan Weiss photo.**

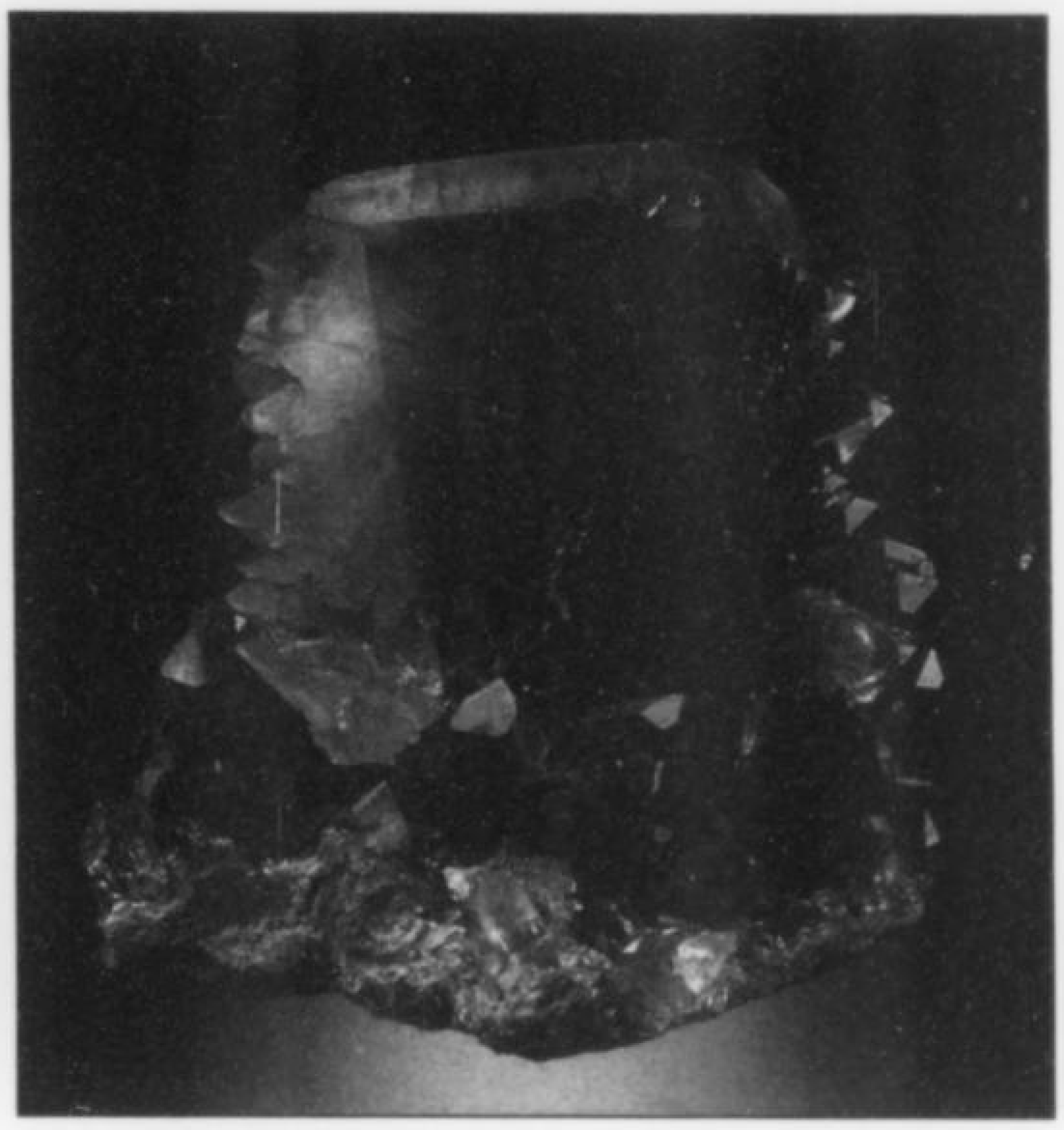


Figure 25. **Smoky quartz gwindel, 6 cm, from the Dodo mine. Van Scriver collection; Jeff Scovil photo.**

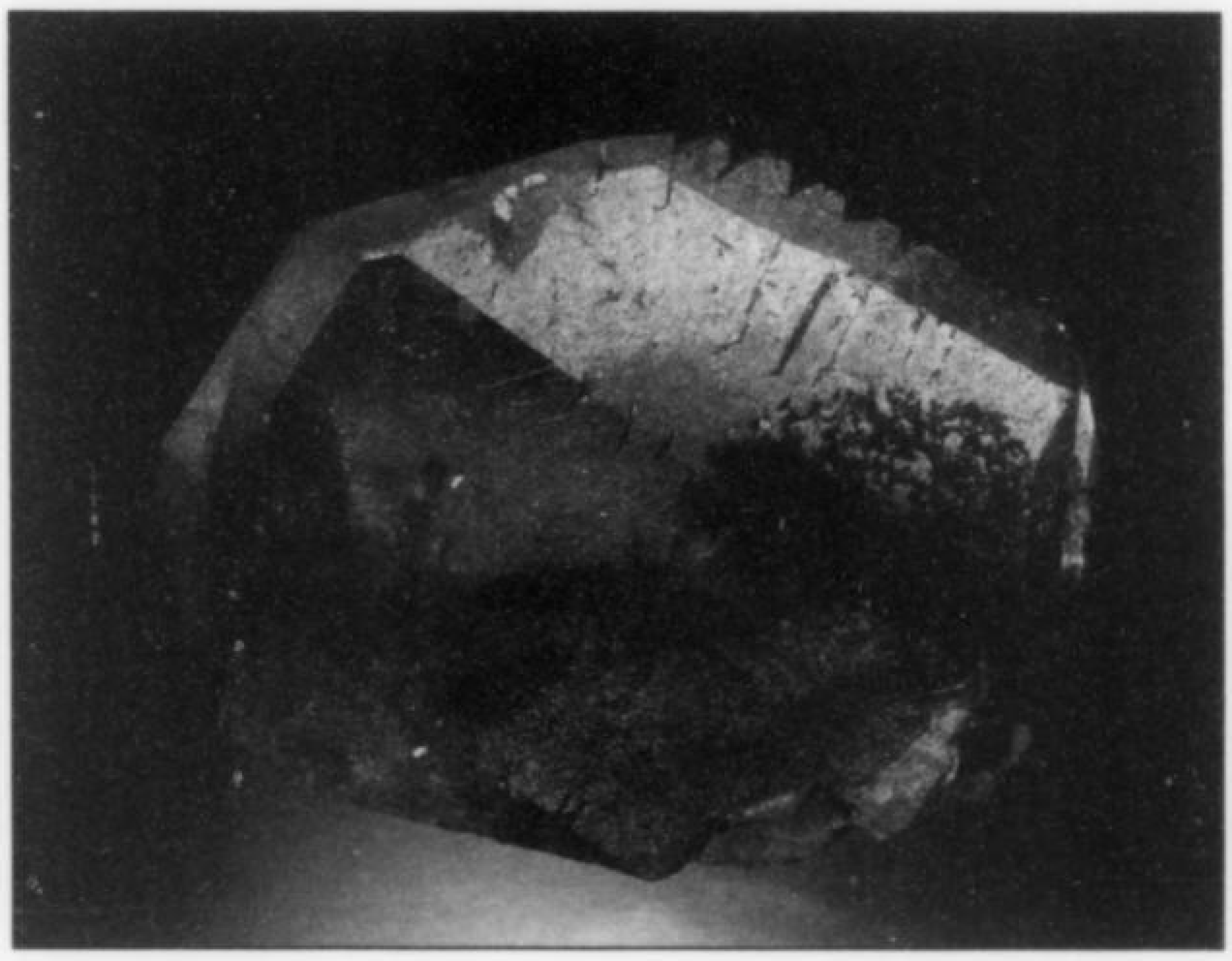
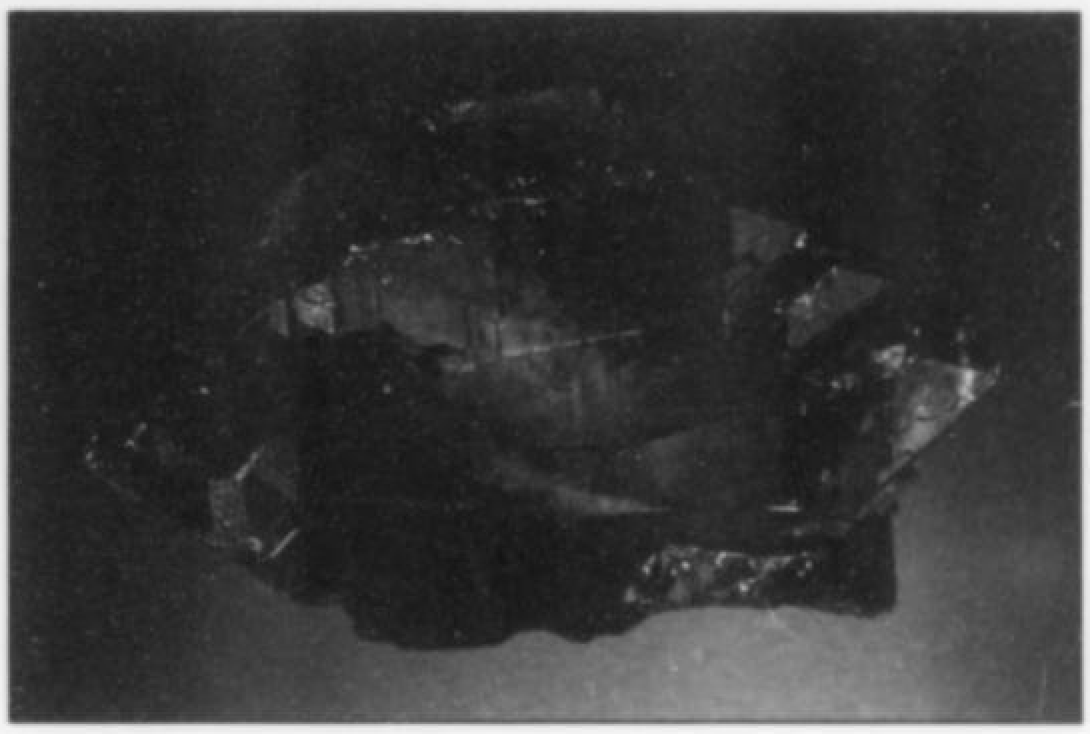


Figure 26. **Smoky quartz gwindel, 9.3 cm, from the Dodo mine. Van Scriver collection; Jeff Scovil photo.**

Figure 27. **Smoky quartz gwindel, 15.1 cm, from the Dodo mine. Bill Shelton collection; Jeff Scovil photo.**



crystal aggregates to 5 mm, in association with calcite, sphalerite and fluorapatite.

Psilomelane

Psilomelane, a mixture of manganese oxides, forms black dendrites on the faces of quartz and calcite crystals. Not uncommonly it appears as compact earthy masses in mineralized fissures.

Pyrrhotite $Fe_{1-x}S$

Pyrrhotite is widespread in the deposit. In the crystal clefts, two types have been identified. The first type is columnar, barrel-shaped crystals measuring up to 6 x 10 x 15 cm; these are usually in part limonitized. The second type is thin, hexagonal, platy crystals to 1 cm, as inclusions in or encrustations on calcite crystals. Typical associations are chalcopyrite, sphalerite, galena, chlorite and fluorapatite.

Pyrite FeS_2

Pyrite is also widespread. It is likewise found as inclusions in or overgrowths on quartz and calcite crystals. The dominant form is the cube, sometimes in combination with the octahedron. The average crystal size barely exceeds 2 cm; but in one cleft were found fractured, rounded crystals to more than 10 cm across.

Quartz SiO_2

The average weight of the clear quartz crystals of the deposit is between 2 and 5 kg. Of course, in any middle-sized cleft, crystals weighing a few dozen kilograms may also be found, and in large clefts, crystals up to a few hundred kilograms. Even crystals weighing one or two tons are not unusual in this deposit! The habit, for the most part, is pseudohexagonal, with equal development of prism faces and a dominance of prism over rhombohedral faces, as in the "normal" Alpine cleft habit. The crystals are mostly short prismatic, with an average length/width ratio of 1.7 to 3.

The coloring of the crystals is preponderantly pale smoky, but

Figure 28. **Titanite crystal cluster, 2.5 cm across, from the Dodo mine. Pljaskov-Van Scriver specimen. Wendell Wilson photo.**

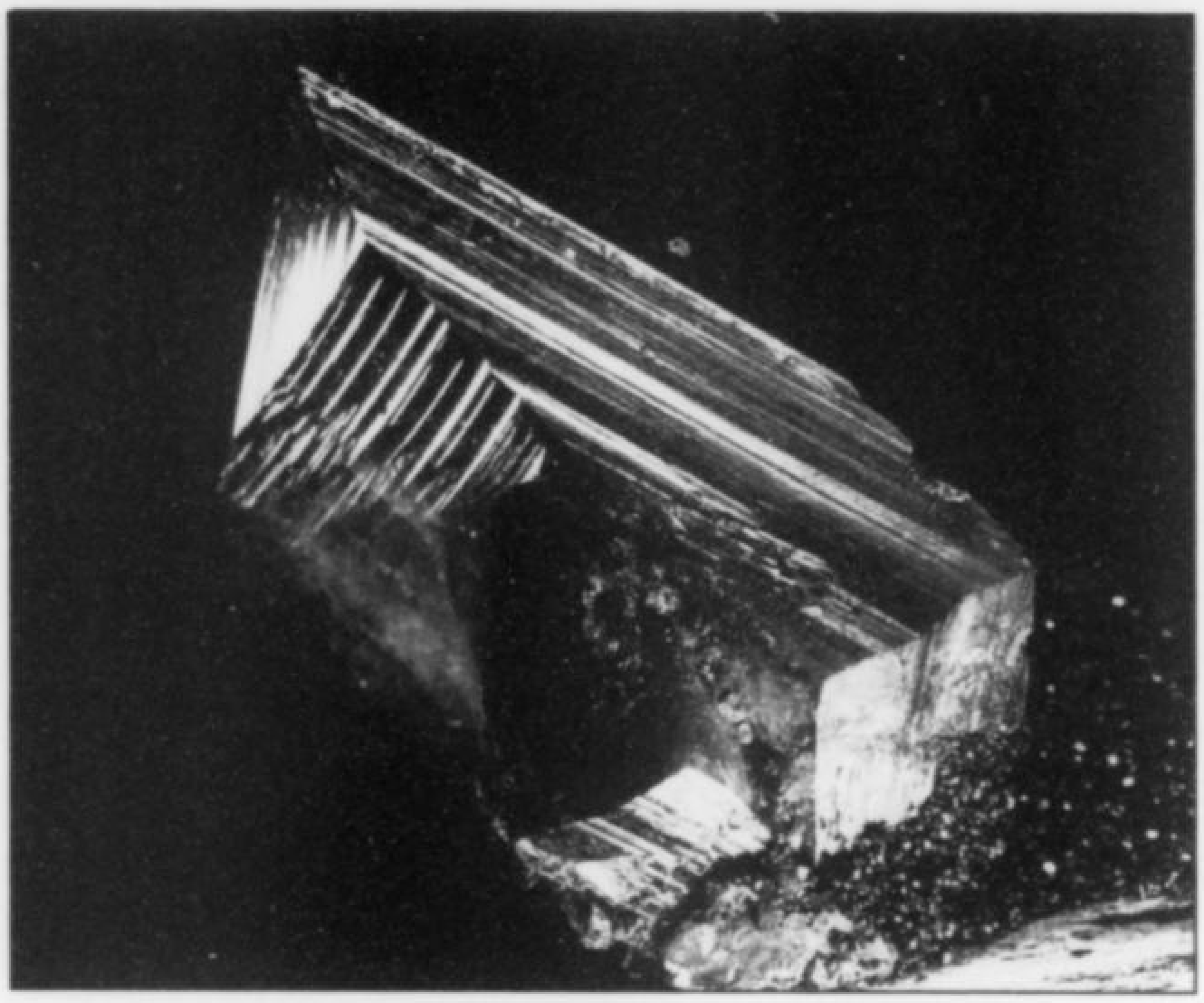


Figure 29. **Titanite twin, 3.3 cm, with chlorite on matrix from the Dodo mine. Private collection; Stefan Weiss photo.**

Figure 30. **Titanite twins on schist from the Dodo mine, 7.7 cm. Van Scriver collection; Jeff Scovil photo.**

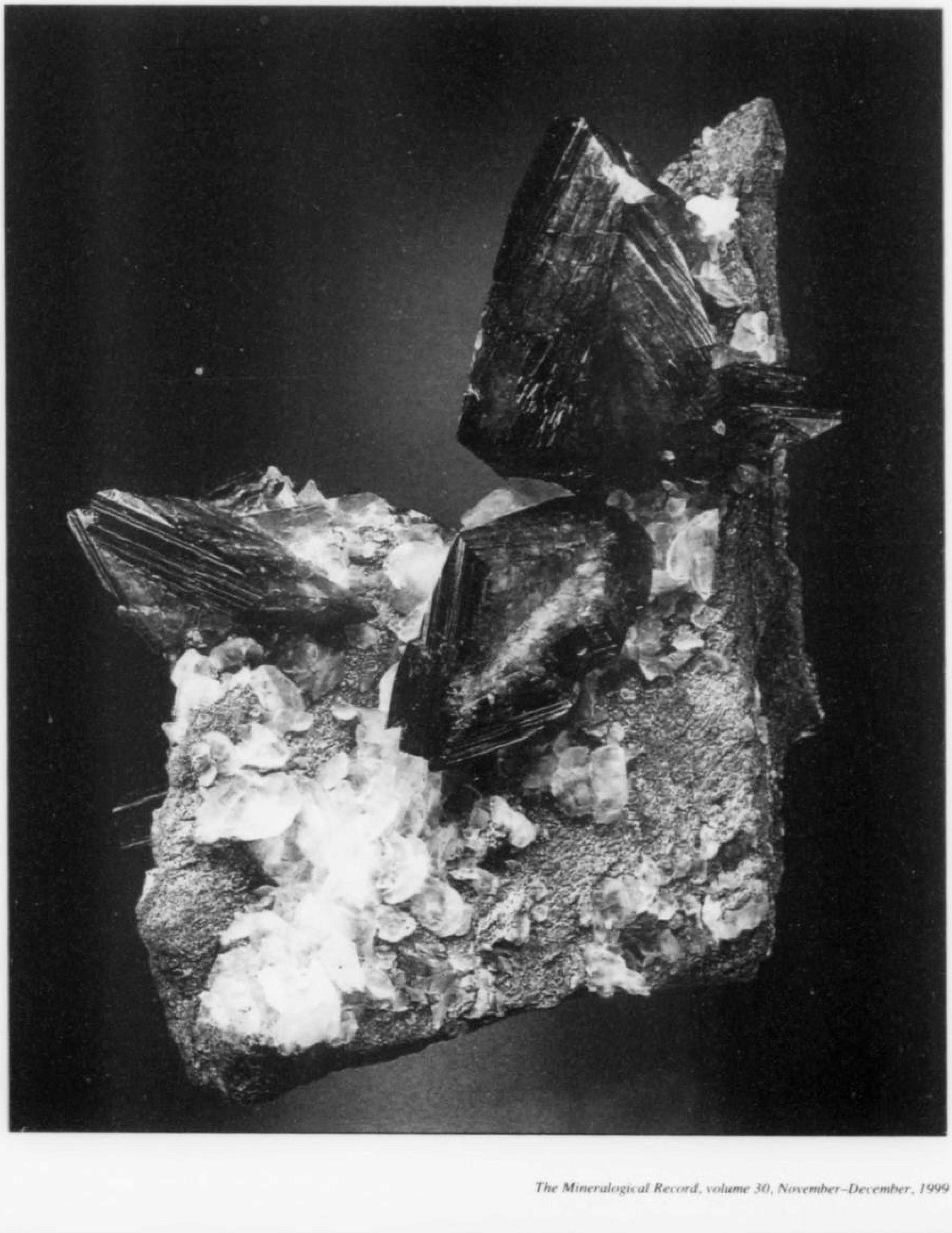


***Table 1.* Minerals of the Dodo deposit.**

Elements	
Gold	Au
Graphite	C
Sulfides	
Arsenopyrite	FeAsS
Boulangerite	$Pb_5Sb_4S_{11}$
Chalcopyrite	$CuFeS_2$
Cobaltite	CoAsS
Cosalite	$Pb_2Bi_2S_5$
Galena	PbS
Meneghinite	$Pb_{13}CuSb_7S_{24}$
Pyrrhotite	$Fe_{1-x}S$
Pyrite	FeS_2
Sphalerite	(Zn,Fe)S
Tetrahedrite	$(Cu,Fe,Ag,Zn)_{12}Sb_4S_{13}$
Oxides, Hydroxides	
Anatase	TiO_2
Brookite	TiO_2
Goethite	FeO(OH)
Hematite	Fe_2O_3
Ilmenite	$Fe^{2+}TiO_3$
Magnetite	Fe_3O_4
Psilomelane	Mn-oxides
Rutile	TiO_2
Fluorides	
Fluorite	CaF_2
Carbonates	
Ancylite-(Ce)	$SrCe(CO_3)_2(OH)\cdot H_2O$
Ankerite	$Ca(Fe^{2+},Mg,Mn)(CO_3)_2$
Azurite	$Cu_3^{2+}(CO_3)_2(OH)$
Calcite	$CaCO_3$
Cerussite	$PbCO_3$
Kainosite-(Y)	$Ca_2(Y,Ce)_2Si_4O_{12}(CO_3)\cdot H_2O$
Malachite	$Cu_2^{2+}(CO_3)(OH)_2$
Parisite analog	$(Sr,Ca)(Ce,La,Nd,Pr)[F_2 \mid (CO_3)_3]$
Smithsonite	$ZnCO_3$
Sulfates	
Anglesite	$PbSO_4$
Gypsum	$CaSO_4\cdot 2H_2O$
Melanterite	$Fe^{2+}SO_4\cdot 7H_2O$
Phosphates	
Fluorapatite	$Ca_5(PO_4)_3F$
Monazite-(Ce)	$(Ce,La,Nd,Th)PO_4$
Xenotime-(Y)	YPO_4
Silicates	
Actinolite	$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$
Albite	$NaAlSi_3O_8$
Allanite-(Ce)	$(Ce,Ca,Y)_2(Al,Fe^{2+},Fe^{3+})_3(SiO_4)_3(OH)$
Almandine	$(Fe^{2+},Ca,Mn^{2+})_3(Al,Fe^{3+})_2(SiO_4)_3$
Biotite	$K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$
Chamosite	$(Fe^{2+},Mg,Fe^{3+})_5Al(Si_3Al)O_{10}(OH,O)_8$
Chrysocolla	$(Cu^{2+},Al)_2H_2Si_2O_5(OH)_4\cdot nH_2O$
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$
Clinozoisite	$Ca_2Al_3(SiO_4)_3(OH)$
Epidote	$Ca_2(Fe^{3+},Al)_3(SiO_4)_3(OH)$
Hemimorphite	$Zn_4Si_2O_7(OH)_2\cdot H_2O$
Kainosite-(Y)	$Ca_2(Y,Ce)_2Si_4O_{12}(CO_3)\cdot H_2O$
Montmorillonite	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2\cdot nH_2O$
Muscovite	$KAl_2AlSi_3O_{10}(OH)_2$
Orthoclase	$KAlSi_3O_8$
Piemontite	$Ca_2(Al,Mn^{3+},Fe^{3+})_3(SiO_4)_3(OH)$
Prehnite	$Ca_2Al_2Si_3O_{10}(OH)_2$
Quartz	SiO_2
Rectorite	clay mineral (mica/smectite)
Schorl	$NaFe_3^{2+}Al_6(BO_3)_3Si_6O_{18}(OH)_4$
Thomsonite	$Ca_2Na[Al_5Si_5O_{20}]\cdot 6H_2O$
Titanite	$CaTiSiO_5$
Tremolite	$Ca_2Mg_5Si_8O_{22}(OH)_2$
Zircon	$ZrSiO_4$
Zoisite	$Ca_2Al_3(SiO_4)_3(OH)$

absolutely colorless "rock crystal" is not uncommon. Colorless crystals are mostly found in clefts associated with the quartz lenses and diabase intrusions. Crystals from clefts in the schistose country rock show a smoky coloring. Dark smoky quartz is not characteristic of this deposit and is only rarely encountered.

Still rarer is amethyst, in scepter growths on columnar quartz crystals. The size of the amethyst crystals averages only 5–8 mm, and never exceeds 2 or 3 cm. Commonly, this amethyst contains inclusions of platy or acicular goethite crystals.

Multiple phases of growth, dissolution and regeneration are typically seen in the tension fissures of the deposit. Flattened, distorted, doubly terminated crystals, crystals with solution pits on their faces and edges, and skeletal crystals are all characteristic of the Dodo deposit. Fairly common also are large twisted crystals (gwindels) and crystals with "white stripes" (fadens). The gwindels are most often found in small pockets and mineralized fissures along the flanks and upper horizon of the Dodo deposit. The Dodo gwindels are somewhat smaller in size than those from the nearby Puiva deposit. But only the Dodo mine has produced clusters of three to six quartz gwindels on matrix.

The quartz crystals commonly contain impurities to a varying extent. Included fragments of sericite schist are most common, along with inclusions of other cleft minerals. Aesthetic "compositions" can result, which resemble landscapes. The minerals which most commonly form inclusions within the quartz crystals or overgrowths on their faces are chlorite, muscovite (sericitic), rutile, brookite, anatase, calcite, titanite, epidote, ilmenite, pyrite, cosalite, boulangerite and ancylite-(Ce).

Rectorite

Rectorite clay forms leafy pale green, 1–2 cm aggregates on the faces of quartz crystals.

Rutile TiO_2

Rutile is not widely distributed as a primary mineral in the Dodo deposit; only on the western and southern flanks are found isolated crystal clefts containing primary rutile. But this rutile differs strongly from that in other deposits. Its color is white through grayish white (!), and the luster is silky. Fibers less than 5 microns thick may be up to 10 cm long. Primary rutile forms asbestiform or cottony aggregates either filling spaces in quartz or calcite druses or as inclusions in the crystals. Not uncommonly rutile occurs as parallel groups of fibers which, as inclusions, give quartz crystals a shimmering milky turbidity resembling a cat's-eye effect. Thus mineralogists refer to rutile from Dodo as "asbestiform," while collectors call it "cottony" rutile.

Secondary, yellow to red-brown rutile is commonly found in the deposit, associated with anatase, brookite, ilmenite and titanite.

Smithsonite $ZnCO_3$

Smithsonite has developed as an alteration product of sphalerite, as white through whitish gray, opaque crystalline aggregates and crusts.

Sphalerite $(Zn,Fe)S$

Sphalerite, like rutile, is found more commonly on the southern and western flanks of the deposit, where it makes lustrous black tetrahedrons to 1.5 cm (exceptionally to 5 cm). It occurs intergrown with calcite, chlorite, chalcopyrite, pyrrhotite and quartz.

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

Tetrahedrite occurs in the cleft fillings and as inclusions in quartz, in small tetrahedrons, and as massive grains to 10 cm. Associations include chalcopyrite, galena and quartz.

Thomsonite $Ca_2Na[Al_5Si_5O_{20}]\cdot 6H_2O$

Thomsonite occurs in the cleft fillings as transparent, platy crystals to 2 mm.

Titanite $CaTiSiO_5$

Titanite is common, especially in clefts in diabase and greenschist. The average crystal size is about 2 cm, but the largest crystal known to the author is 16 cm long (!). Titanite forms complex, sharp, platy crystals in V-twins, and also in the typical alpine "sphene" habit. V-twins making distinctive little "shoes" are typical of Dodo. The color ranges from pale to dark brown, reddish brown, brown, yellow-green, blue and colorless. Blue titanite contains an order of magnitude more yttrium than does titanite of other colors.

Commonly one sees color zoning in which the pyramids and pinacoids are green or yellowish green, and the prisms reddish brown or dark brown (resulting in a kind of "hourglass" pattern). Titanite occurs intergrown with fluorapatite, calcite, adularia and other cleft minerals.

Tremolite $Ca_2Mg_5Si_8O_{22}(OH)_2$

Tremolite is encountered only rarely. It is found in cleft fillings as cottony aggregates of threadlike crystals with a grayish white color.

Tourmaline Group

Tourmaline is observed as acicular inclusions of black *schorl* in quartz crystals and also loose in the cleft fillings (with asbestiform rutile).

Xenotime-(Y) YPO_4

Xenotime-(Y) forms brownish yellow, prismatic crystals to 1 mm associated with anatase, ancylite-(Ce), brookite, cosalite, calcite and other minerals.

Zircon $ZrSiO_4$

Zircon occurs in the cleft fillings as prisms to 1 mm of grayish pink color. Together with this recrystallized zircon, a clastic zircon (as gray rounded grains) is found in the country rock of the deposit, as the probable source material for the "regenerated" zircon of the clefts.

Zoisite $Ca_2Al_3(SiO_4)_3(OH)$

Zoisite is found in the lower part of many quartz vugs, as gray-green prisms to 2 cm long.

ACKNOWLEDGMENTS

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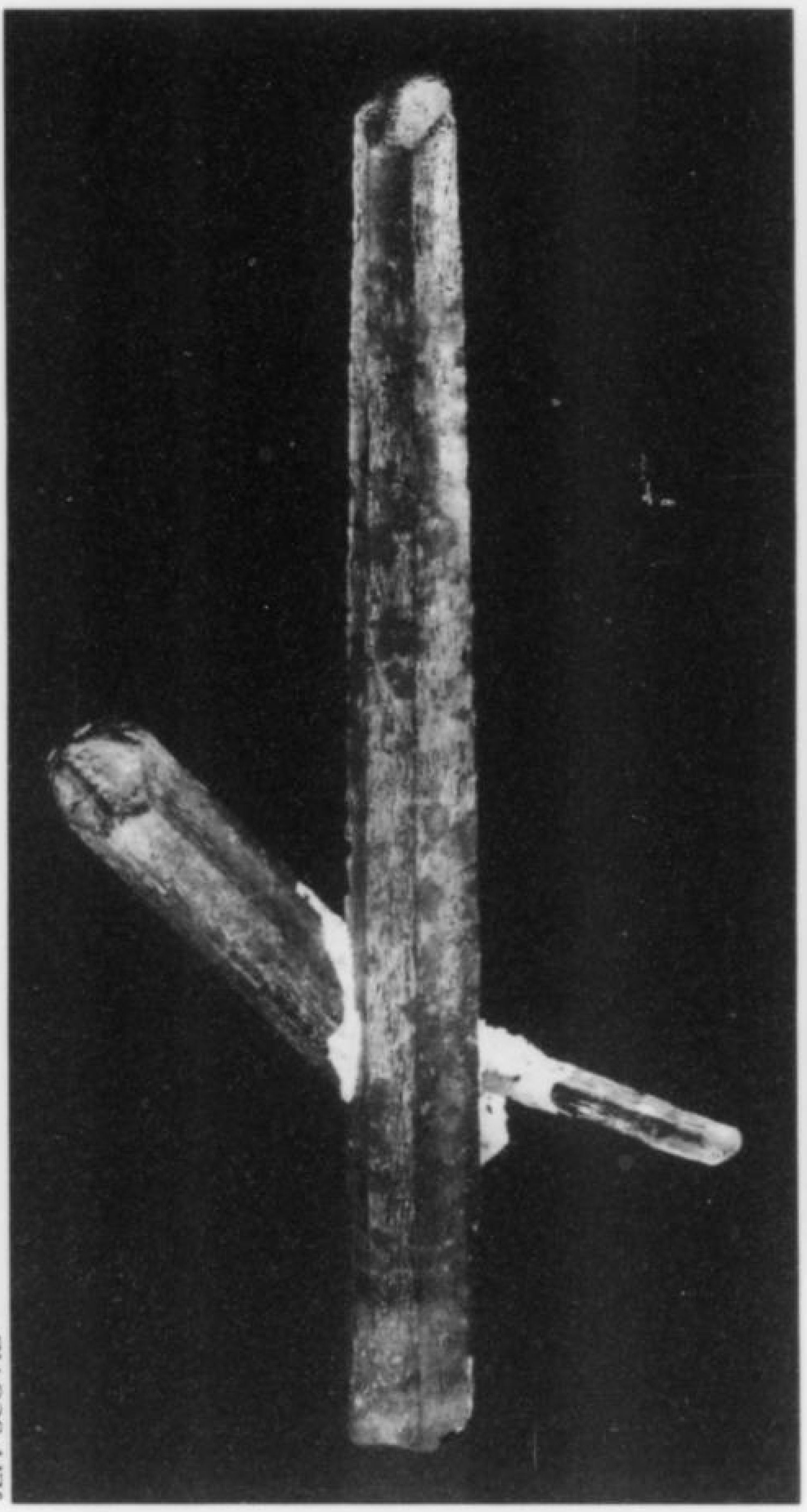

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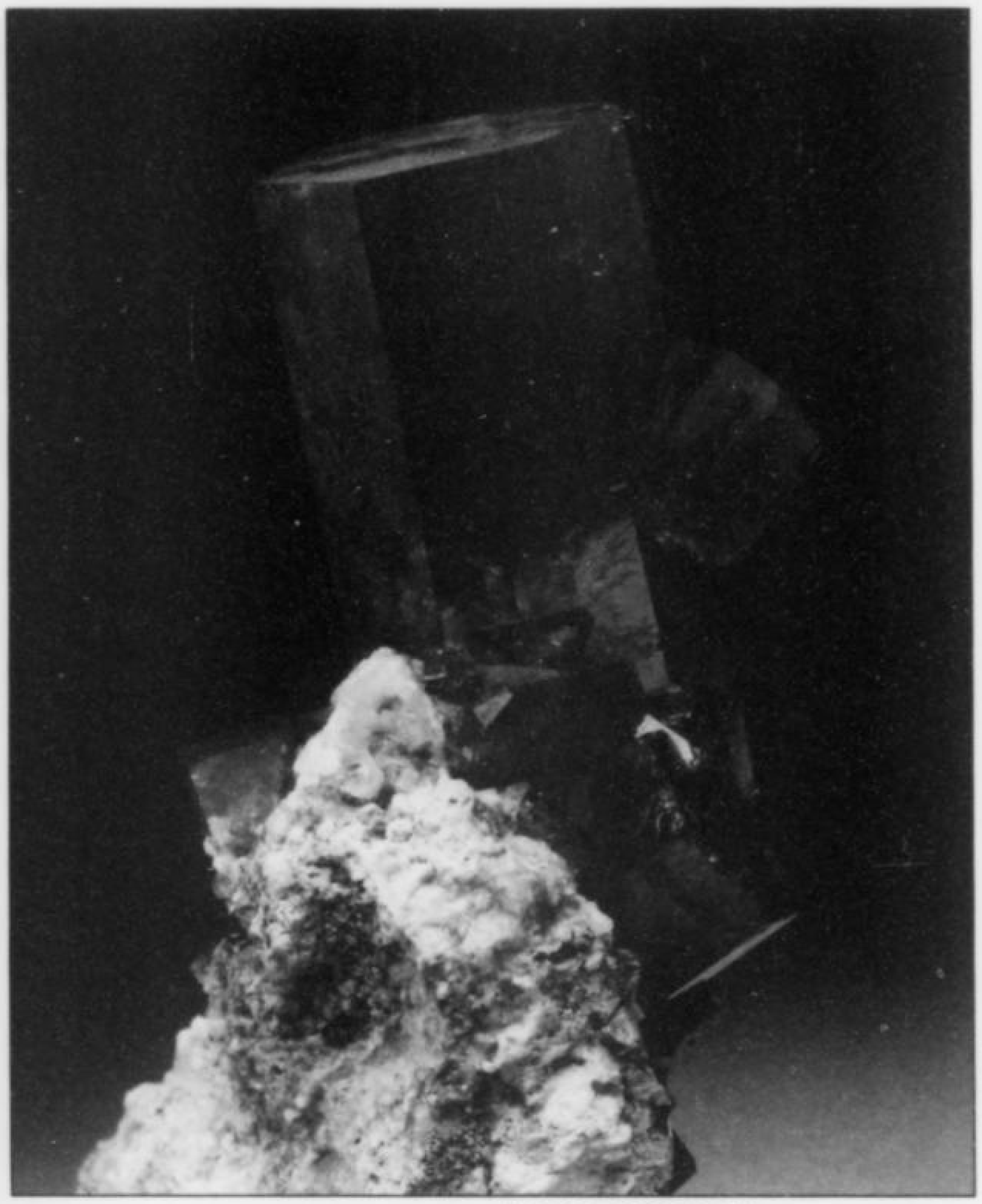

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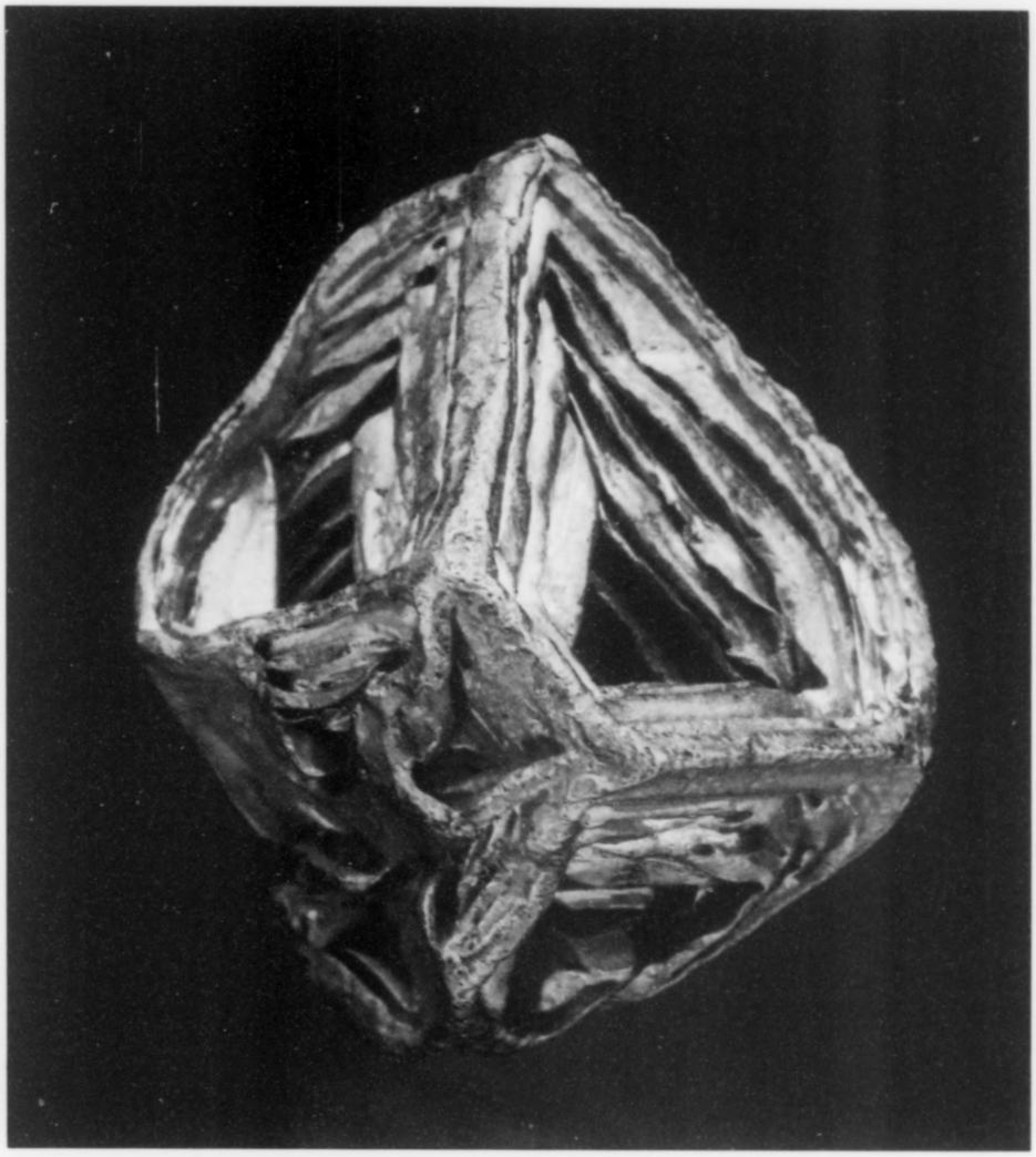

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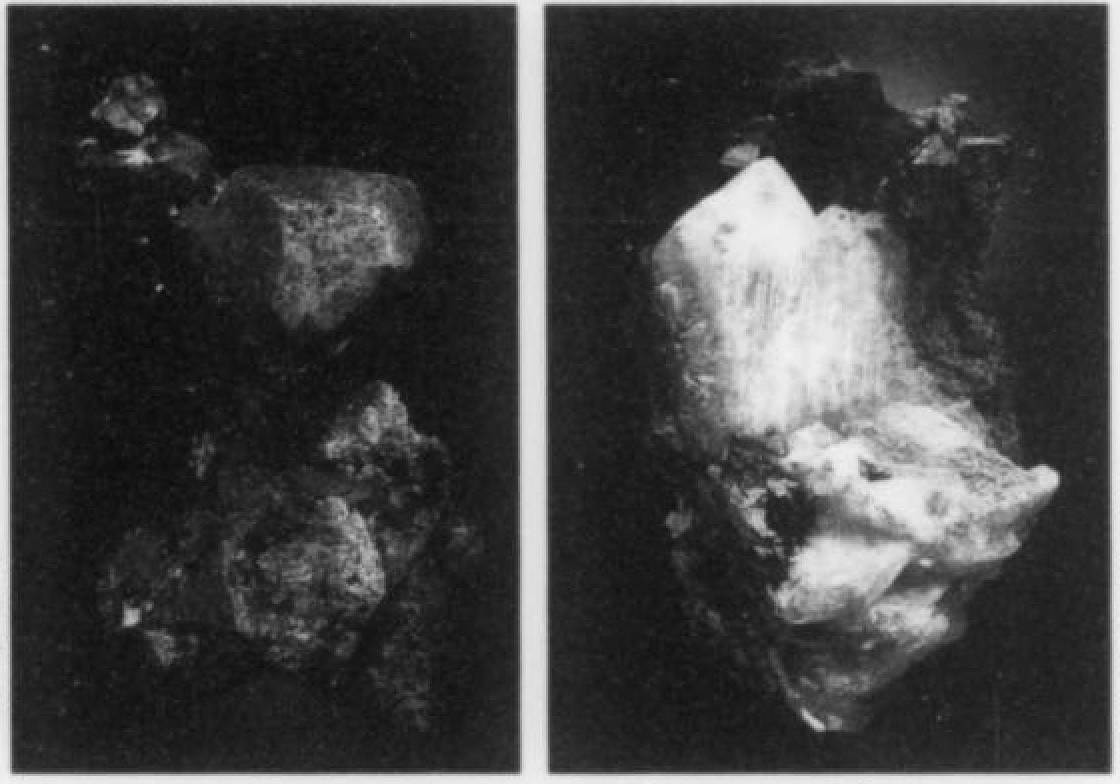

Left: Copper
Michigan 5.1 cm
Right: Anglesite
Tsumeb 6.2 cm

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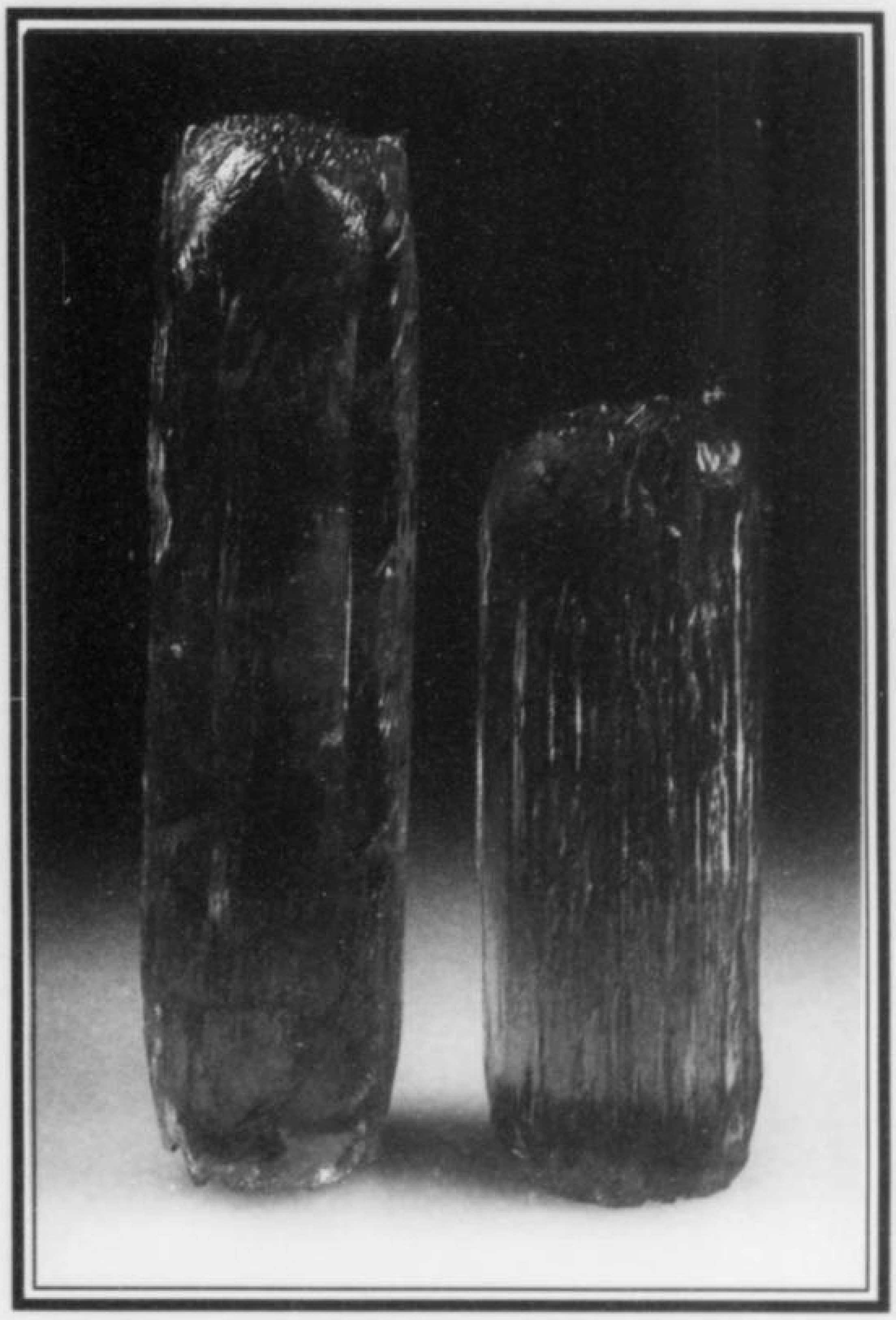
Pyromorphite, Idaho, 8.7 cm



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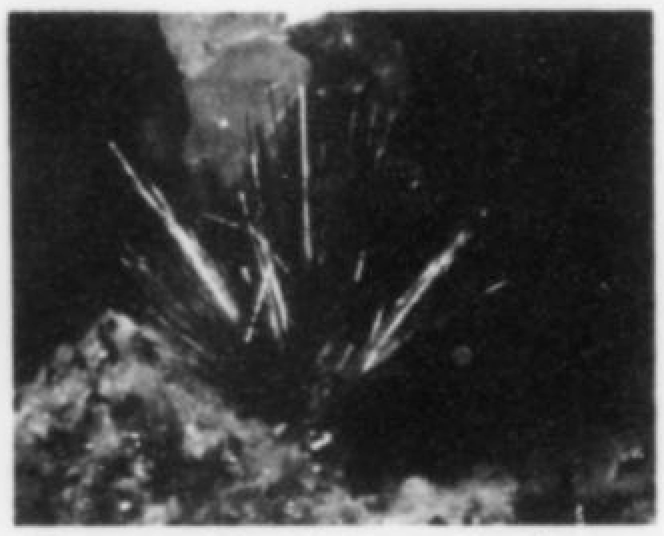

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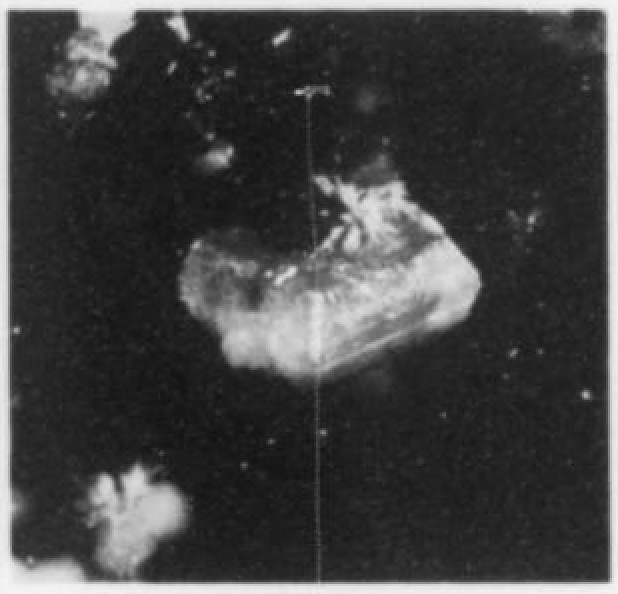

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THE PUIVA DEPOSIT
SUBPOLAR URALS, RUSSIA

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The Puiva mine in the Subpolar Ural Mountains is an extraordinary Alpine cleft-type deposit which has yielded the world's finest specimens of ferro-axinite, world-class quartz gwindels, excellent titanite crystals, and a variety of other species. It is currently being mined for specimens as well as for industrial-grade quartz.

INTRODUCTION

Incredible specimens of ferro-axinite and smoky quartz gwindels have been available on the Western mineral market since around 1992, when they first appeared at the Tucson Gem and Mineral Show (Moore, 1993). Although the deposit was discovered in 1936, it was not until 1991 that mining efforts began to focus specifically on specimen recovery.

The Puiva deposit is situated in a remote area of the Tyumen Oblast, in what is known as the Beresovsk district of the autonomous Chanty-Mansijsk region. The Dodo mine is 10 km to the north, and the town of Saranpaul is about 100 km east-southeast. The mine site is near the crest of the Subpolar Urals (a range connecting the Polar Urals to the north and the Northern Urals on the south). The highest point in the immediate neighborhood is Mount Kobyla (1386 meters). The topography is typically Alpine and very rugged, with a severe climate. Summer is short and cold, with thick fogs and frequent rain showers. In winter, strong storms with heavy snowfalls are common.

The Puiva deposit is exposed on the surface over an area measuring approximately 1 by 1.5 km, at an altitude of 600 to 850 meters.

HISTORY

The mineralization at Puiva was discovered in 1936 by the Soviet prospecting agency NKOP-Trusts #13. During the pre-war years (1937–1941) the extent of the deposit was investigated, and near-surface quartz crystal pockets were exploited, solely for piezoelectric quartz. Approximately 100 tons of quartz crystals were recovered.

The site lay abandoned for the next 20 years, but a new stage of development took place in 1961–1975. Successful exploration for crystal-bearing zones resulted in the opening of opencast workings as well as underground mining. Crystallized quartz for industrial use was the chief material sought, piezoelectric quartz being

---

*Formerly Chief Geologist at the Puiva deposit, and part of the Polar Urals Exploration Program.

Figure 1. **The village of Puiva and the Puiva mine site at the head of the valley (left), late June 1987. Burlakov photo archive.**

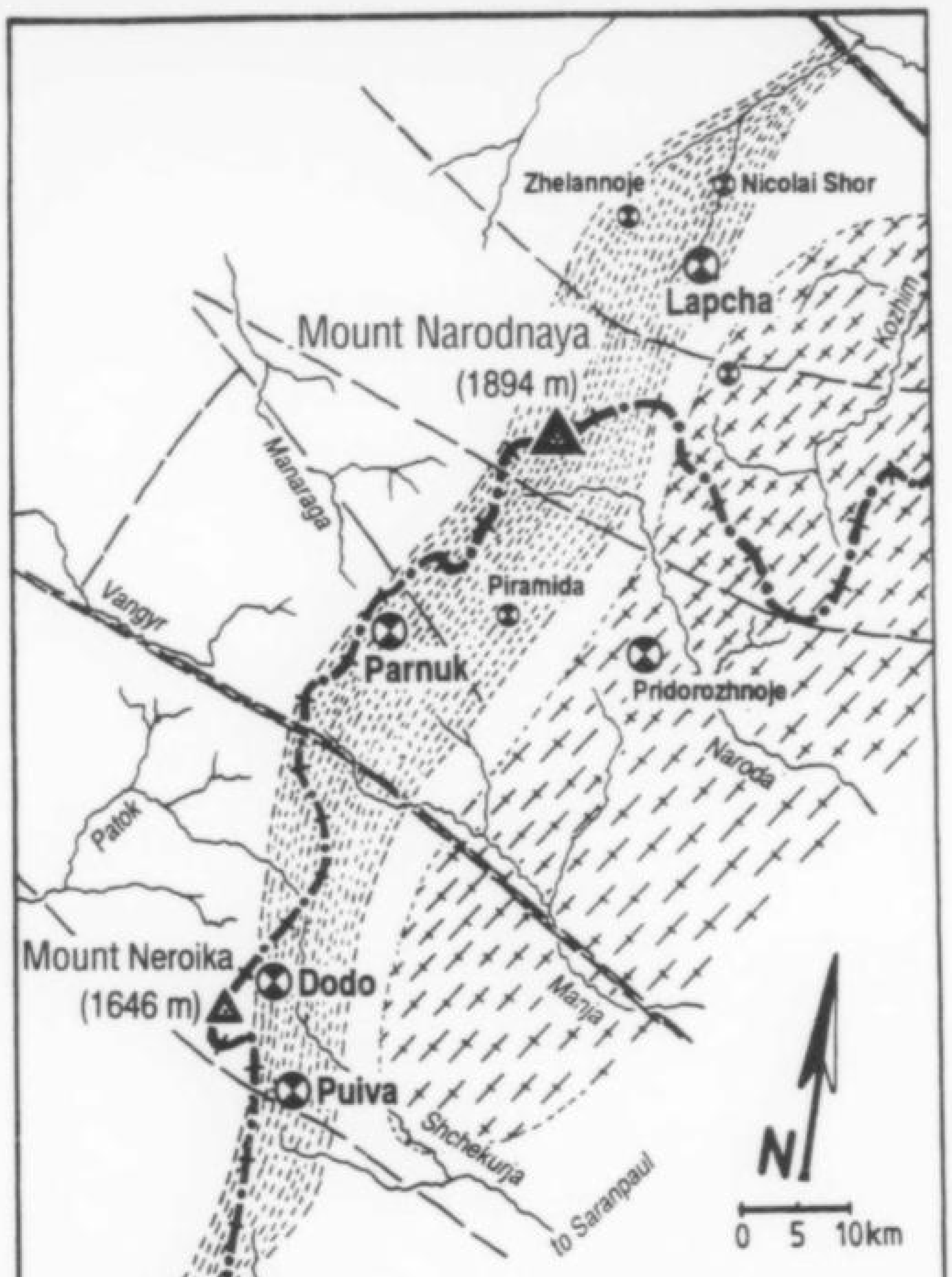

Figure 2. **General geology of the Alpine-type quartz deposits in the Subpolar Urals (after Bukanov, 1995). (1) Granite gneiss dome—Proterozoic, (2) Central schist/greenstone zone, (3) Large shear zone—the Ural Transverse Faults, (4) Local thrust fault structures, (5) Ural Divide (watershed).**

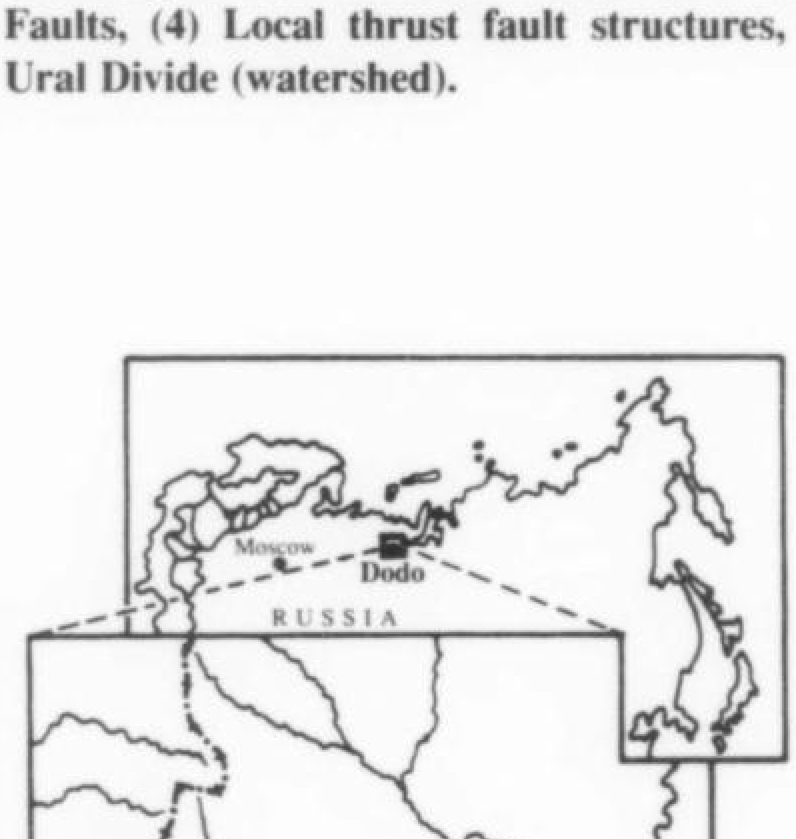

Figure 3. **Locality map.**

Figure 4. **Recording drill core data at the Puiva mine site, with fresh August snow nearby, 1987. E. Burlakov photo.**

merely a byproduct. During this period about 120 tons of quartz crystals were taken out.

The third stage of development, beginning in 1974, saw the production of transparent masses of quartz from quartz veins. From 1974 to 1987 a total of 228 tons of subhedral quartz crystals and 2,300 tons of anhedral "lens" quartz were removed. In 1987 the author estimated the remaining reserves of piezoelectric quartz, crystal quartz and vein quartz for the Soviet State Commission for Raw Materials. Updated to 1999, the best estimate is that, with mining now at a depth of 650 meters, there are a few hundred tons of quartz crystals still to be recovered.

It can be said that since 1991 a fourth stage of development has been under way. Collector specimens and faceting grade material became an important focus of mining. Prior to 1991, mineral specimens for collectors had been saved only incidentally and in small quantities. But since then, crystal pockets containing ferro-axinite and rutilated quartz have been systematically sought and exploited. At the present time, the area designated as Block #12 is being mined exclusively for specimens.

GEOLOGY

The Puiva deposit is located in the southern part of the Neroika quartz-vein field. Country rocks consist of Middle Riphean (late Precambrian) sediments of the Puiva Series which have been subjected to greenschist-facies and epidote-amphibolite-facies metamorphism. The schist sequence is intruded by numerous dikes of widely varying composition, from felsic to mafic. Diabase dikes are the most common.

To the east the deposit is bounded by outcrops of Ordovician quartzites and conglomerate of the western limb of the Puiva Syncline. To the west and southwest the area is bounded by tectonic faults of the Neroika tectonic zone. On the southeast is the sublatitudinal projection of the Keftalyk granitoid massif, of Pre-Ordovician age. The deposit itself is in sediments of the upper schist sequence (R2pv2) in the brachyanticlinal core, and sediments of the schist-quartzite sequence (R2pv3) of the Puiva series on the anticlinal flanks. The upper schist sequence consists of gray, finely banded, phyllite-like quartz-sericite schist with intercalations of apovolcanic greenschist. The schist-quartzite sequence consists of interbedded albite-sericite quartzite-schist.

Faults in the area vary in age, morphology and character of movement. They have been categorized as pre-ore, ore-controlling, and post-ore with respect to the formation of quartz. Post-ore faulting consists of diagonal shears and kinks.

Three roughly parallel crystal-bearing zones have been recognized: the Western, Central, and Eastern Zones. The width of these zones totals 150 to 300 meters; the length extends to about 1 km. The three zones are separated from each other by 50 to 150-meter-wide barren zones. The most extensively developed, and the most productive of the zones is the western one; within it are concentrated most of the major quartz crystal occurrences in the Puiva area. Ferro-axinite pockets have been opened in the western and northern flanks of this zone.

Quartz veins in the Puiva deposit generally strike north-south to NNE-SSW and dip at 5° to 30°. They can be divided structurally and morphologically into three basic types:

(1) Lenticular quartz masses with shear zones subparallel to the bedding planes of the schist, and dipping gently (5°–20°) or steeply (50°–70°) to the west. Quartz veins of this type extend 5 to 30

Figure 5. **The author, while working as mine geologist at Puiva in March 1985, with a huge cluster of quartz crystals.**

meters along strike, 2 to 10 meters down dip, and are 20 to 30 cm thick. They are not crystal-bearing.

(2) Quartz veins oriented approximately perpendicular to the bedding plane and dipping 20° to 60° west or east. Veins of this type are 3 to 10 meters along strike, 1.5 to 4 meters down dip, and 20 to 30 cm thick. Their lower zones usually contain quartz crystal pockets formed in tension gashes and fault pockets, surrounded by hydrothermal alteration aureoles. Within this type of vein are found the quartz-poor open pockets containing ferro-axinite crystallization.

(3) Complex quartz lenses with "fracture clefts," found filling tectonic fissures and incorporating loose chunks of country rock. In size they measure 10 to 30 meters along strike, 3 to 7 meters down dip and are up to 5 meters in thickness. Lenses of this type are ordinarily crystal bearing and contain the largest crystal pockets. In fact, each lens commonly contains at least three crystal pockets.

On the average, the Puiva clefts contain an order of magnitude fewer quartz crystals than the crystal-bearing clefts encountered in the nearby Dodo mine. "Small" veins usually contain less than 30 kg of quartz crystals; medium-size veins yield 300 kg to 1.5 tons. The largest vein yet opened in the deposit (lens no. 31/36) delivered 50 tons of quartz crystals; the next largest produced 28 tons; other large veins have yielded somewhat less than 20 tons each.

Aside from the presence of so much ferro-axinite, the Alpine-type mineralogy of the Puiva clefts differs very little from the

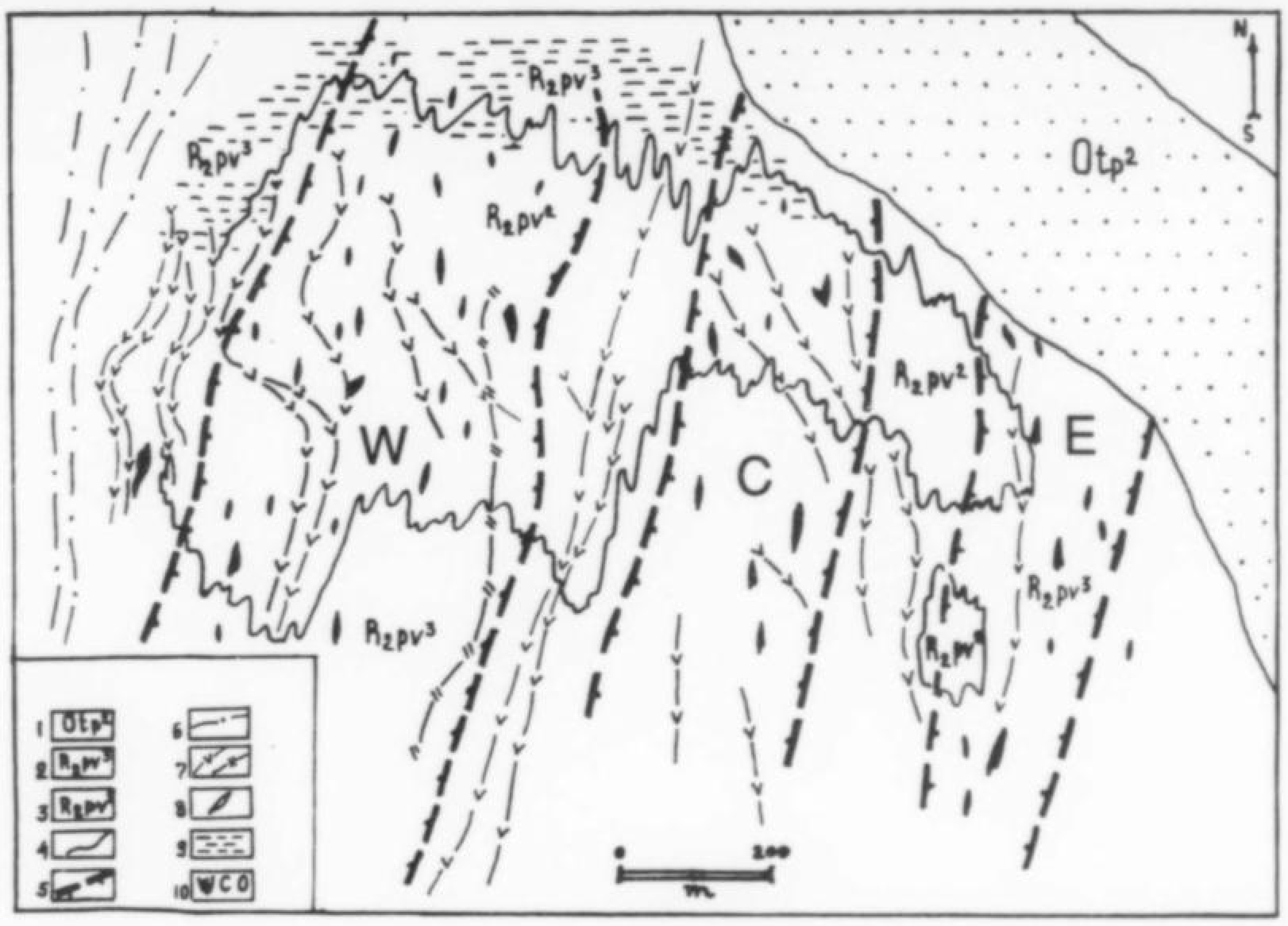

Figure 6. Geology of the Puiva area. (1) Ordovician quartzites and conglomerates, (2,3) Schists and quartzites of the Puiva Series, (4) Contacts, (5) Margin of crystal-bearing zones, (6) Faults, (7) Dikes, (8) Crystal-bearing quartz veins, (9) Ferro-axinite zone, (10) Crystal-bearing zones (W = West, C = Central, O = East).

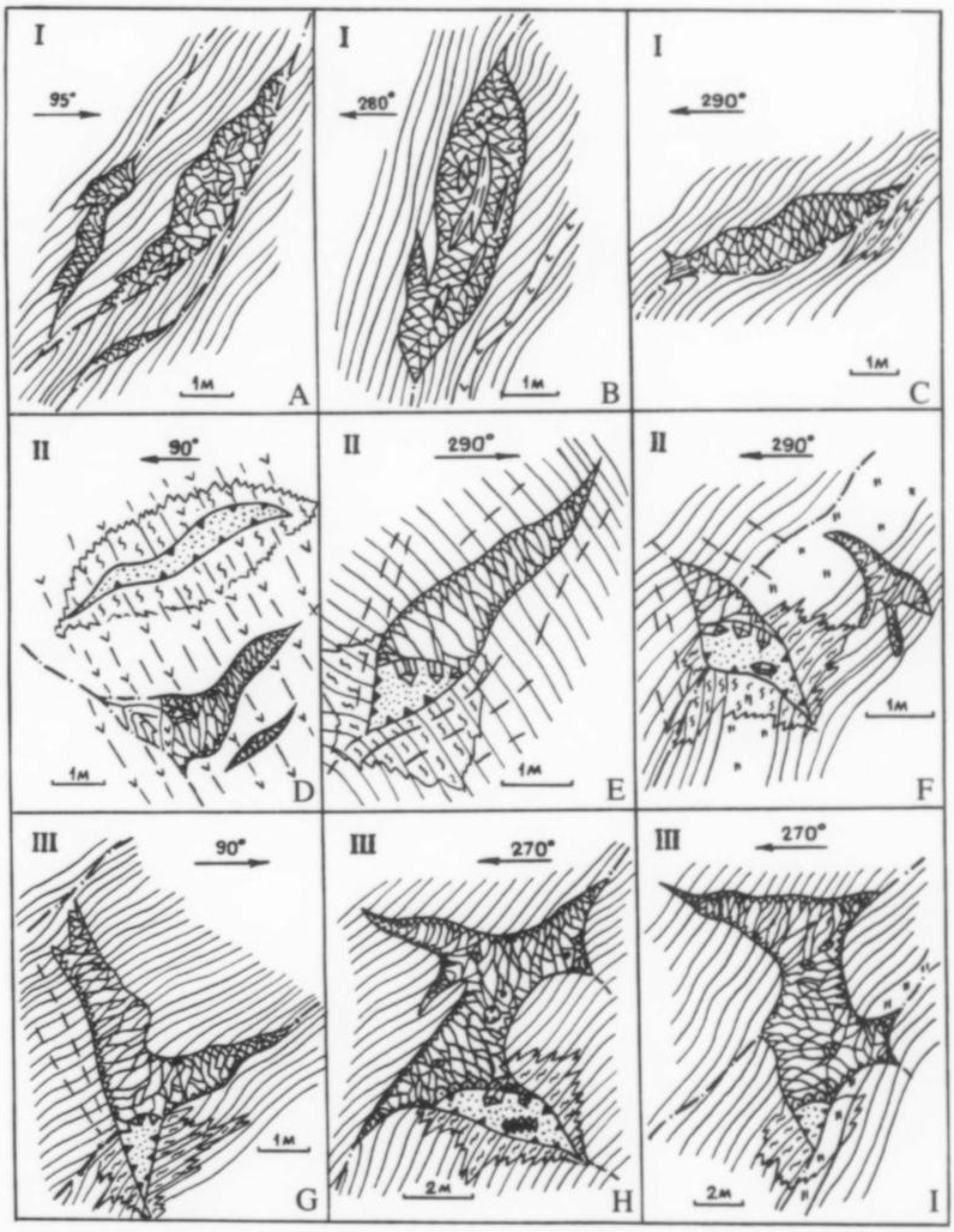

Figure 7. Types of quartz lenses and clefts in the Puiva deposit (east-west sections). Key at bottom: (1) quartz-sericite phyllite/hydrothermal leaching zone, (2) Diabase (a) and Albitophyr (b) intrusions, (3) Cleft-forming shear zones (a) and independent fissures (b), (4) Milky quartz lens (a), transparent quartz bordering clefts (b), (5) Types of quartz veins and clefts: (I) Massive quartz lenses, subparallel to schist bedding plane, (II) Crystal-bearing structures with typical leaching zones, perpendicular to schist bedding plane, (II) Folded-over structures with partially recrystallized quartz lenses, often containing quartz lenses, often containing quartz gwindels. (6) Crystal-bearing clefts and pockets.

Figure 8. **Russian geologist extracting smoky quartz crystal clusters from a pocket in the Puiva mine, 1995. E. Burlakov photo.**

mineralogy of the Dodo deposit clefts (Burlakov, 1995). However, at Puiva fluorapophyllite sometimes substitutes for chlorite in the pocket fill, amounting in some cases to 30% or 40% of total pocket volume.

As in the Dodo deposit, crystal pockets at Puiva fall into three categories, the first two being most common:

(1) Pockets contained within quartz lenses.

(2) Mineralized fissures and clefts in country rock.

(3) Mineralized fracture zones.

As already mentioned, the crystal-bearing quartz veins of the Puiva deposit are typical of Alpine cleft-type mineralization. However, as at the Dodo mine, the author's investigations suggest that the larger veins are intermediate between hydrothermal and Alpine-type. A detailed discussion of the formation of Subpolar Urals Alpine-type cleft deposits may be found in Bukanov (1974), and Burlakov (1989) (see also under "Paragenesis" in the companion article on the Dodo mine, page 431–432 in this issue).

MINERALOGY

The Puiva and Dodo deposits have long been recognized as among the most remarkable occurrences in the Subpolar Urals. They are also among the largest deposits, and have been worked for over 60 years. The commercial recovery of collector specimens has yielded examples of ferro-axinite and quartz which may well rank as the finest in the world, to say nothing of the substantial number of other Alpine mineral species that have been recovered in good crystals. Thus far the Dodo mine has produced 54 cleft minerals, and the Puiva mine has yielded 53. As of 1984, very little attention had been paid to the mineralogy of Puiva; only 40 species had been recognized, and none had been analyzed. Consequently the author's own publications (Burlakov, 1989, 1997, and the current report) remain the only sources of information on Puiva mineralogy.

The distinctive aspects of Puiva mineralogy may be summarized as follows:

(1) Zeolites and fluorapophyllite are very common; no other deposit in the Polar and Subpolar Urals contains such a variety of these minerals.

(2) Pyrrotite is widely distributed in the clefts; pyrite is the typical iron sulfide elsewhere in the Urals.

(3) Ferro-axinite is common in the Puiva crystal pockets (other boron minerals such as datolite and tourmaline are not common).

(4) Rutile is uncommon at Puiva, and brookite and anatase are unknown. And yet, other titanium minerals such as ilmenite and titanite are fairly common.

Table 1 lists only those cleft/vein species from Puiva which have been chemically and structurally analyzed. Among them are some species only recently identified by X-ray analysis, such as synchisite.

The following descriptions cover only those minerals which are of collector interest, or are particularly characteristic of the Puiva deposit. Minerals which are essentially identical in appearance, composition and distribution to those found in the Dodo deposit are excluded; see Burlakov (1995) or the companion article in this issue.

Actinolite $Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$

Actinolite is found fairly commonly in the deposit; it is especially characteristic in the ferro-axinite zones. Matted or jumbled aggregates of acicular crystals of actinolite are found as cleft fillings, and fibrous or needle crystals as inclusions in quartz; the inclusions are uniformly distributed through the quartz crystals, and give them a greenish color. Sometimes, parallel bundles of actinolite crystals in quartz produce in the quartz a "cat's-eye" effect.

Almandine $(Fe^{2+},Ca,Mn^{2+},Mg)_3(Al,Fe^{3+})_2(Si,Ti)_3O_{12}$

Garnet from the Puiva clefts looks identical to that from the Dodo deposit—transparent red rhombic dodecahedrons to 7 mm—but differs chemically. The almandine portion amounts to 51.4% (Dodo: 58.3%); spessartine 18.4% (Dodo: 4.0%); andradite 18.2% (Dodo: 0%); grossular 10.6% (Dodo: 37.4%). The generalized formula is $(Fe^{2+}_{1.54}Ca_{0.57}Mn^{2+}_{0.55}Mg_{0.04})_3(Al_{1.64}Fe^{3+}_{0.26})_2[Ti_{0.01}Si_{2.99}O_{12.0}]$.

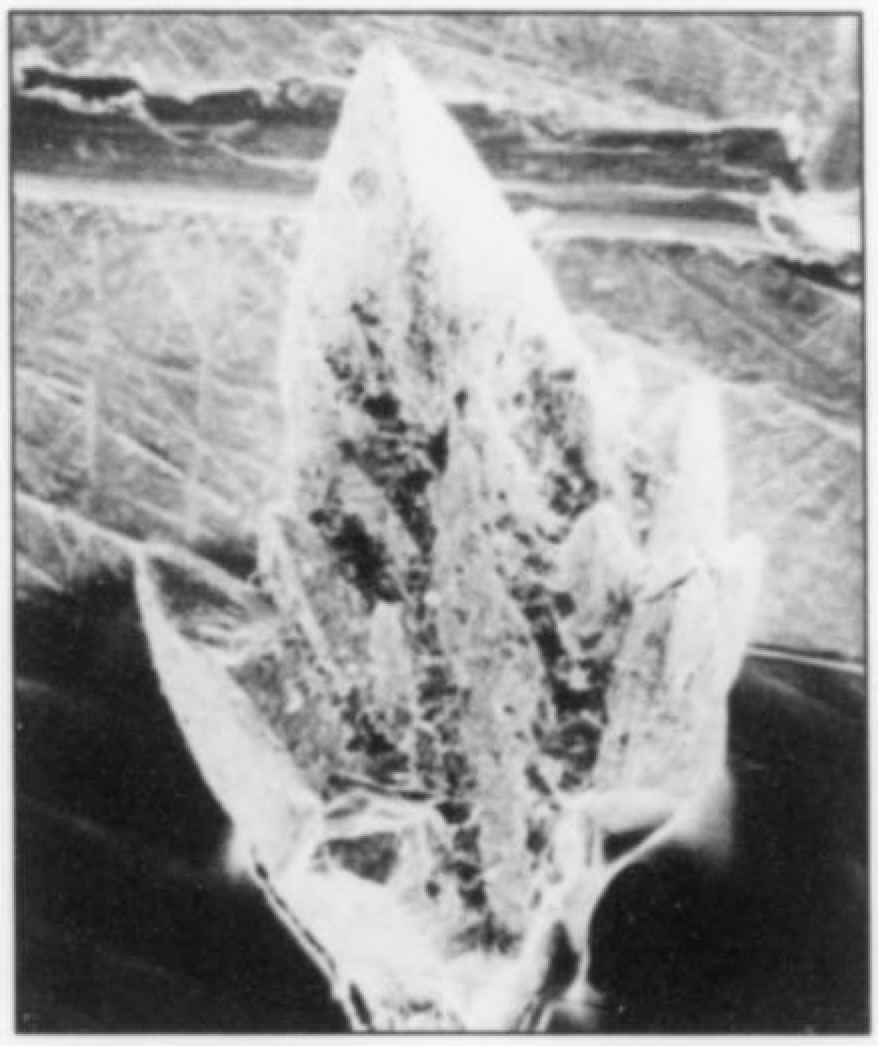

Figure 9. **Ancylite-(Ce) crystal cluster, 0.45 mm, from Puiva. SEM photo by E. Burlakov.**

Ancylite-(Ce) $SrCe(CO_3)_2(OH)\cdot H_2O$

Ancylite-(Ce) was first found at Puiva by the author in 1985. It forms gray, colorless or pink pointed pyramidal crystals 0.1 to 0.5 mm in size. The chief habits are highly elongated rhombic dipyramids or a combination of rhombic prisms and dipyramids. Chemical analysis yields the formula $(Sr_{0.28}Ca_{0.21})_{0.49}Ce_{0.70}La_{0.47}Nd_{0.12}$-$Pr_{0.04})_{1.32}[OH/(CO_3)_2]$. Ancylite crystallized during the last stages of the growth of quartz crystals, and is associated with chlorite, apatite, titanite, calcite, fluorite and kainosite. In the final phase of ancylite formation, pyrite crystallized as tiny cubes on the ancylite crystal faces.

Breithauptite NiSb

Breithauptite was discovered by the author in several tension gashes, as roughly isometric, reddish gray crystals, in contact zones with galena and chalcopyrite. The cobalt content varies widely between clefts (from 0.6 to 2.3% by weight), and the bismuth content reaches 4.1% by weight. The generalized composition is $(Ni_{0.97}Co_{0.02})_{1.0}(Sb_{0.90}S_{0.06}Bi_{0.04}As_{0.01})_{1.0}$.

Calcite $CaCO_3$

Calcite is found in almost all of the clefts. It makes extremely aesthetic crystal specimens, and is outstanding collector material. Of all the Subpolar Ural deposits, Puiva offers the greatest variety of calcite crystal habits, consisting of varied combinations of simple forms. Calcite grows during all paragenetic stages in the clefts, beginning earlier than quartz and ending later; in the Puiva deposit (alone) there are six generations of calcite. Usually crystals are found in the lower part of a cleft. Average crystal sizes are in the 5 to 10-cm range, although single crystals can reach a weight of 100 kg. The colors are remarkably varied, from milky white through pink and brown. Not uncommonly, wholly transparent varieties of the "Iceland spar" type (third generation) are found.

Chabazite $(Ca_{0.5},K,Na)_4[Al_4Si_8O_{24}]\cdot 12H_2O$

Chabazite is found filling clefts and lining the walls. Rhombohedrons to 2 mm form crusts and efflorescences on quartz and calcite crystals.

Chalcopyrite $CuFeS_2$

Chalcopyrite crystals to 1 or 2 mm are common in the clefts. Rarely, crystals can reach a few centimeters. In 1986 a crystal measuring more than 10 cm was found; it is presently in Moscow's Fersman Museum.

Datolite $Ca_2B_2Si_2O_8(OH)_2$

Datolite forms rounded crystals to 5 cm and granular masses in the spaces between quartz crystals. Color ranges from pale yellow to pale green and colorless.

Ferro-axinite $Ca_2Fe^{2+}Al_2BSi_4O_{15}(OH)$

Ferro-axinite from Puiva has been world-famous since the beginning of the 1990's, with many specimens being shown prominently at important exhibitions and available for sale at shows. In terms of size, beauty and quality, ferro-axinite specimens from Puiva are without peer in the world.

The history of Puiva ferro-axinite began in 1984, when, during work on the 705-meter level of the extreme northwestern Extension 14, a ferro-axinite cleft was accidentally discovered. The cleft measured 50 cm by 1 x 1.5 meters, and contained about 30 kg of ferro-axinite, along with 50 kg of low-quality quartz crystals. Except for a few fine specimens, the quality of the ferro-axinite was not high, so this first ferro-axinite discovery sparked no special interest among collectors.

During the period 1985–1987, a detailed reconnaissance of a

Figure 10. **Ferro-axinite crystals to 8 cm, on matrix with tremolite, from Cleft 10/39, Puiva. E. Burlakov collection; Stefan Weiss photo.**

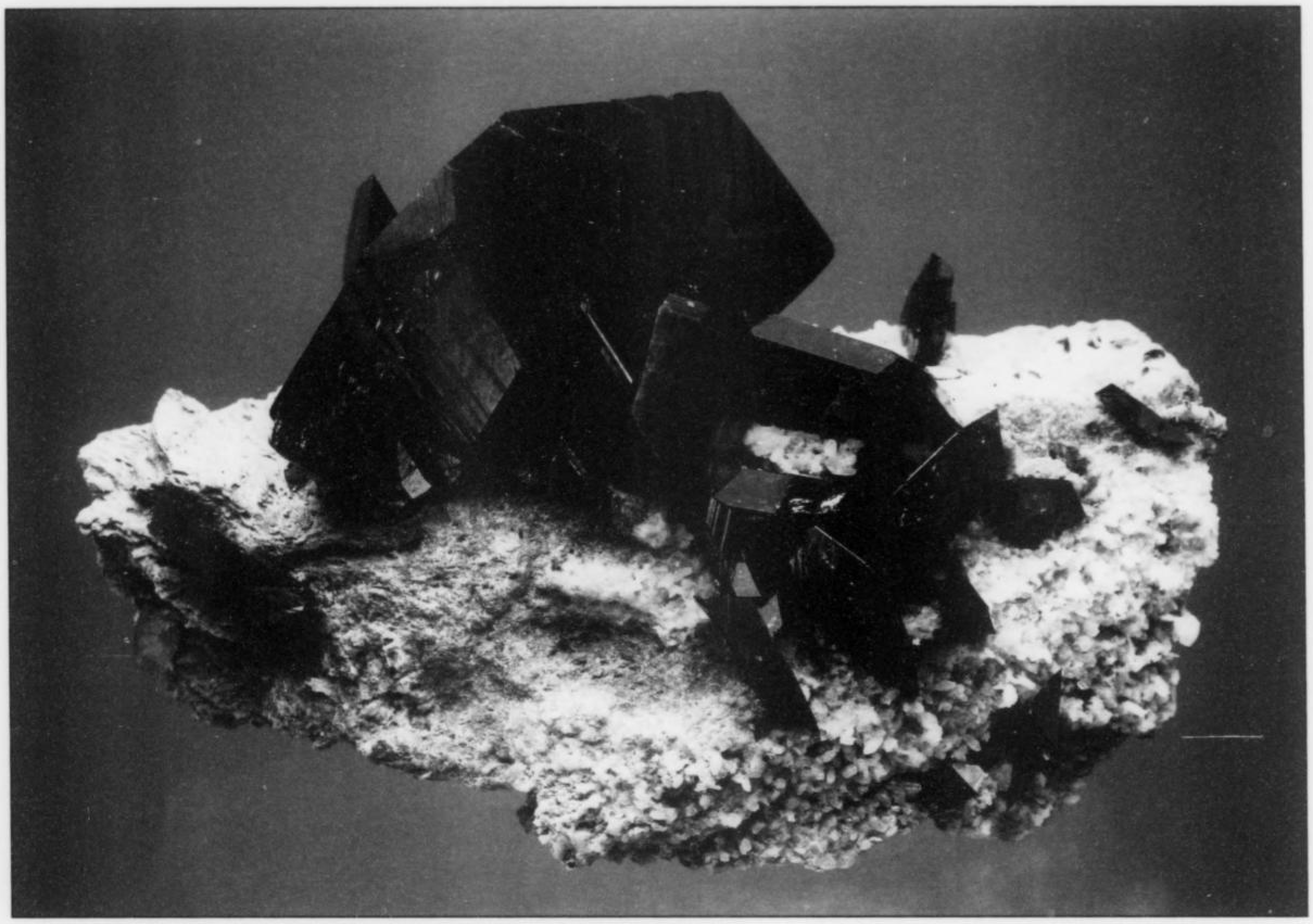

Figure 11. Ferro-axinite crystals on matrix, 15.2 cm, from Puiva. Collector's Edge specimen; Jeff Scovil photo.

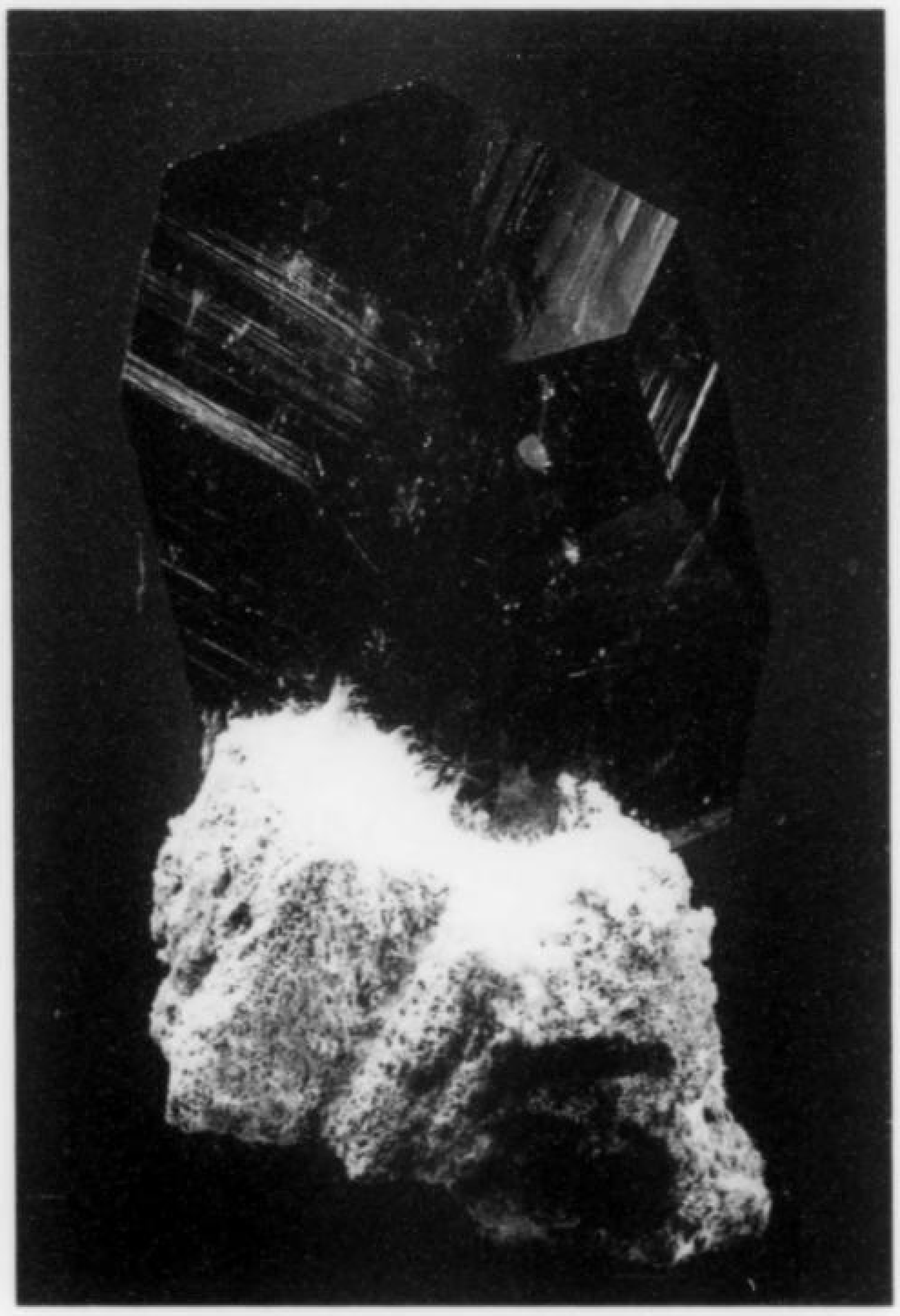

Figure 12. Ferro-axinite crystal cluster, 7.2 cm, from Puiva. Rock Currier collection; Wendell Wilson photo.

Figure 13. Ferro-axinite crystal on matrix, 4 cm, from Puiva. Richard Kosnar collection.

Figure 14. **Ferro-axinite crystal, 4.7 cm, from Puiva. Richard Kosnar collection; Jeff Scovil photo.**

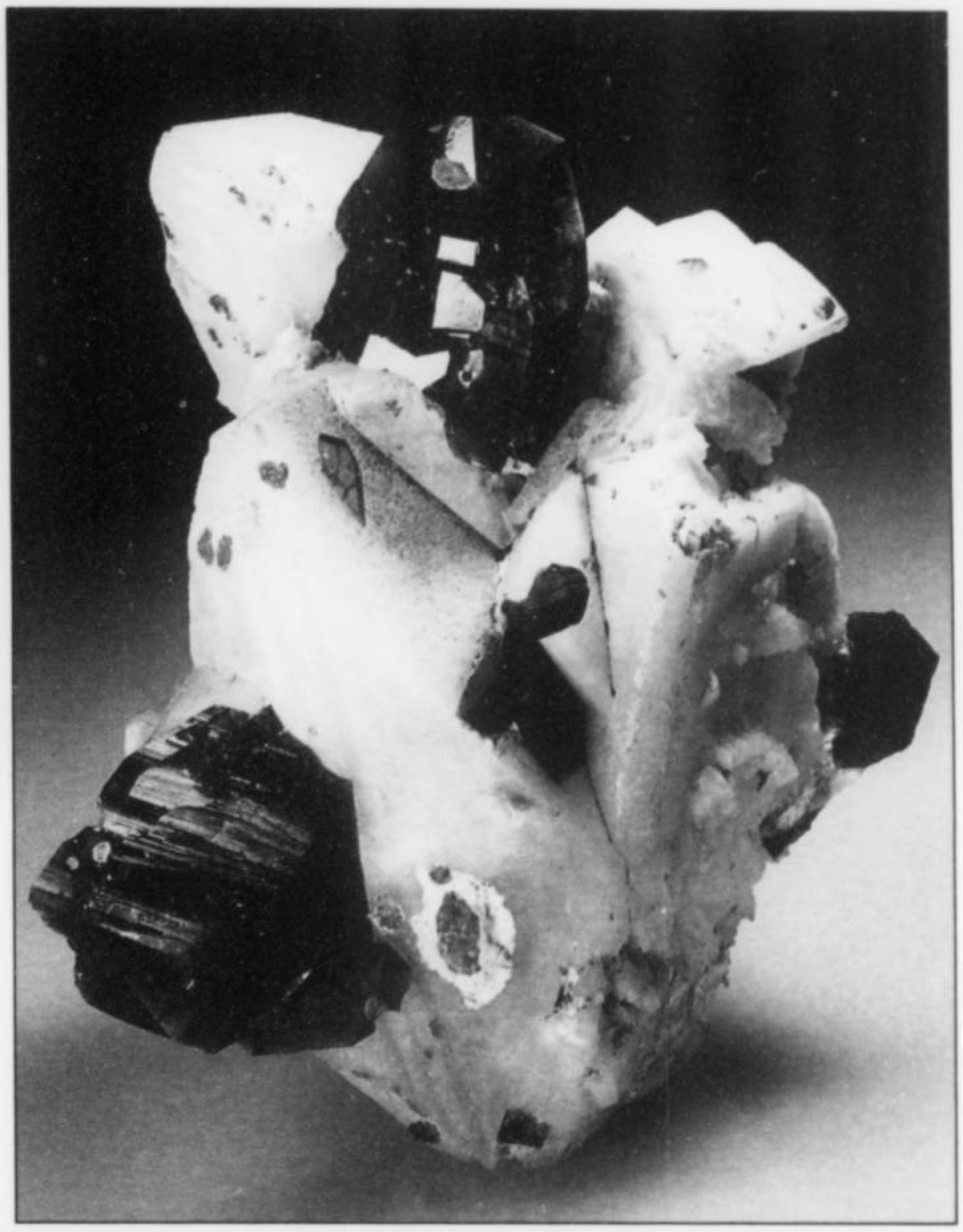

Figure 15. **Ferro-axinite crystals on orthoclase (*adularia*) crystals, 13.4 cm, from Puiva. Ulrich Burchard collection; Wendell Wilson photo.**

Figure 16. **Ferro-axinite crystal, 3.8 cm, from Puiva. H.-J. Wilke specimen; Wendell Wilson photo.**

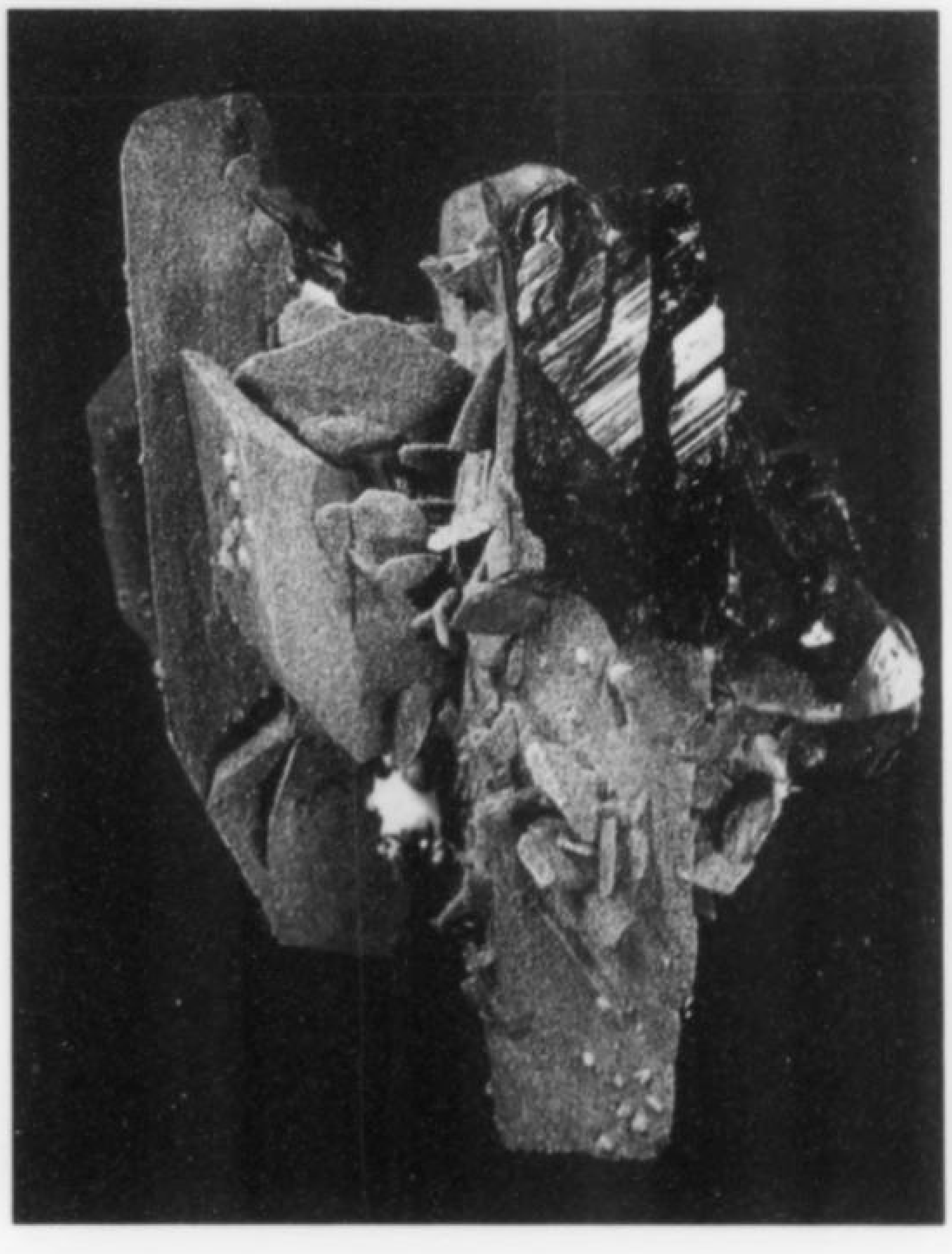

Figure 17. **Ferro-axinite crystals partially covered and included by chlorite, 8 cm, from Puiva. E. Burlakov collection and photo.**

hydrothermally mineralized greenstone zone with ferro-axinite clefts was undertaken, and the zone was pursued to a depth of 200 meters. This zone proved to be not very productive of quartz crystals, and was judged unpromising for future work. But in 1990 the author succeeded in co-ordinating its development with an ongoing research project on the north flank of the western crystal-bearing zone, where ferro-axinite mineralization occurs.

Then the author was called away on other business; and two months later, an extraordinary 1.5 x 9 x 15-meter ferro-axinite cleft (# 10/39) was discovered. From this cleft were taken more than 200 kg of ferro-axinite specimens of the highest quality. The greater part of this material was illegally collected and taken out of the country. Up to the present time, five more ferro-axinite clefts have been discovered, but neither for quality nor quantity of their materials are they comparable to Cleft 10/39; only here have ferro-axinite crystals reached sizes of 20 cm and more—and these of outstanding quality. Here, too, occurred adularia, calcite, fluorapophyllite and quartz intergrown with the ferro-axinite. In addition the cleft produced epidote, clinozoisite, titanite, datolite, pink fluorite, fluorapatite, actinolite and chlorite.

Flawless, transparent and fracture-free axinite crystals can occasionally reach sizes of more than 3 cm, but the central areas of the largest crystals are often full of tension cracks, and faces show rounded dimples of intergrown chlorite. Almost all ferro-axinite crystals contain actinolite needles in varying amounts; some are so pervaded with these that the ferro-axinite takes on a silky appearance. The colors of the ferro-axinite vary from cleft to cleft. The most beautifully colored crystals are the violet-brown to lilac, strongly pleochroic ones found in Cleft 10/39. On the ceiling of Tunnel 40 the ferro-axinite color was tea-brown, sometimes with a yellowish schiller.

Fluorapatite Ca$_5$(PO$_4$)$_3$F

Fluorapatite is widely distributed in the Puiva deposit. In almost every cleft one can find millimetric crystals; larger (centimetric) and well-developed crystals are very much rarer. The most beautiful fluorapatites, as far as the author knows, ever found in the Subpolar Urals came from the Puiva mine: colorless, pale bluish or pale greenish, transparent tabular crystals from 4 to 7 cm! Fairly commonly, fluorapatite crystals display visible zoning, the zones bounded by chlorite inclusions. Fluorapatite is often intergrown with quartz, titanite and calcite; most commonly it is found as floater crystals in chlorite sand.

Fluorapophyllite KCa$_4$Si$_8$O$_{20}$(F,OH)·8H$_2$O

Fluorapophyllite is found only in the deep levels of the deposit, where it sometimes fills up to 30% of the volume of clefts. It is found encrusting quartz crystals or entire cleft walls, or filling spaces between quartz or calcite crystals, which it "cements." Apophyllite crystals show a dipyramidal prismatic habit; their size typically ranges from 3 to 10 mm. In a single mineralized fissure in diabase, zoned pale pink crystals to 3.5 cm were discovered. Most commonly, fluorapophyllite is water-clear, and colorless or pink. This fluorapophyllite is fluorine-rich; only one analysis has shown a significant hydroxyl component in addition to fluorine.

Fluorite CaF$_2$

Fluorite is common in the axinite-bearing zone, where it occurs as well-formed pink octahedrons with fluorapophyllite. Crystal sizes reach 1.5 cm. Fluorite also is found as masses to 3 cm, intergrown with calcite and adularia.

Heulandite (Ca$_{0.5}$,Na,K)$_9$[Al$_9$Si$_{27}$O$_{72}$]·~24H$_2$O

Heulandite is found as transparent, tabular or equant crystals reaching 1.5 cm and filling clefts.

Figure 18. **Fluorapatite crystal, 3.3 cm, from Puiva. Tom Gressman collection; Wendell Wilson photo.**

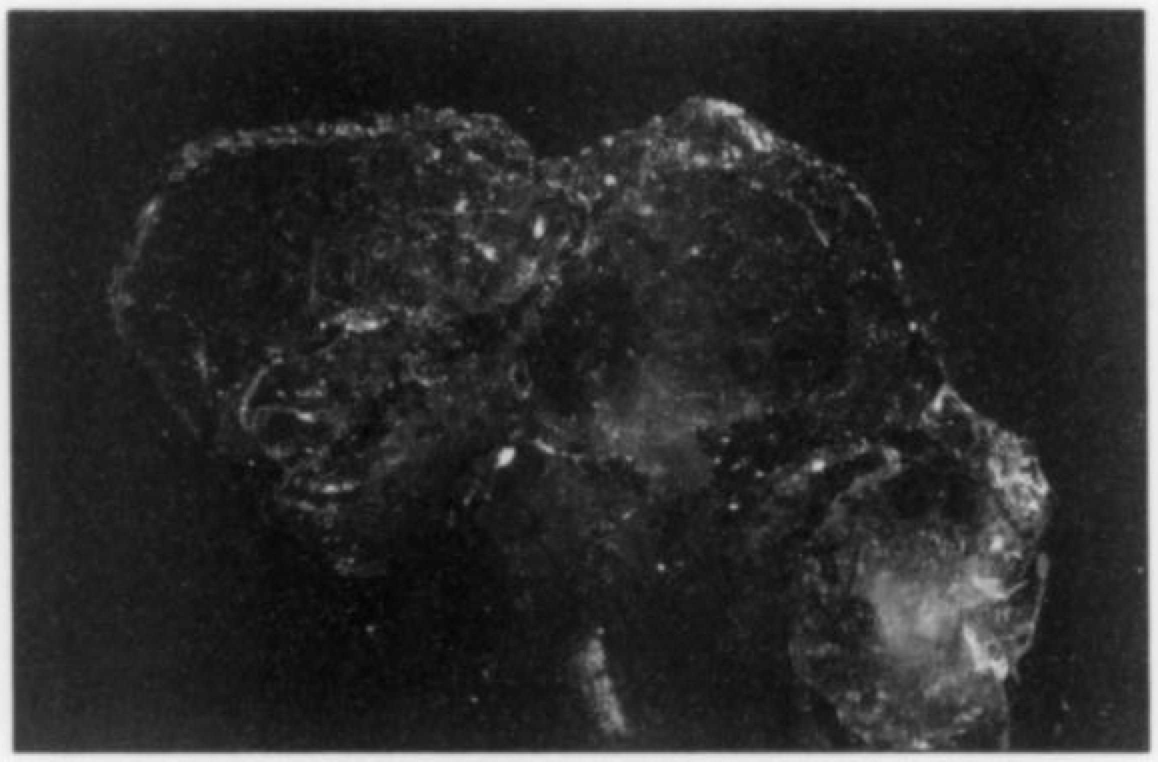

Figure 19. **Fluorapatite crystal, 3.5 cm, from the Puiva mine. E. Burlakov collection and photo.**

Figure 20. **Pink fluorite crystals (octahedron + trisoctahedron forms) to 6 mm, with fluorapophyllite, from Puiva. E. Burlakov collection; Stefan Weiss photo.**

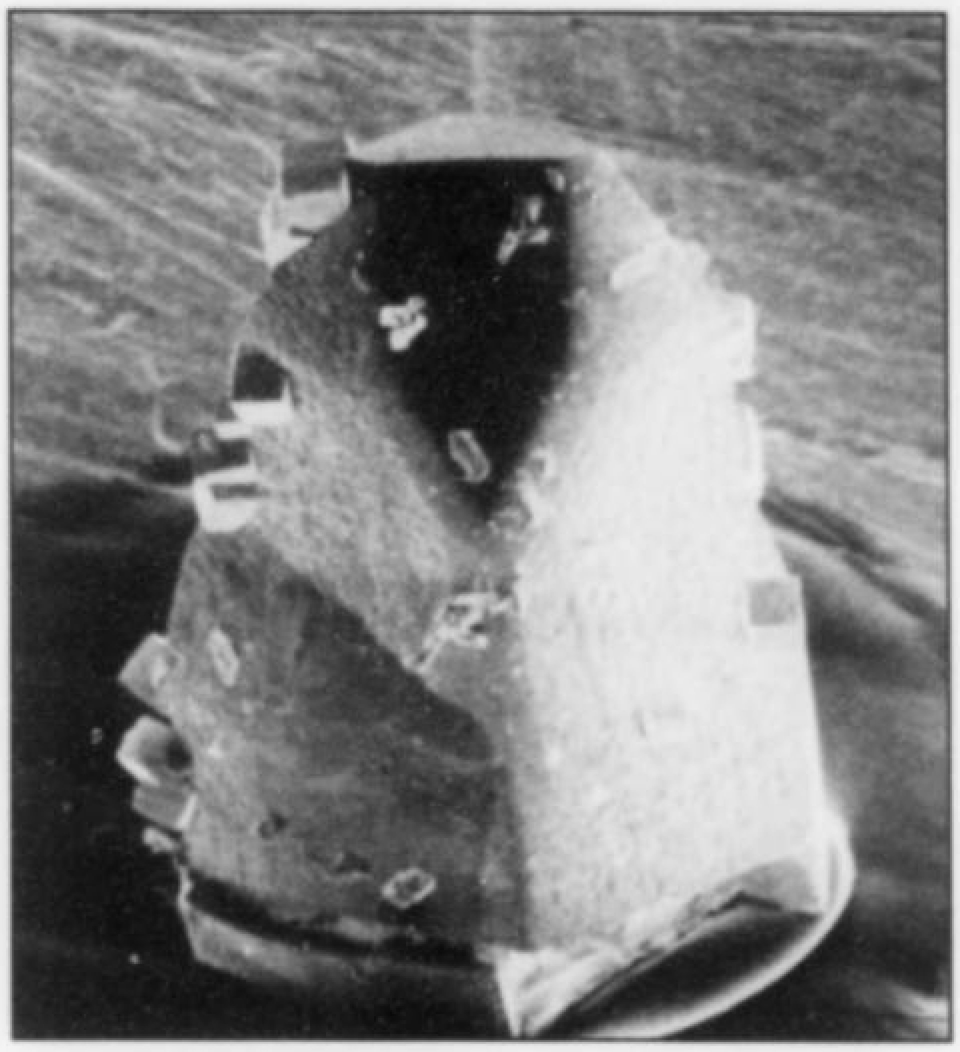

Figure 21. **Kainosite-(Y) crystal, 0.35 mm, with pyrite crystals, from Puiva. SEM photo by E. Burlakov.**

Kainosite-(Y) $Ca_2(Y,Ce)_2Si_4O_{12}(CO_3)\cdot H_2O$

Kainosite-(Y) occurs at Puiva in two different parageneses: kainosite (I) is found as a cleft filling with chlorite and fluorapophyllite, and on terminal faces of quartz crystals, where it may be intergrown with ancylite; in these cases, pyrite occurs as a still later growth on the two rare-earth species. Kainosite (I) makes obelisk-shaped pyramidal crystals of a more flattened habit than for kainosite from Dodo. These crystals are white, yellowish or colorless.

Kainosite (II) is found as transparent 1 to 2-cm crystals (!), intergrown with pyrrhotite and calcite. The best specimen is in the Fersman Museum (Moscow). Kainosite (II) is dazzlingly yellow, and it differs from kainosite (I) in the rare-earth element composition: after yttrium and cerium, samarium and neodymium predominate in kainosite (II), while dysprosium predominates in kainosite (I).

Laumontite $Ca_4[Al_8Si_{16}O_{48}]\cdot 18H_2O$

Laumontite occurs as columnar crystals, radial aggregates and compact masses. Crystals reach 5 mm, and are milky white or colorless and transparent.

Orthoclase $KAlSi_3O_8$

The transparent variety of orthoclase is widely distributed at Puiva. It occurs as single crystals (combinations of the rhombic prism and pinacoid), and as Baveno twins. The mostly snow-white, translucent crystals can reach 25 cm in size. Particularly attractive aesthetically are the associations of orthoclase with smoky quartz and ferro-axinite.

Pyrophyllite $Al_2Si_4O_{10}(OH)_2$

Pyrophyllite forms radiating spherules to 2 cm in size on the faces of many quartz crystals. The mineral is yellowish gray or greenish gray, with a pearly luster.

Quartz SiO_2

In the Puiva deposit, as compared with the Dodo mine, relatively small clefts containing fewer than 500 kg of clear quartz prevail. Accordingly, the crystals in these clefts are of more modest dimensions: the lengths range between 10 and 30 cm, the weights between 10 and 15 kilograms.

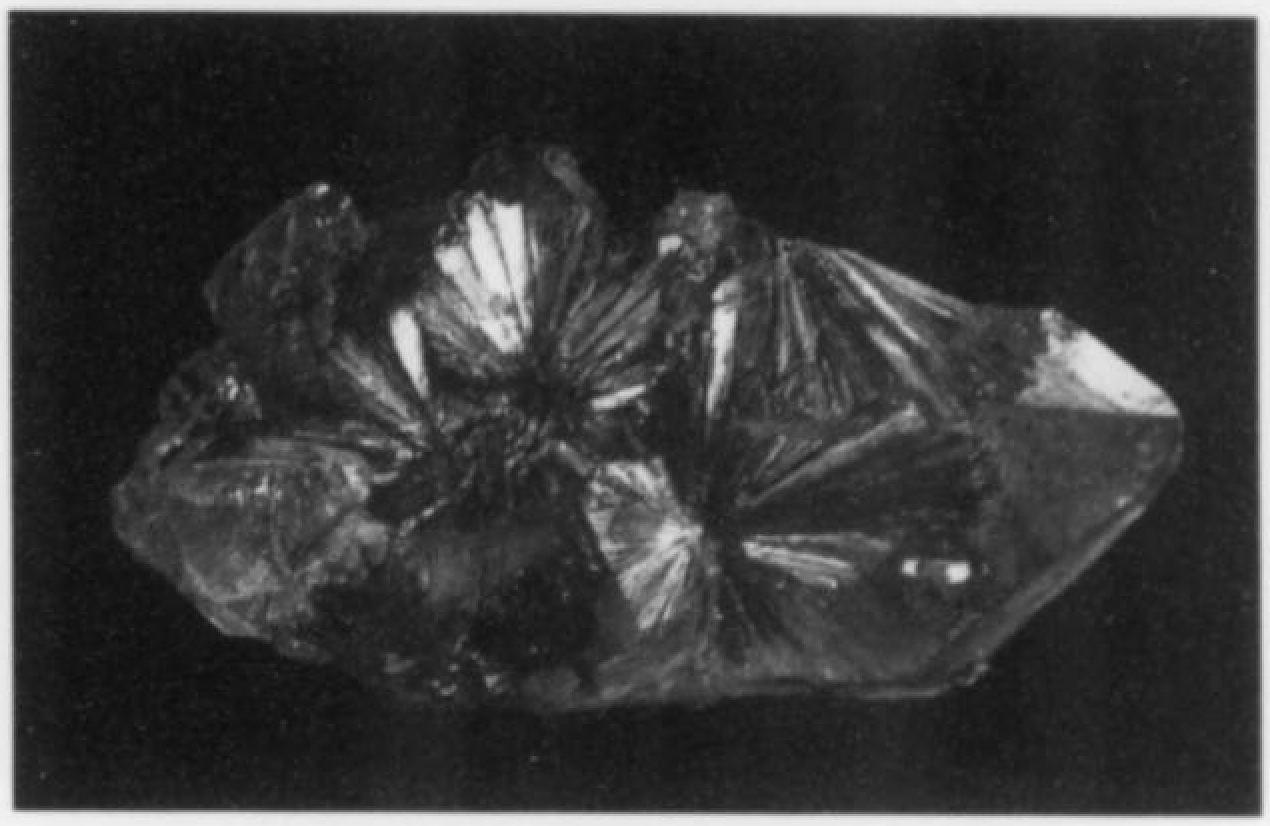

Figure 22. **Prophyllite on quartz, 3.4 cm, from Puiva. E. Burlakov collection; Stefan Weiss photo.**

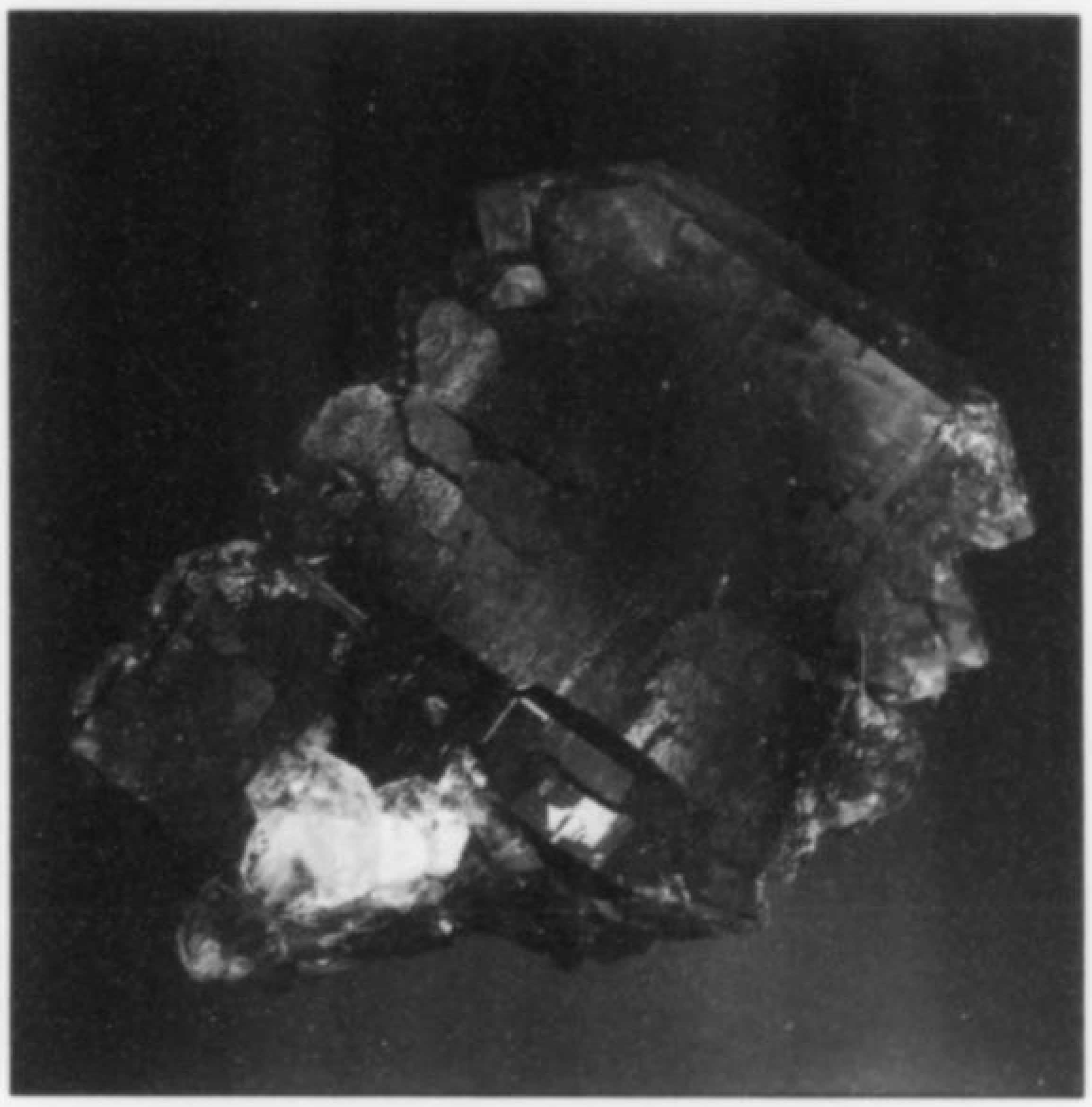

Figure 23. **Smoky quartz gwindel, 8.3 cm, from Puiva. Van Scriver specimen; Jeff Scovil photo.**

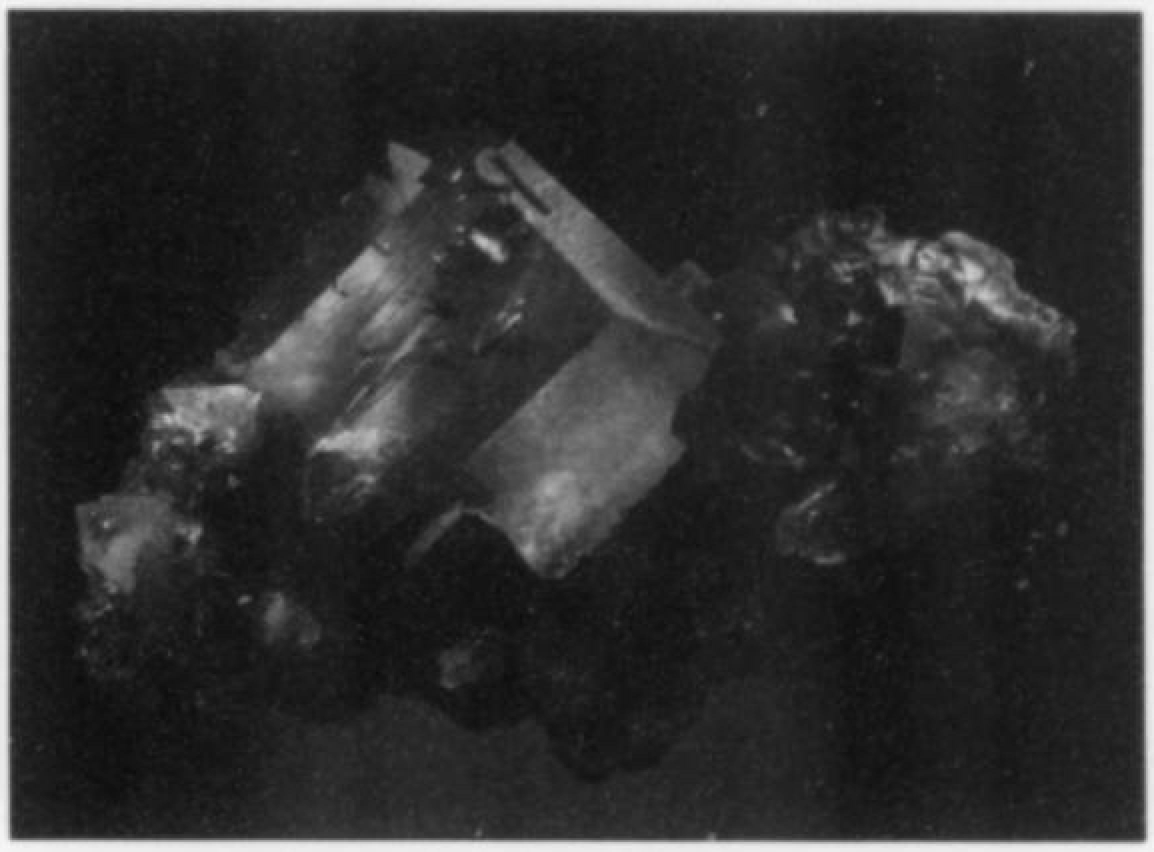

Figure 24. **Smoky quartz gwindel, 7.6 cm, from Puiva. Richard Kosnar collection; Jeff Scovil photo.**

Figure 25. **Smoky quartz gwindel, 25 cm, from Puiva. Collection and photo: E. Burlakov.**

Figure 26. **Smoky quartz gwindel, 13.1 cm, from Puiva. Richard Kosnar collection; Jeff Scovil photo.**

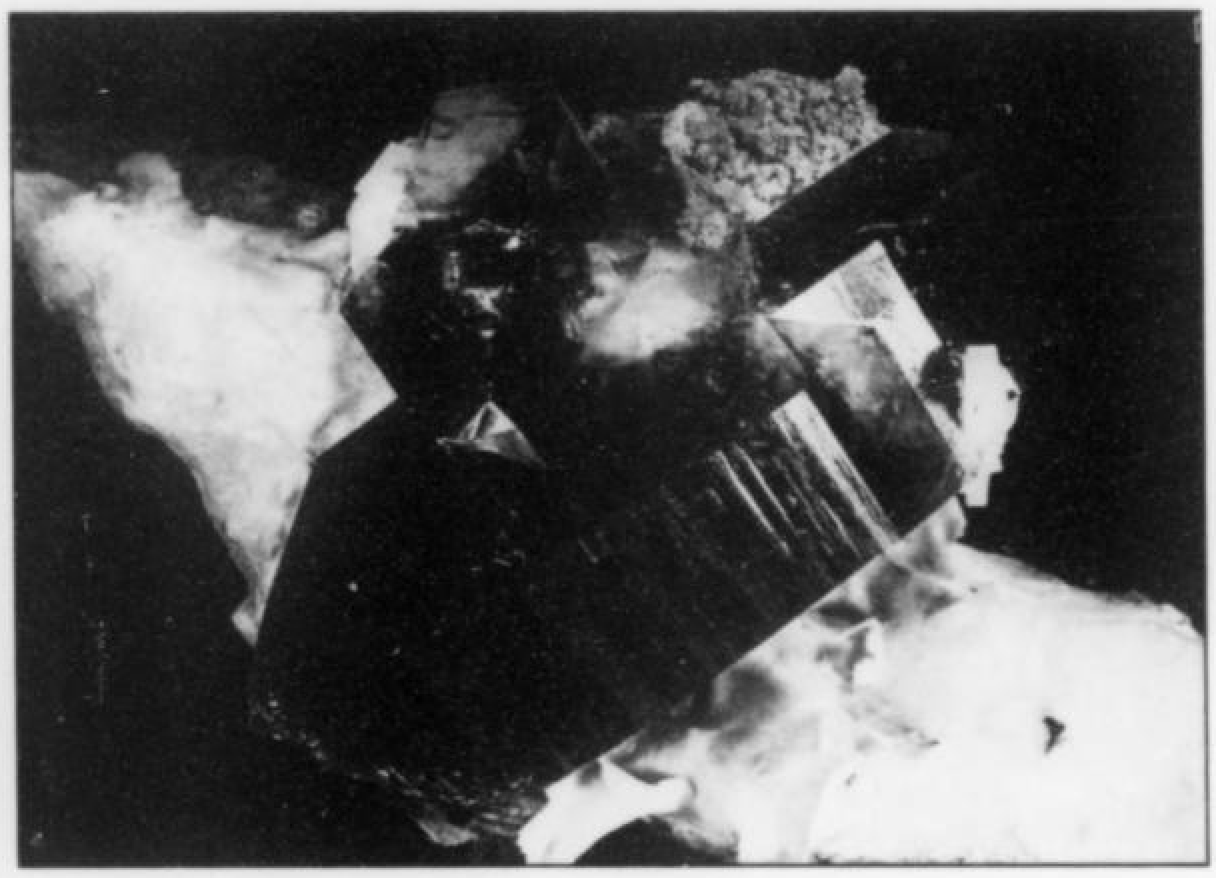

Figure 27. **Smoky quartz with actinolite ("byssolite"), on white orthoclase, 9 cm. Burlakov collection and photo.**

In the rare larger clefts, crystal weights can reach 50 to 150 kilograms, and only in Cleft 31/36 were crystals weighing more than 150 kg found. The biggest specimen, extracted in 1985, weighs about a ton and is 1.2 x 2.1 meters in size.

The quartz crystals are short to medium prismatic (rarely needle-like), with a length/width ratio of 3:1 to 6:1. Their habit is the typical pseudohexagonal-prismatic. In color, many crystals are pale smoky to grayish smoky; some, very beautiful ones are a rich tea color.

The crystals grow both on the cleft walls and in the quartz lenses. The most valuable specimens are taken from the mineralized fissures. Near the clefts bearing quartz alone, quartz/calcite and quartz/adularia clefts are often noted.

Ferro-axinite, titanite, fluorapatite, various zeolites, and fluor-

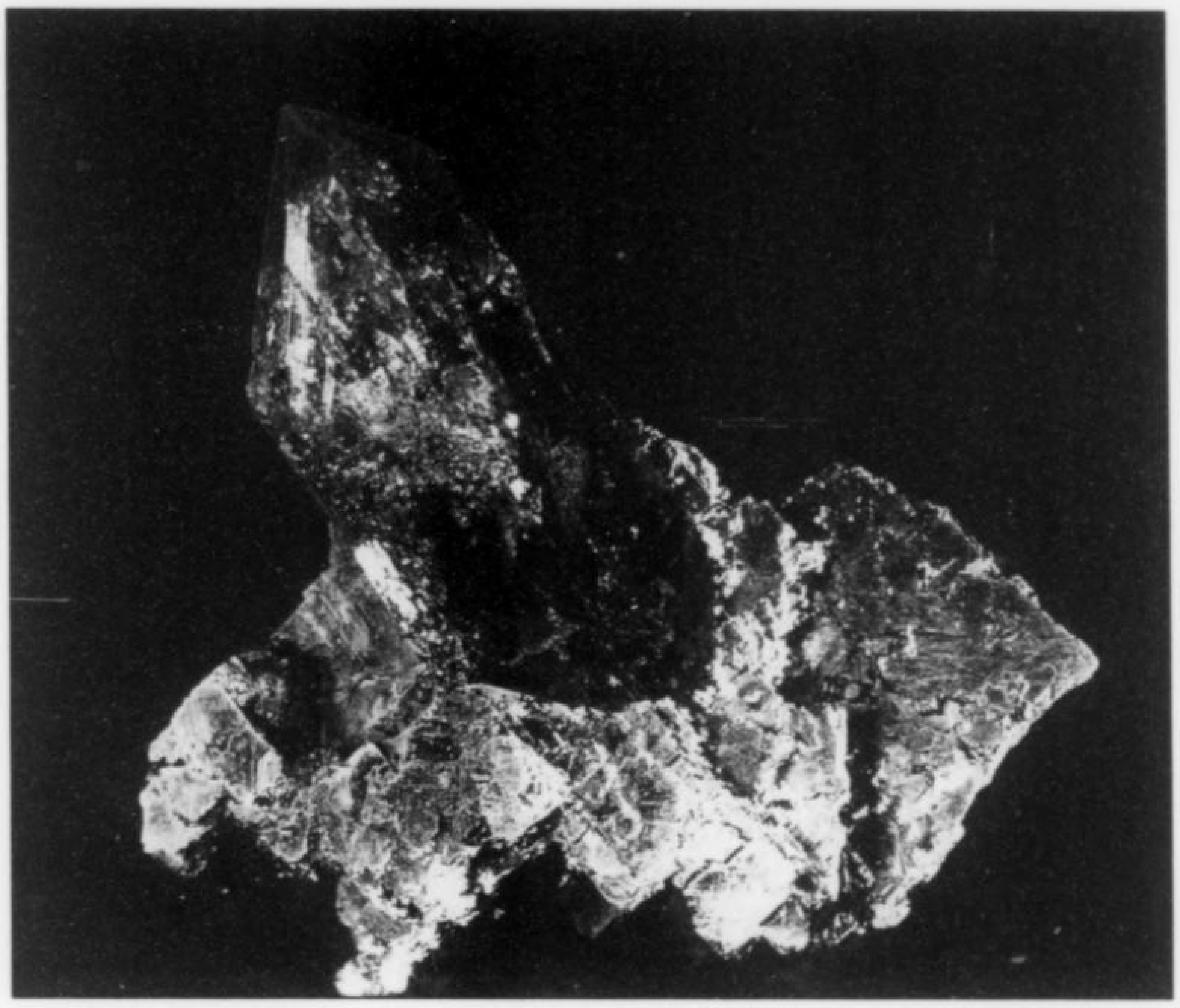

Figure 28. **Smoky quartz crystal, 4.5 cm, on bismuthian galena, from Puiva. Burlakov collection and photo.**

Figure 29. **Quartz crystal, doubly terminated and rutilated, 12 cm, from the eastern crystal-producing zone at Puiva. Korendasev collection; E. Burlakov photo.**

apophyllite occur as inclusions in the quartz and overgrowths on it. Commonly the quartz crystals are coated with a thin layer of shimmering chlorite, making especially attractive specimens. Sometimes one sees rock fragments enclosed in the quartz crystals, so that, together with the chlorite inclusions, wonderful "pictures" are created resembling varied landscapes.

The Puiva deposit is famed for its quartz gwindels, sometimes more than 25 cm high. Puiva has produced the most valuable specimens of this "twisted quartz" in the whole Ural Mountains region. In the clefts, other extraordinary varieties of recrystallized quartz are also encountered fairly commonly, including tabular and doubly terminated crystals. All of these are of great interest to quartz collectors.

Rutile TiO_2

Rutile is fairly rare at Puiva. Rutile-bearing clefts are confined to the eastern flank of the deposit. Here, rutile is found as needle-like or hair-crystal inclusions with a golden or copper-red color in quartz.

Sphalerite (Zn,Fe)S

Large, black, tetrahedral sphalerite crystals to 2.3 cm have been collected on a schist matrix from Puiva.

Stilbite $(Ca_{0.5},Na,K)_9[Al_9Si_{27}O_{72}]\cdot 28H_2O$

Stilbite is found in clefts with pyrite, heulandite, fluorite and epidote, as excellently developed sheaf-shaped aggregates with zoned colors. Crystal can reach 2 cm, and are colorless and transparent or milky white, rarely dark brown or orange-red.

Stilpnomelane $K(Fe^{2+},Mg,Fe^{3+})_8(Si,Al)_{12}(O,OH)_{27}$

Stilpnomelane as a mineral of the Ural Mountain Alpine clefts was first discovered at Puiva. Its identity was established by X-ray, infrared spectroscopy, and optical data. Its high refractive index (1.748) implies that this is a Mg-Fe stilpnomelane. It is found as leafy to scaly crystals and aggregates intergrown with orthoclase, fluorapatite and quartz. Crystals range up to 6 mm long and 1 mm

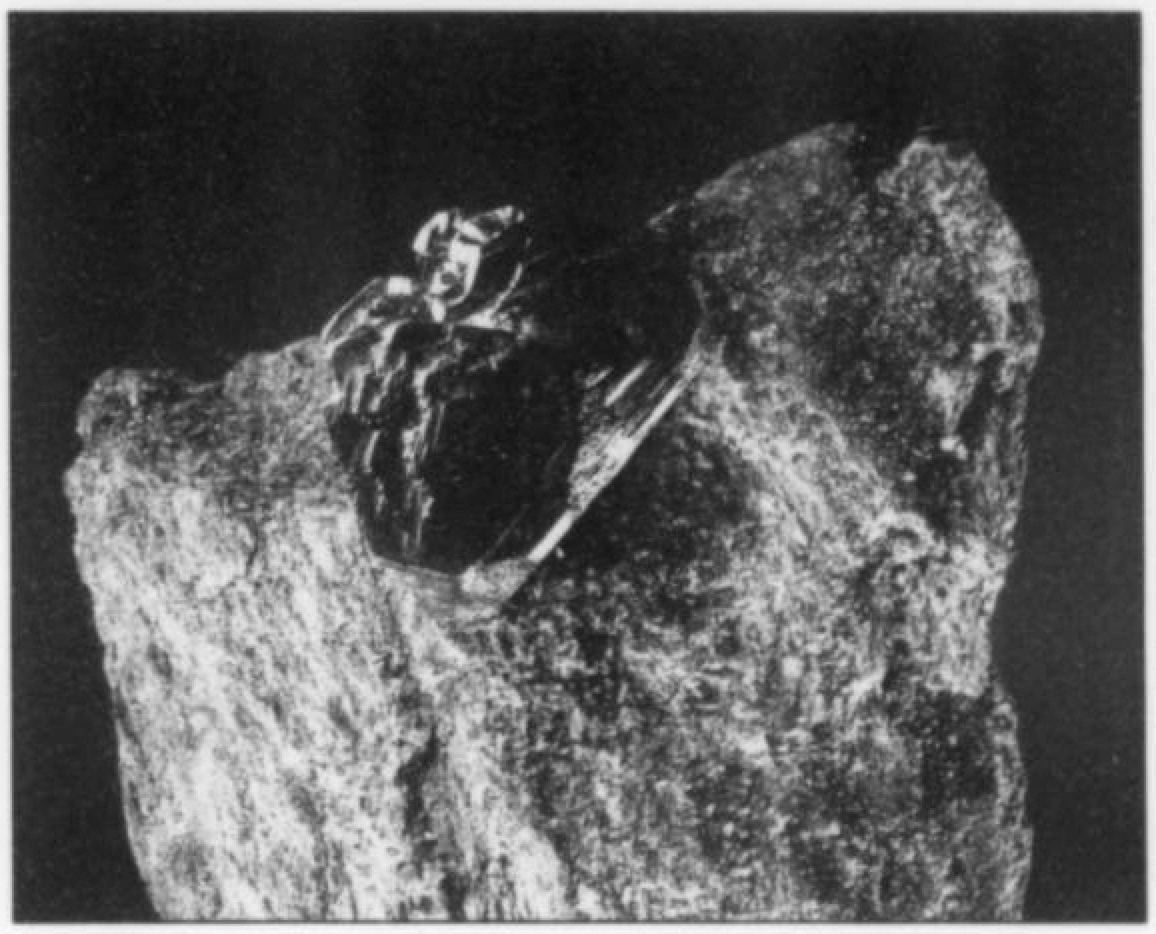

Figure 30. **Sphalerite crystal, 2.3 cm, on schist from Puiva. E. Burlakov collection; Stefan Weiss photo.**

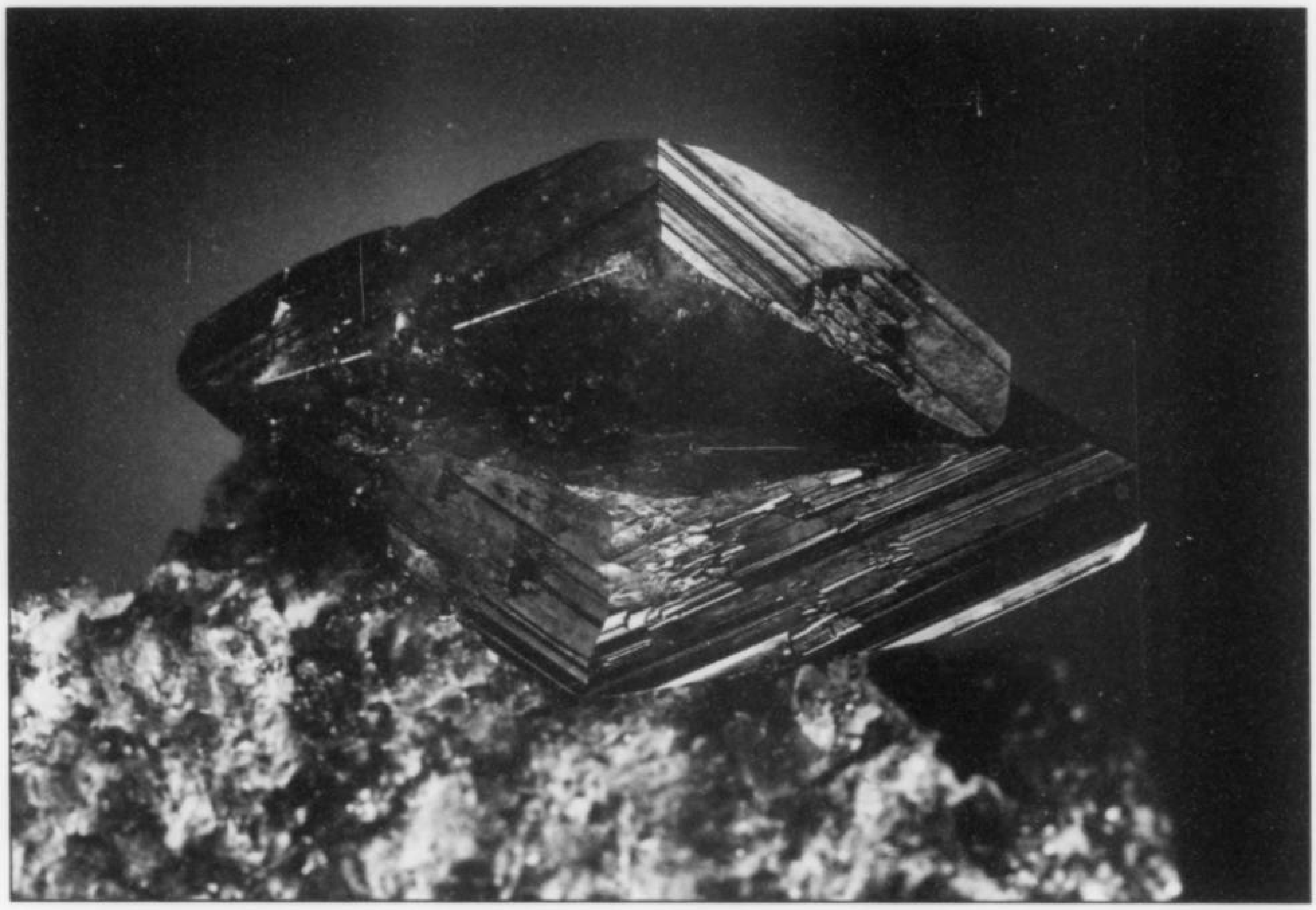

Figure 31. **Titanite twin, 2.9 cm, on matrix from Puiva. Richard Kosnar collection; Jeff Scovil photo.**

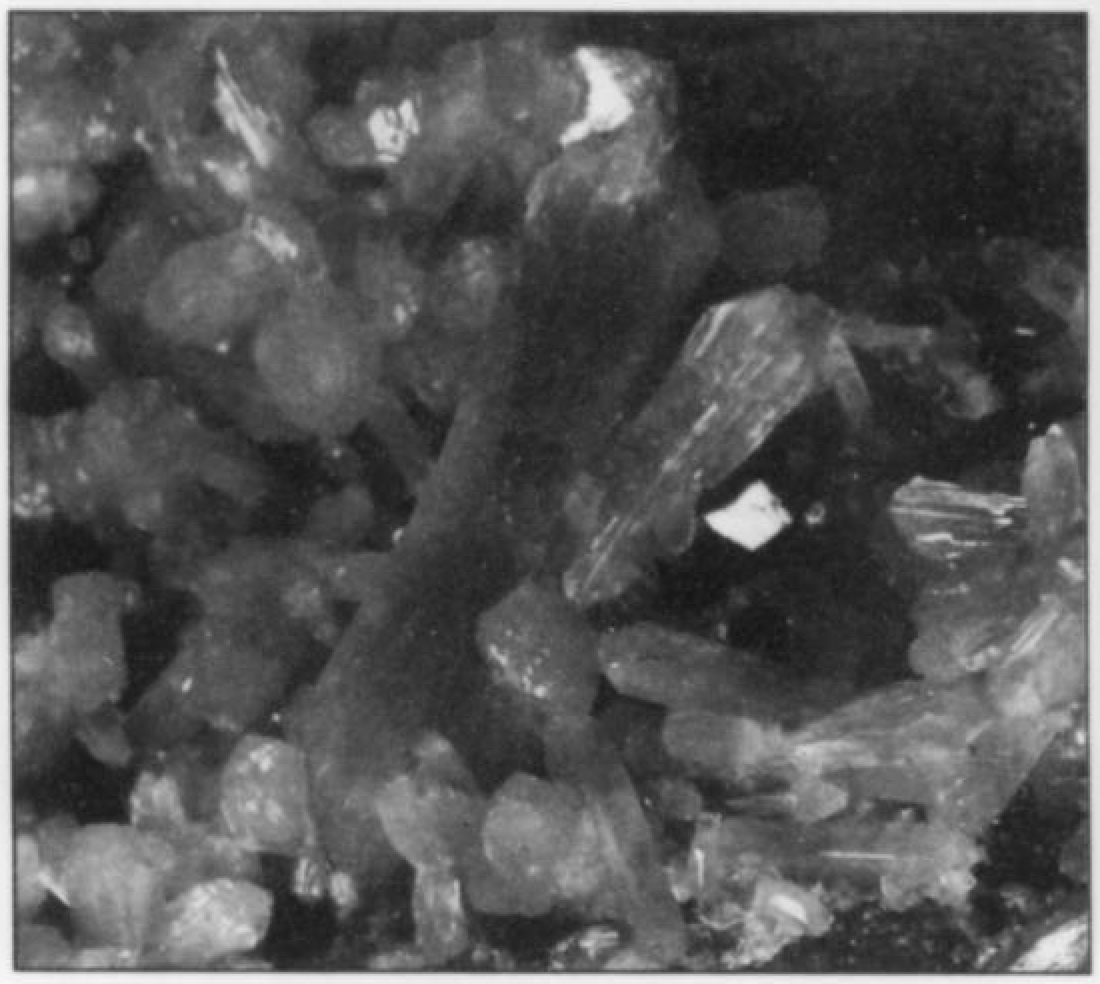

Figure 32. **Stilbite sheaves to 2 cm, with chalcopyrite and colorless heulandite on schist, from Puiva. E. Burlakov collection; Stefan Weiss photo.**

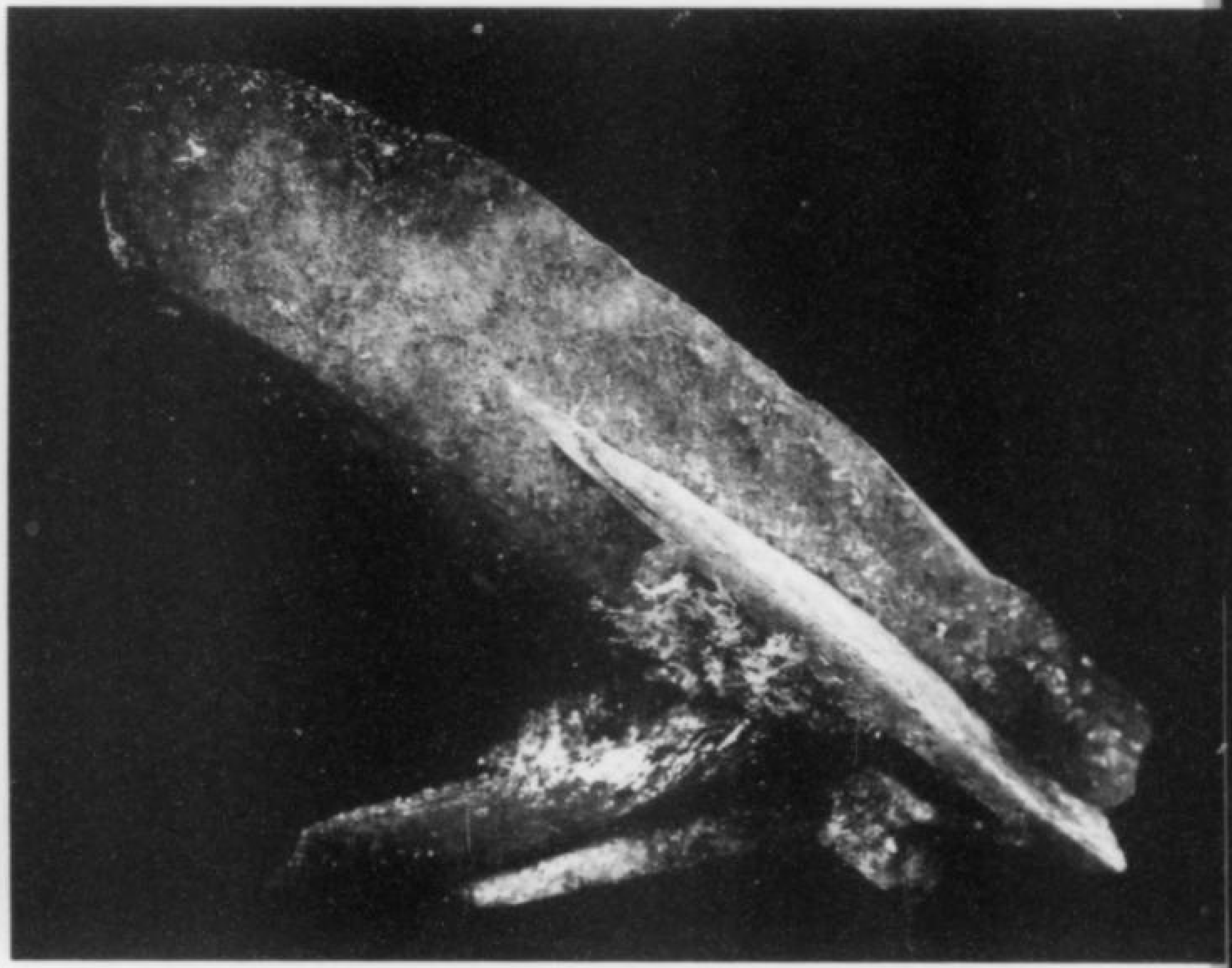

Figure 33. **Titanite crystals to 1.1 cm, with clear, tabular fluorapatite crystals on matrix, from Puiva. E. Burlakov collection; Stefan Weiss photo.**

thick. The color is black through greenish black, or dark brown in thin plates. Sometimes stilpnomelane forms pseudomorphs after garnet.

Synchisite-(Ce) $Ca(Ce,La)(CO_3)_2F$

Synchisite-(Ce) is rare at Puiva. It forms pseudohexagonal tabular crystals to 2 mm, as well as aggregates resembling "iron roses." The color is creamy white, gray or gray-green. Late-formed synchisite crystals rest on faces of quartz crystals.

Titanite $CaTiSiO_5$

Titanite is widely distributed in the deposit, although crystals over 1 cm are not common. In Cleft 159/38, titanite crystals reached lengths of 10 to 12 cm!

Three morphological habits of Puiva titanite may be distinguished; as a rule they occur in different parts of the deposit. Titanite (I) forms thin-tabular, envelope-shaped, untwinned crystals with a pink to pinkish violet color. They are commonly transparent, have a high adamantine luster, and reach 2 cm in size.

Table 1. **Alpine cleft-type minerals from the Puiva deposit.**

Sulfides, Sulfosalts	
Arsenopyrite	$FeAsS$
Breithauptite	$NiSb$
Chalcopyrite	$CuFeS_2$
Galena	PbS
Pyrite	FeS_2
Pyrrhotite	$Fe_{1-x}S$
Sphalerite	$(Zn,Fe)S$
Ullmannite	$NiSbS$
Oxides, Hydroxides	
Hematite	Fe_2O_3
Ilmenite	$Fe^{2+}TiO_3$
Goethite	$FeO(OH)$
Psilomelane	Mn-oxides
Rutile	TiO_2
Fluorides	
Fluorite	CaF_2
Carbonates	
Ancylite-(Ce)	$SrCe(CO_3)_2(OH)\cdot H_2O$
Calcite	$CaCO_3$
Cerussite	$PbCO_3$
Malachite	$Cu_2^{2+}(CO_3)(OH)_2$
Smithsonite	$ZnCO_3$
Synchisite-(Ce)	$Ca(Ce,La)(CO_3)_2F$
Sulfates	
Anglesite	$PbSO_4$
Gypsum	$CaSO_4\cdot 2H_2O$
Phosphates	
Fluorapatite	$Ca_5(PO_4)_3F$

Silicates	
Almandine	$(Fe,Ca,Mn,Mg)_3(Al,Fe^{3+})_2(Si,Ti)_3O_{12}$
Actinolite	$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$
Albite	$NaAlSi_3O_8$
Biotite	$K(Fe^{2+},Mg)_3AlSi_3O_{10}(OH)$
Chrysocolla	$(Cu^{2+},Al)_2H_2Si_2O_5(OH)_4$
Clinochlore-Chamosite	$(Mg,Fe^{2+})^5Al(Si_3Al)O_{10}(OH)_8$
Clinozoisite	$Ca_2Al_3(SiO_4)_3(OH)$
Chabazite	$(Ca_{0.5},K,Na)_4[Al_4Si_8O_{24}]\cdot 12H_2O$
Datolite	$Ca_2B_2Si_2O_8(OH)_2$
Epidote	$Ca_2(Fe^{3+},Al)_3(SiO_4)_3(OH)$
Ferro-axinite	$Ca_2Fe^{2+}Al_2BSi_4O_{15}(OH)$
Fluorapatite	$Ca_5(PO_4)_3F$
Fluorapophyllite	$KCa_4Si_8O_{20}(F,OH)\cdot 8H_2O$
Hemimorphite	$Zn_4Si_2O_7(OH)_2\cdot 2H_2O$
Heulandite	$(Ca_{0.5},Na,K)_9[Al_9Si_{27}O_{72}]\cdot\sim 24H_2O$
Kainosite-(Y)	$Ca_2(Y,Ce)_2Si_4O_{12}(CO_3)\cdot H_2O$
Laumontite	$Ca_4[Al_8Si_{16}O_{48}]\cdot 18H_2O$
Montmorillonite	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2\cdot nH_2O$
Muscovite	$KAl_2AlSi_3O_{10}(OH)_2$
Orthoclase	$KAlSi_3O_8$
Piemontite	$Al_2Si_4O_{10}(OH)_2$
Pyrophyllite	$Al_2Si_4O_{10}(OH)_2$
Quartz	SiO_2
Schorl	$NaFe_3^{2+}Al_6(BO_3)_3Si_6O_{18}(OH)_4$
Stilbite	$(Ca_{0.5},Na,K)[Al_9Si_{27}O_{72}]\cdot 28H_2O$
Stilpnomelane	$K(Fe^{2+},Mg,Fe^{3+})_8(Si,Al)_{12}(O,OH)_{27}$
Thomsonite	$Ca_2Na[Al_5Si_5O_{20}]\cdot 6H_2O$
Titanite	$CaTiSiO_5$
Tremolite	$Ca_2Mg_5Si_8O_{22}(OH)_2$
Zoisite	$Ca_2Al_3(SiO_4)_3(OH)$

Titanite (I) is characteristic of clefts in the upper horizons of the deposit, in the western crystal-bearing zone.

Titanite (II) forms twinned, sometimes almost isometric-looking crystals with a distinctive "little ship" aspect. The color is dark reddish brown through brownish red, with highly variable transparency. Crystal sizes reach 1 cm. Titanite (II) is common in lower horizons in the central crystal-bearing zone of the deposit.

Titanite (III) forms elongated tabular untwinned crystals and twins of an average size of 3–5 cm, although the largest are 12 cm. The color is yellowish brown through gray-green. Crystals usually are opaque, but may be translucent on edges. Titanite (III) is characteristic of the ferro-axinite zone, where it is found in clefts with calcite, ferro-axinite, and matted, asbestiform aggregates of tremolite.

Tremolite $Ca_2Mg_5Si_8O_{22}(OH)_2$

Tremolite is common in the upper horizons of the deposit, and in the ferro-axinite zone. It forms gray-white through snow-white, matted or chaotic aggregates of acicular crystals, which may fill 50% of the volume of a crystal-bearing cavity.

Ullmannite NiSbS

Ullmannite is extremely rare, occurring only in one cleft, in grains small than 0.1 mm, along the contacts between breithauptite and pyrite grains.

ACKNOWLEDGMENTS

The author expresses his sincerest thanks to Mr. V. V. Bukanov and to Mrs. N. P. Popova for their advice and assistance in carrying out mineralogical investigations in the Polar Urals. Thomas P. Moore kindly provided an English translation of an earlier version of this article which appeared in *Lapis*.

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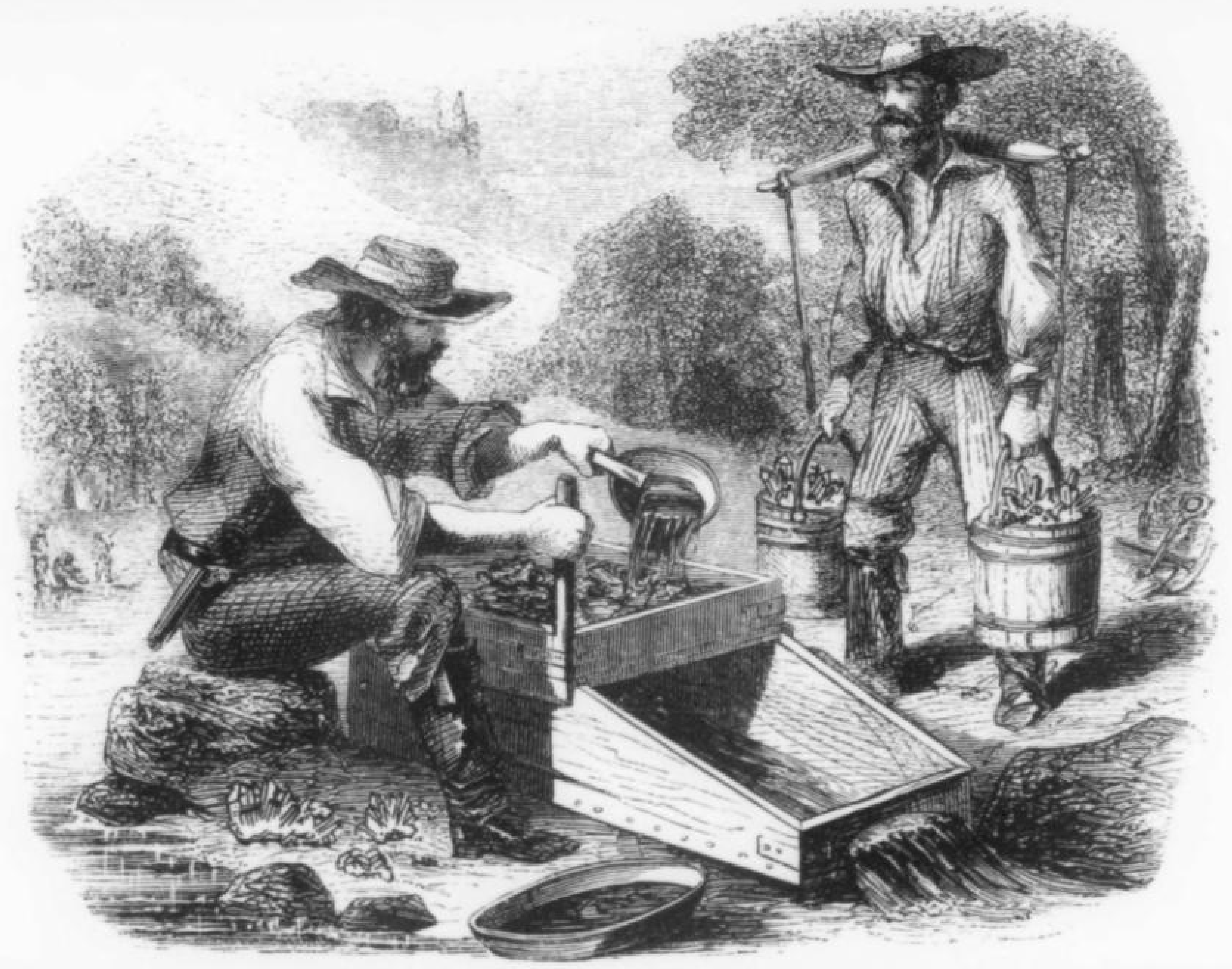

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What's New

in Minerals

New Jersey Shows 1999

by Joe Polityka

During the last nine months (December–August 1999) I have traveled to mineral shows in Maryland, Long Island (New York), Delaware, Pennsylvania and New Jersey. With the exception of the New Jersey Earth Science Show in April, all were typically small, club-run shows of the kind held regularly all over the world. They usually attract around a thousand attendees over one weekend, and feature about 15 dealers, most of whom sell jewelry and lapidary items. These shows have a loyal local following but rarely attract "foreign" collectors such as yours truly. I have attended shows like these for years and always come away with something nice; I suggest you pay your local show a visit next time around. A "sleeper" might be waiting to surprise you!

On January 30 I attended the annual mineral sale at Rutgers University in New Brunswick, New Jersey. Most of the minerals offered for sale there are from the New Jersey traprocks (diabase and basalt). You never know what will show up at this affair; minerals that have been collected locally are often donated to the University to be sold as fund-raisers. I picked up attractive specimens of New Jersey **chabazite, thompsonite** and **heulandite** at reasonable prices.

And, yes, Rutgers does have a mineral exhibit. Most of the specimens are from old classic American and European localities. Franklin and Paterson, New Jersey, are well-represented, of course, as are Bisbee, Arizona, and the classic English occurrences. The wall case of English calcite and fluorite is outstanding. My favorite specimen in this case is a cabinet-size group of doubly terminated calcite crystals from Egremont, Cumberland.

If you are passing through central New Jersey or the neighborhood of Exit 9 on the New Jersey Turnpike, I recommend that you visit the Rutgers mineral museum.

The New Jersey Earth Science Show (April 24–25) was held this year at a new location: the Robert E. Littell Community Center in Franklin. Attendance was up 25% over last year, the majority being paying adults. Many of the most prominent dealers had booths inside, and tailgaters were allowed to set up behind the show building. The weather was perfect but the show floor was overcrowded (a problem to be corrected next year when the show moves to larger quarters across the street at the Hardyston School; more displays and a dozen more dealers will be accommodated there).

This year 24 dealers were present, including *Weinrich Minerals*, where many specimens from the Steve Neely collection were being offered. Fluorite, barite and calcite from the U.S. and England were (to me, at least) the most desirable. The Illinois **fluorite** was top-quality, the best ever found in the district.

John Betts was offering a 1950's collection of New England minerals, mostly pegmatite species from Mt. Mica and Newry (Maine), and the Gillette, Strickland, Branchville, and Roncari quarries (Connecticut).

Xonotlite sprays to 2.5 cm, some with terminated crystals, were available in the booth of Fred Parker. The species (X-ray analyzed) was found at the Hunting Hill quarry, Rockland, Maryland. The specimens remind me of the old flattened artinite sprays from Staten Island, New York.

Wright's Rock Shop had their usual wide selection of minerals, notably some excellent, cabinet-size **calcite** crystal clusters from Jalgaon, India, and some nice calcite with golden yellow **barite** from the Meikle mine, Nevada.

Dave Bunk Minerals had many exception museum-size specimens, and fine smaller pieces including a superb, 8-cm Michigan **copper** which was purchased by an Eastern collector.

The Rocksmiths had something new: gemmy purple **fluorite** crystals from the Christina mine, Agios Constantinos, Laurion, Greece. The crystals average about 1 cm in size. Only six specimens were available but more may be on the way.

Next year's show will feature **gold** specimens from prominent collections.

Rochester Mineralogical Symposium 1999

by Jeff Scovil

[April 15–18]

For me, the spring show schedule starts off with the Rochester Mineralogical Symposium. The event this year was enjoyable as usual, with enlightening presentations (Al Falster's included rat-killing techniques in Madagascar and was quite memorable), and the chance to chat with friends old and new. Rochester is not usually a hotbed of new mineral finds, but there is always something if you look.

Chris Tucker Minerals of Montana had some fine **barite** specimens from near Myers, Treasure County, Montana; they bear some similarities to the dark golden barite from Elk Creek, South Dakota. The Myers barites are also golden brown, forming on pale yellow calcite druses encrusting cavities in septarian nodules. The crystals of golden barite are in some cases overgrown by a second generation of colorless barite, often with stepped, multiple terminations. Crystal size ranges up to 19 cm (7.5 inches!). Most of the specimens were collected this past winter, but the locality has been known to collectors for about 20 years.

The San Antonio el Grande mine (level 8) at Santa Eulalia, Chihuahua, Mexico has recently produced some very nice, pale purple **creedite** crystal clusters, in some cases associated with powdery yellow **greenockite** (CdS). Dan Belsher of *Blue Sky Mining* sent me a sample just before the Symposium, and Leonard Himes of *Minerals America* had some specimens in Rochester. The creedite crystals, up to 5 mm each, occur as crusts and small clusters scattered across matrix.

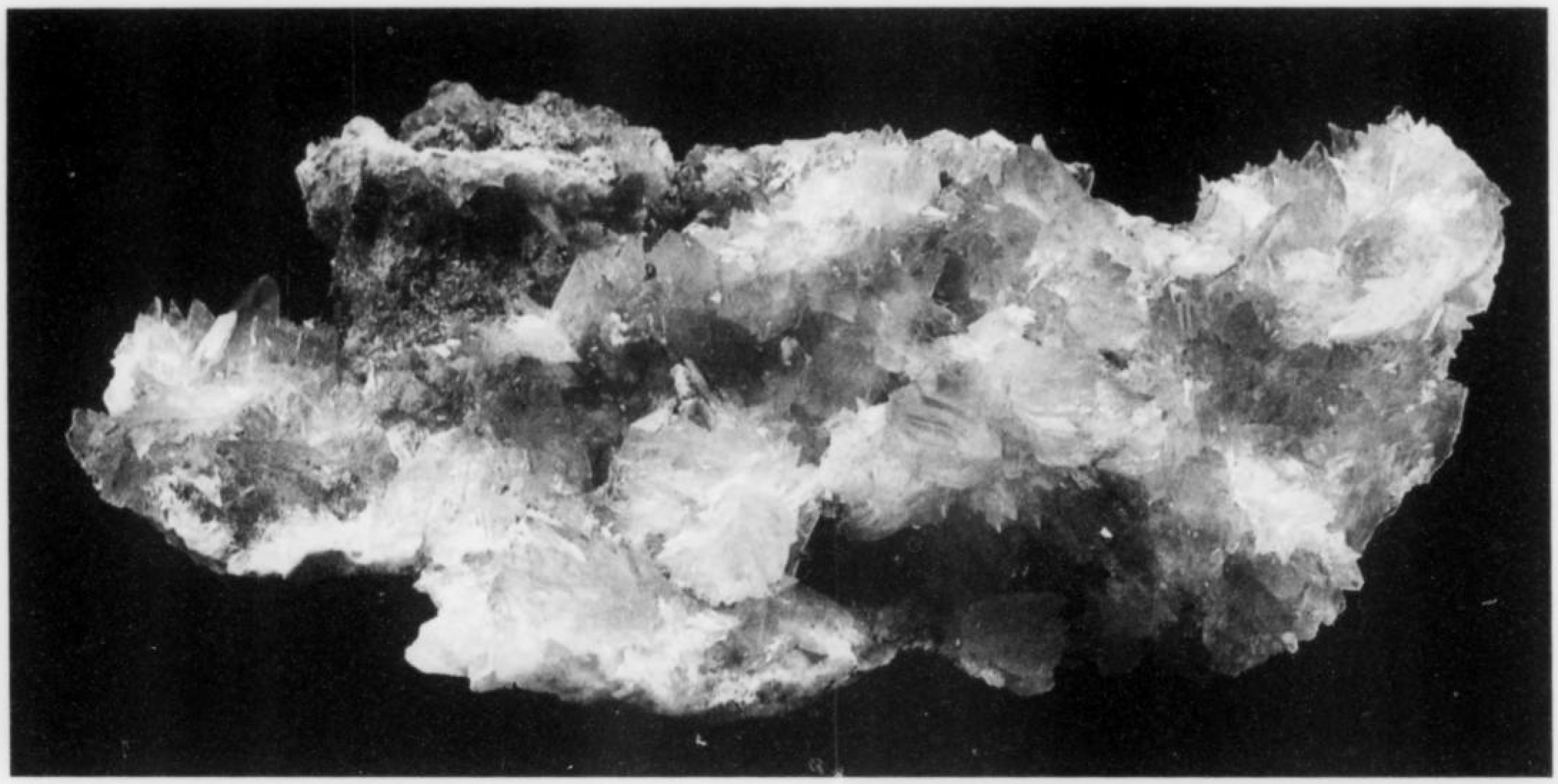


Figure 1. (above) **Creedite with yellow greenockite, 9 cm, from Level 8, San Antonio el Grande, Santa Eulalia, Chihuahua, Mexico. *Minerals America* specimen; Jeff Scovil photo.**

Figure 2. (below) **Barite crystal, 4 cm, with calcite, from Myers, Treasure County, Montana. Bob Berman collection; Jeff Scovil photo.**

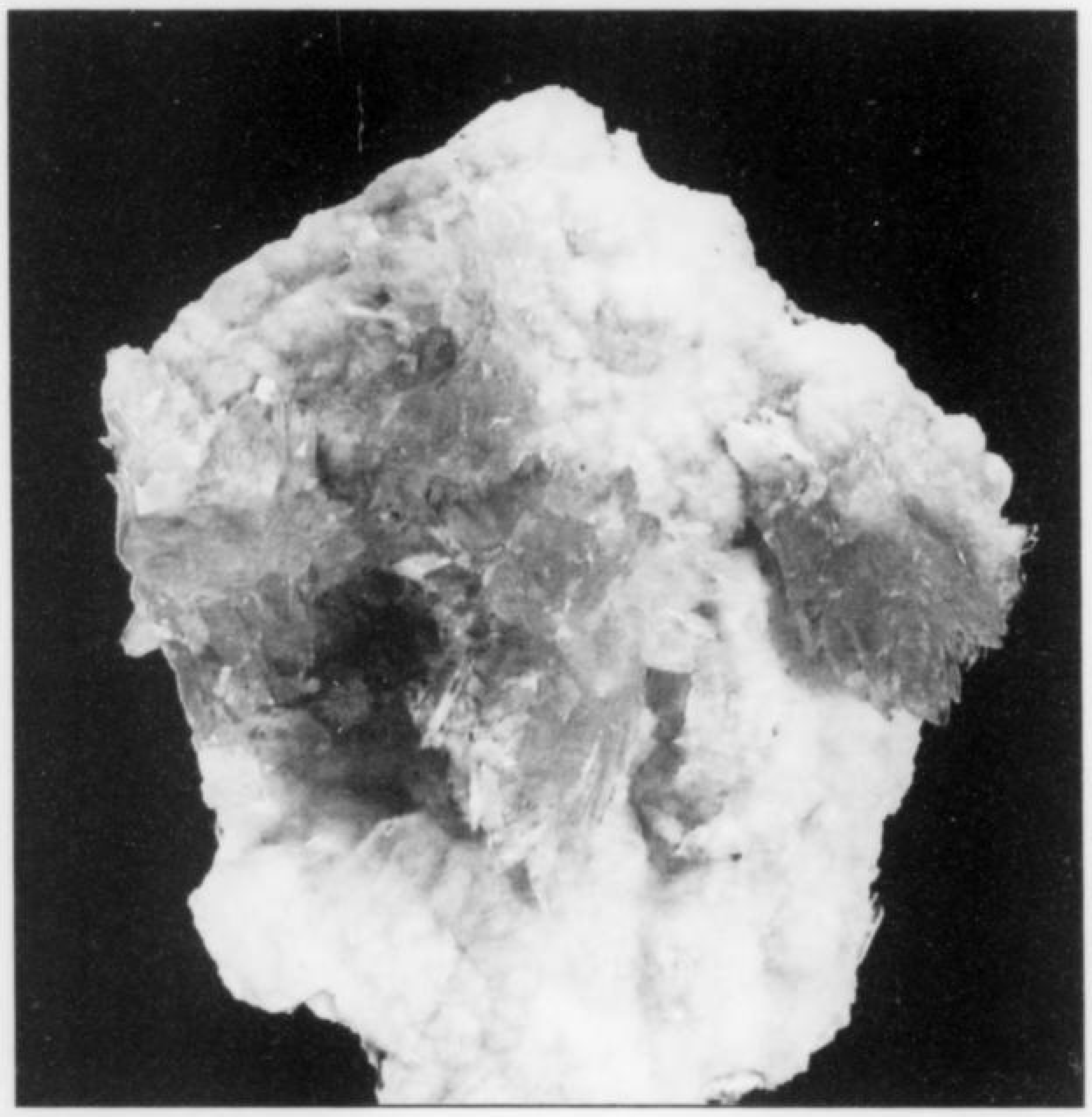


Figure 3. (above) **Creedite on matrix, 4.5 cm, from Level 8, San Antonio el Grande, Santa Eulalia, Chihuahua, Mexico. *Blue Sky Mining* specimen; Jeff Scovil photo.**

Figure 4. (left) **Ishikawaite [(U,Fe,Y,Ca)-(Nb,Ta)O_4] crystal, 4.2 cm, from East Standpipe Hill, Topsham, Maine. Don Swenson collection; Jeff Scovill photo.**

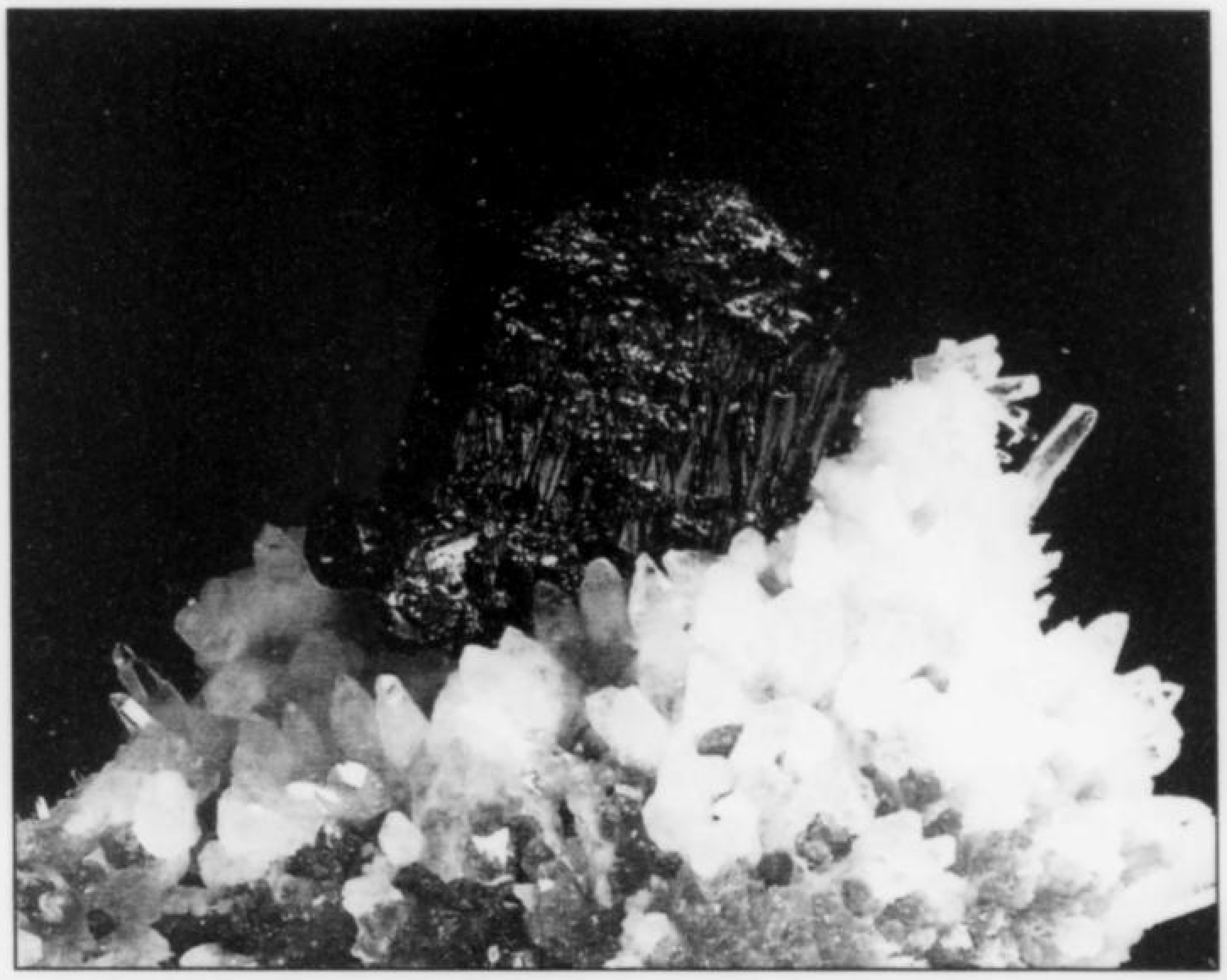
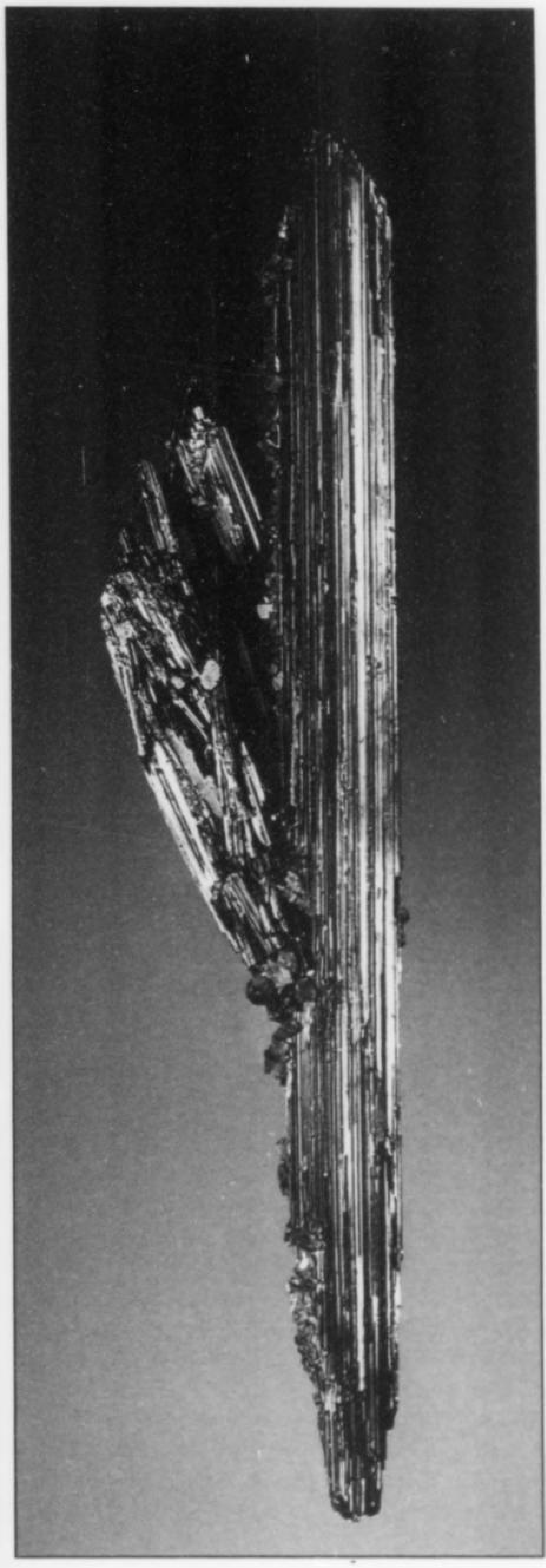


Figure 5. (left) **Pyrargyrite crystal, 2.2 cm, on quartz from Level 530, Santo Niño vein, San Luis mine, Fresnillo, Zacatecas, Mexico. Dave Bunk specimen; Jeff Scovil photo.**

Figure 6. (below) **Stibnite, 17 cm, from the Murray mine, Elko County, Nevada. *Geoprime* specimen; Jeff Scovil photo.**



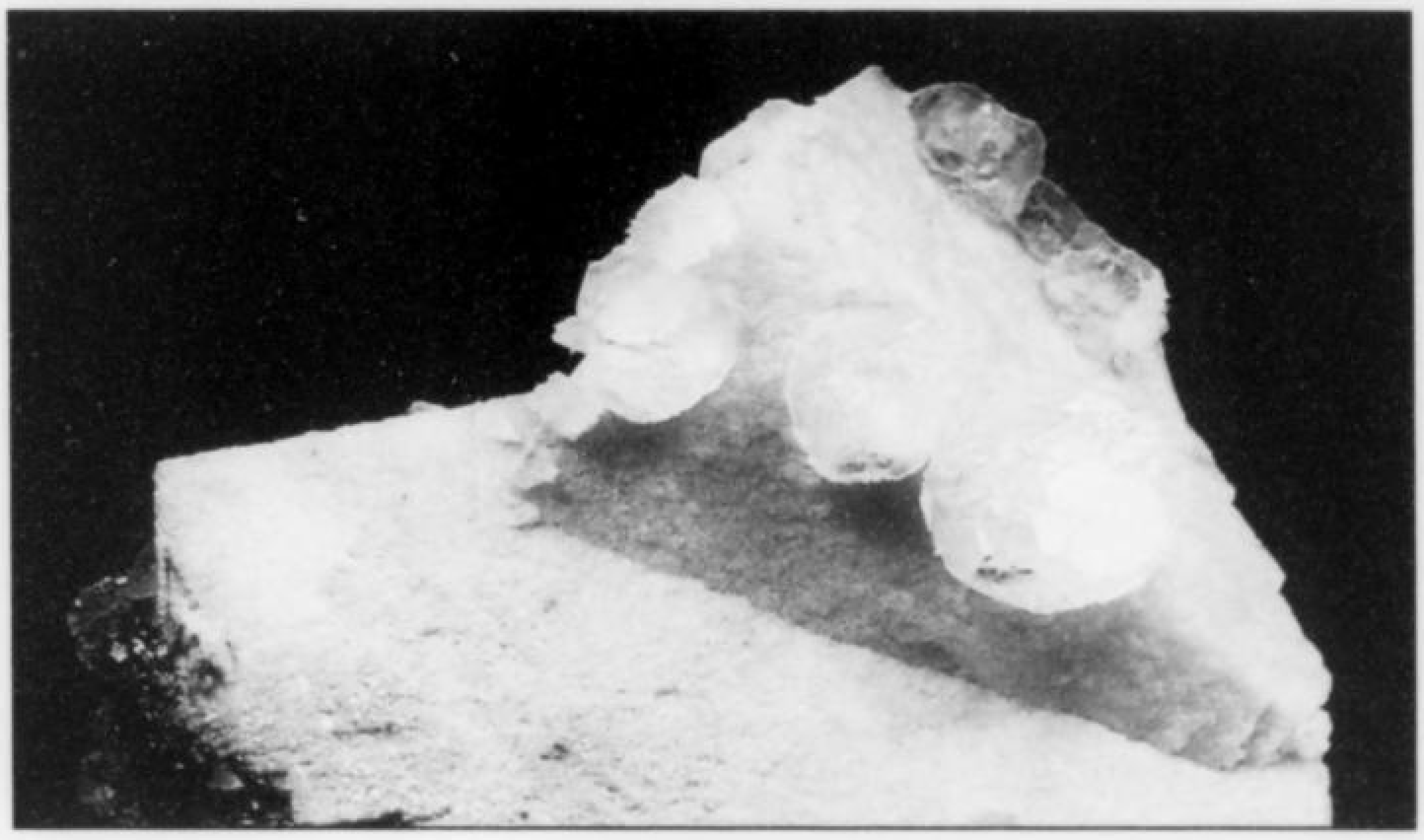


Figure 7. (above) **Fluorite on calcite, 9.6 cm, from Naica, Chihuahua, Mexico. *Jeff and Gloria's Minerals* specimens; Jeff Scovill photo.**

Figure 8. (right) **Stibnite crystal group, 16 cm, from Murray, Elko County, Nevada. *Geoprime* specimen; Jeff Scovil photo.**

Cincinnati Show 1999

by Jeff Scovil

[April 30–May 1]

Just two weeks after the Rochester Symposium came the Cincinnati, Ohio, show. Jeff Fast of *Jeff and Gloria's Minerals* stopped off at the show on his way back from a buying trip in Mexico, and showed off some of his new discoveries. Most interesting was a batch of **calcite** specimens, each of which is penetration-twinned and coated by a rough, pink, second generation of calcite. The crystals contain a sprinkling of highly modified, nearly colorless **fluorite** crystals to just over 1 cm.

Dave Bunk had a number of fine Mexican specimens, especially the **pyrargyrite** crystals to 2.2 cm on amethyst and milky quartz from the Santo Nino Vein (530 level) San Luis mine, Fresnillo, Zacatecas.

Costa Mesa Show 1999

by Jeff Scovil

[May 14–15]

The West Coast Gem and Mineral Show is held each year in Costa Mesa, California, so people just call it the Costa Mesa Show. All sorts of goodies were to be found there, but little that was really new. I did see more of the new and spectacular **stibnite** coming out of the Murry mine, Elko County, Nevada. I first saw these in the *Geoprime* booth at the Pomona Show last November, and was looking forward to seeing what further work there would turn up; I wasn't disappointed. The recently collected specimens are fine clusters of lustrous, undamaged crystals without matrix. The crystals are reminiscent of the fine Chinese specimens of recent years.

Springfield Show 1999

by Tom Moore

There is a goodly number of things to report on from Springfield this year, for the very good reason that Springfield is getting to be a goodlier and goodlier mineral show all the time. This year, besides the usual educational talks and the usual 200+ dealers and assorted amenities in the giant Eastern States Exposition building show hall, there were the 50 dazzling cases-worth of tremendous mineral specimens from the collection of show manager Marty Zinn. You may recall that Wendell Wilson's article about Marty in vol. 30, no. 4 gave early notice that Marty would be taking the cream of his collection out to Springfield from Colorado for display this year. Well, the showing of this great private collection made a rock-solid anchor for the show. In addition to healthy crowds of the general public, luminaries like Carl Francis, Paul Powhat, Dave Wilber, Johannes Keilmann and many others not always on hand for Springfield in years past, could be seen cruising around the inside of the large fishbowl-circle of Zinn Collection cases, emitting appropriate sounds of awe.

Those who had their copies of the *Mineralogical Record* issue with the article about Marty could have spotted here nearly all of the specimens photographed for the article, such as the 3-cm Bolivian phosphophyllite twin, the "toenail" matrix Colombian emerald, the large Peruvian rhodonite and Brazilian brazilianite, and (adrenaline peak surge here) the 3.5-cm cruciform Freiberg proustite, all these in a dramatic lead-off case. With its brethren in the Colorado case reposed the exquisite 11-cm matrix specimen of green octahedral fluorite from the American Tunnel mine, Silverton, Colorado—also pictured in the article. Although small, the cases almost without exception were tastefully uncluttered and effectively presented in general, such that most of these specimens looked even better in this context than they do when the lucky guest at Marty's home espies them in his basement collection room. As the article says, Marty favors aesthetic items, and tends to have many, many specimens of the same thing if they are aesthetic enough; consequently there were many individual cases devoted to "classic" beautiful things of the same kind: gorgeous, all, were the cases on Sweet Home mine (CO) rhodochrosite, Colorado Quartz mine (CA) gold, Himalaya mine (CA) elbaite, Red Cloud mine (AZ) wulfenite, Ojuela mine (Mexico) adamite, Dallas–Ft. Worth Airport (TX) pyrite, and lots of others. Then there were the cases devoted to localities: in widening order, these included Tsumeb, Colorado, the Indian Deccan Plateau, the eastern U.S., and the former Soviet Union. Individual species represented by cases all their own included fluorite, quartz, beryl, copper, silver, azurite/malachite, and many others you might easily guess. Finally there was a couple of cases devoted to "stalactiform" specimens, à la the Zinn/Rock Currier display at the 1997 Denver Show. And whenever possible, a copy of a magazine on whose cover a fabulous Zinn specimens was pictured kept company with the specimen itself in the appropriate case. I have never before seen more of a better private mineral collection on exhibit at a Show. *Next* year at Springfield, and along the same lines, Colorado collector/dealer Dave Bunk will be showing part of his mysterious Colorado collection—"mysterious" because, I am told, it has never before been seen publicly.

The ambitiousness in the field of displays is surely a major reason why Springfield is acquiring clout in the mineral-show world; and the fact was reflected this year in a broadened "coverage" among the dealers attending. Besides the usual full representation of eastern U.S. and Canadian dealers, and besides the westerners who have come for some time (e.g., Kristalle, Mountain Minerals International, and XTAL), there was Harvey Gordon, visiting with some of his smashing new Barrick Meikle mine barites; there were two Europeans, Alain Carion of Paris and Ernesto Ossola of Anduze, France, coming for the first time; and there was a new, Czech-based Russian, Pavel Bantsekov (Davidkova 88, 182 00 Praha 8), who offered an outstanding small spread of Dalnegorsk specimens. Just scanning quickly over Pavel's uniformly superlative datolite, calcite, quartz, axinite, danburite, fluorite, sulfides, etc. specimens from Dalnegorsk made me hopeful, for the first time in a while, about the continued generosity of Russian localities, or at least of *this* great locality. Anyway, the Springfield Show is certainly flourishing, and the appropriate words are—how did Wendell's article suggest we put it?—"Thanks, Marty!"

So now to the up-close business. Those of us who are aficionados of classic eastern U.S. localities have long believed that the Lane quarry at Westfield, Massachusetts, is firmly a thing of the past—a shame, we have thought, as the **babingtonite** specimens from there are surely the world's best. Well, at Springfield I learned that the old quarry, now under new ownership, has revived blasting operations for traprock, and someone recently has collected a fine lot of new specimens from the place. These were being offered by Rocko Rosenblatt of *Rocko's Minerals* (Box 3A Rt. 3, South Side Spur, Margaretville, NY 12455). Babingtonite crystals to 1 cm form singly or cluster in groups on open seams in weathered basalt, with associated microcrystals or drusy seam linings of quartz, calcite or datolite. Some of the little black babingtonite clusters are "fuzzy"-looking, with toothed edges and a matte luster, while in others the crystals are classically lustrous and sharp. Three flats of nice thumbnail and miniature-size pieces have reached Rocko so far. Also, pretty apple-green **prehnite** in masses and plates of coxcomb-surfaced spheres, New Jersey traprock-style, have come out of the Lane quarry during the past few months; here Rocko's champion specimen is one almost a foot wide, with a vertical prehnite "stalagmite" fully 8 cm high.

Also in the New England Classic category, Shields Flynn of *Trafford/Flynn Minerals* (16 Park Street, Norfolk, MA 02056) was offering five very handsome cabinet specimens of **amethyst** from the old locality of Sweden, Maine, these collected about 10 years ago but held back until now. Clusters of good, transparent amethyst points, zoned from palest to medium purple, cling attractively to white quartz druses on matrix plates from 5 x 5 up to 6 x 15 cm ($300).

I am one of those nomads who has lived in so many places in the U.S. and Europe that the superficial question "where are you from?" sometimes throws me into a pit of existential questioning . . . but more often than not I come up finally with "Pennsylvania," since it's in this state that I was born and lived for my first 17 years. Thus I'm even more of a sucker for old, classic **Pennsylvania minerals** than for Connecticut or even German ones—so you can imagine my pleasure when I saw the spread of old, *really* old and scarce, specimens of this kind from the Richard Kosnar Collection, being offered at Springfield by Richard's son, Brian Kosnar. Most of the 50 or so specimens had come to Kosnar from the Robert Hesse (Glenside, PA) Collection, and most were clean, relatively undamaged and well-preserved for their age. I can't mention them all, but, for example, the famous Wheatley mine near Phoenixville, source of the 19th century's best American pyromorphites, was also the source of the Kosnars' miniature specimens of cerussite, mimetite, wulfenite, malachite, atacamite and stolzite; it was an education just to see these. Similarly surprising specimens were on hand from the old Perkiomenville mine, and for my thumbnail collection I got a brilliantly lustrous, twinned, floater pyrite from the Cornwall iron mine near Cornwall, Lebanon County, Pennsylvania.

Now, from Quebec, for something *new*. The Maxwell brucite quarry at Wakefield, Quebec, has recently turned out perhaps a couple of dozen specimens, in all sizes, of **serpentine pseudomorphs after forsterite** crystals, embedded in a pearly gray-white, coarsely cleavable calcite. The calcite is easily chipped/cleaved away to create specimens with the subhedral to sharp pseudomorph crystals, up to 3.5 cm across, perching finely and upstandingly on the matrix. The crystals' color is an opaque blackish green (with typical serpentine "greasiness") to a pale yellowish green; the luster is dull, and, all right, the specimens are not beautiful. But they are most odd, and should appeal to odd-pseudomorph people; they faintly reminded me of some serpentine-after-forsterite ghost-phenocrysts I once saw in Norway, from the "peridot" locality in that country. The specimens were being offered by the ever-friendly Dan and Shelley Lambert of *Lambert Minerals* (66 Bluebell Dr., Ancaster, Ontario, Canada L9K 1G4).

No prettier, but very fine for the species, are a few floater toenails and miniatures of dull earthy brown but very sharp tabular crystals of **thorite** from the long-known Kemp prospect, Cardiff Township, Ontario—these also with the Lamberts.

Isaias Casanova of *IC Minerals* (P.O. Box 1376, Goldenrod, FL) seemed quite proud of 10 or so excellent Spanish **fluorites** from three currently working mines in Asturias: the Emilio, Caravia and Jaimina. All dug within this past year, these specimens are said to be the leftovers from a much larger stash held back in Spain. The fluorite comes in lovely groups of simple cubic crystals—though some cubes are flattened, and some are not so simple, being attractively modified by tetrahexahedral "riser" faces, four around each cube face. Some crystals are colorless, some a transparent deep purple; some have irregular, watery-looking zonation in colorless/purple. Individual crystals reach 3 cm, and specimens with stacks and clusters of crystals reach small-cabinet size.

I've already alluded to how happy I was to see one of my favorite European dealers, Ernesto Ossola (8 rue du Luxembourg, 30140 Anduze, France), debuting in Springfield: all the happier as Ernesto had brought with him the best large lot of **chalcopyrite** from Cavnik, Rumania, that I've ever seen, although this material has been intermittently available for a good long while. Here were more than 20 specimens from about 5 x 5 to more than 15 x 15 cm across, all consisting of deep, busy Arkansas-style clusters of colorless quartz prisms, the groups spangled all over with brilliantly lustrous, sharp chalcopyrite and pyrite crystals to 1.5 cm across. The pieces resembled gross enlargements of the (nearly always much smaller) Alimon mine, Peru, needle quartz/chalcopyrite/pyrite specimens. Some of the chalcopyrite crystals are tarnished to a lush, iridescent midnight-blue.

To return to *Lambert Minerals* for a final item from Europe, and for another Classics Revived–type surprise . . . a collecting effort in May 1998 at the Whitesmith Workings, Beinn Resipol, Strontian, Argyll, Scotland, yielded some spectacular specimens of **harmotome** from this famous locality for this rare zeolite species. Matrix plates to 17 cm are blanketed with rough, intergrown brown calcite crystals, and over these are thickly scattered glistening snow-white, sharp, very lustrous harmotome crystals averaging perhaps 4 mm but frequently up to 1 cm. I hope I have made these dramatic "museum" specimens sound as beautiful as they are, and I hope the collectors, whoever they are, return soon to this, yet another not-so-defunct-after-all locality, to work more such miracles.

I must circle back to *Rocko's Minerals* again because this stand featured (besides the Lane quarry goodies) several flats with a hundred or so specimens of **schorl** from (sorry, but this is as exact as it gets for now) the Erongo Mountains, Namibia. Rocko's African contacts tell him that these have been dug within the last 3 to 6 months, and that plenty more should appear. Schorl, of course, is a common, often unexciting, drayhorse kind of mineral species, but it *can* make very handsome specimens, as in Brazil, Pakistan, and this new Namibian place. The crystals in this case are high-lustered, jet-black, and blocky to prismatic, with first-order and second-order prism faces on view in more crystals. When doubly terminated (as they very frequently are) the crystals display the hemimorphic nature of tourmaline-group species: on one end, a perfectly flat basal pinacoid face, with matte luster, and on the other, three rhombohedral (trigonal) faces with glassy luster. These interesting crystals are found either singly, as floaters to 5.5 cm long, or in loosely intergrown groups, mostly thumbnail and miniature-sized. Associated species include small crystals of smoky quartz and occasional sharp, though pitted, buff-colored orthoclase crystals. I repeat, these are very attractive schorl specimens, and a fine thumbnail will run you no more than about $10.

Dudley Blauwet of *Mountain Minerals International* was on hand with a couple of new things, amid his usual plethora of Himalayan pegmatite gem excitements. One is a new find of **clinozoisite** from Hashupa, Shigar Valley, Baltistan, Pakistan—in miniatures which (except for color) look exactly like the familiar epidote specimens from the same area. That is, they are thin transparent blades in parallel growth, in picket-fencelike groups to 7 cm long by 3 cm wide by only a millimeter or two thick, and without matrix. But whereas the Pakistani epidote of this type is typically an "epidote" smoky brownish green, these clinozoisites are a very pale brown, though equally transparent and shiny. Dudley had only about ten specimens.

The other new item at this dealership was about 20 loose crystals, the largest one 2.5 cm though most much smaller, of a new gemmy blue **sillimanite**, not from Sri Lanka like the earlier ones but from Le-Oo, Mogok, Mandalay Division, Myanmar (Burma). Obviously these are alluvial crystals, all at least a little rounded:

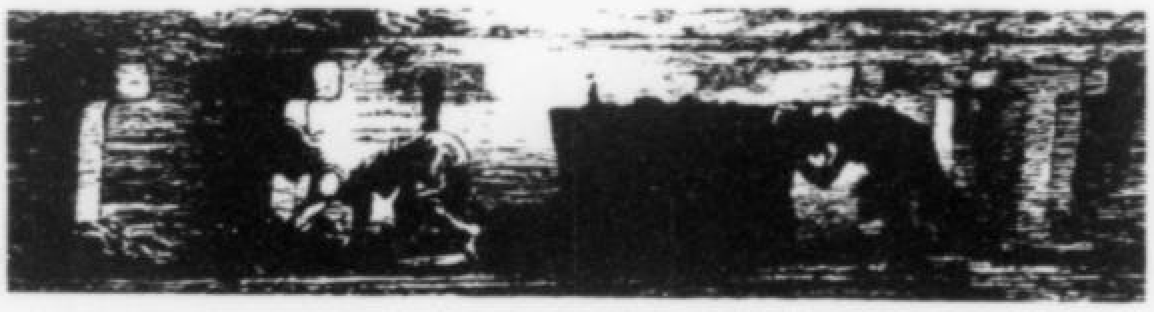
thin prisms with crude to no terminations. The most intensely rounded of those found, Dudley says, have already been cut for gems—and properly, since the color is a very nice medium blue, and gemminess in all the crystals I saw is near-total.

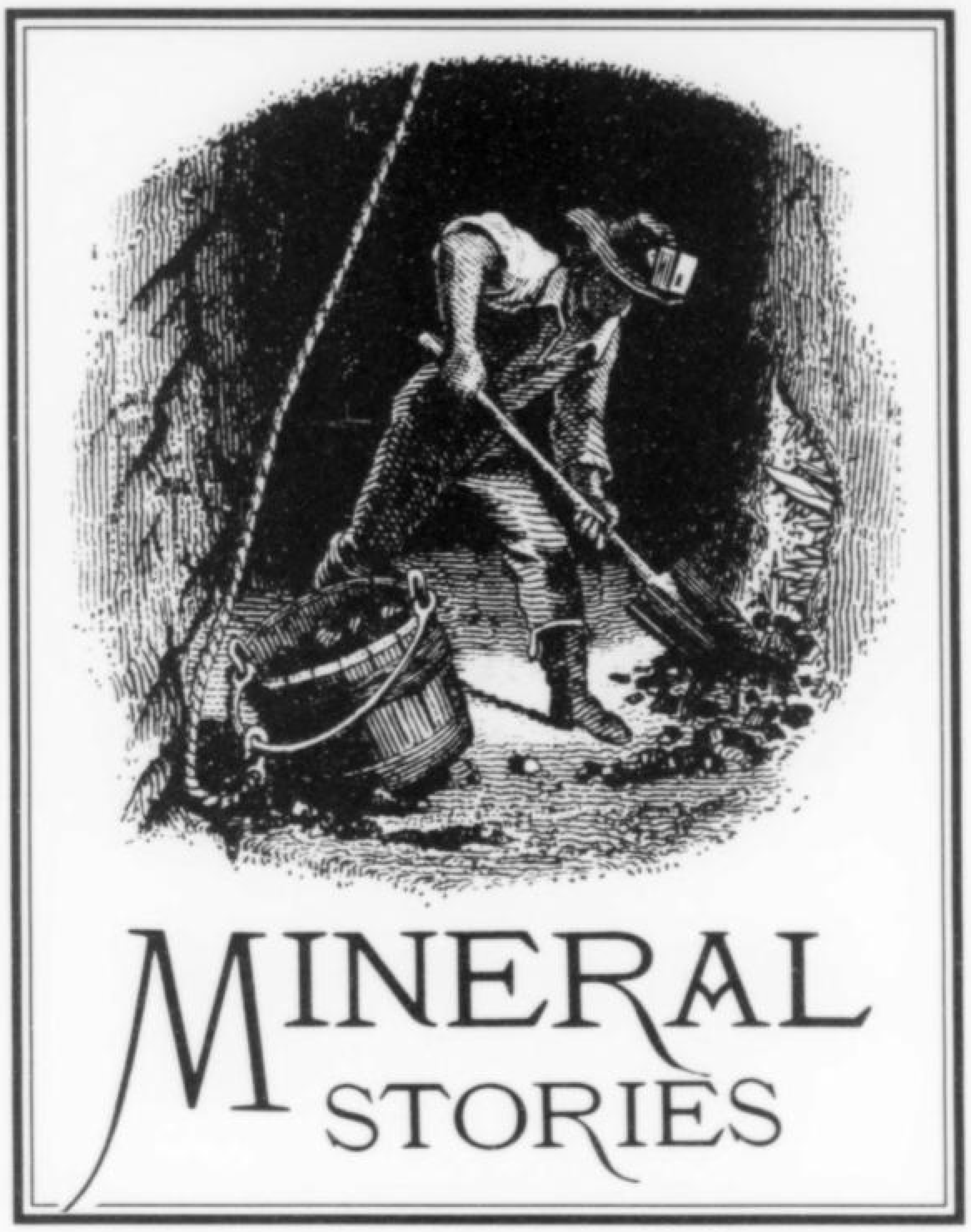
Normally a new-specimen offering consisting of just two thumbnails does not get included in show reports, but an exception must be made here for the two astonishing thumbnail-sized specimens of **bournonite** with **chalcopyrite** from a new Chinese locality; Danny Trinchillo (*DeTrin Minerals*) somewhat uncertainly rendered this locality as the Yang Guang Shi mine, Hunan Province, China. The bournonite comes (as often in the Peruvian localities) in columnar groups of parallel crystals, with perfectly flat terminations of the fat 2.5 cm bundles, with bright chalcopyrite crystals adhering, and with absolutely blinding metallic luster. They are world-class bournonite specimens for their size; let's hope for more. Meanwhile, to keep us interested, there were also selections of very fine Chinese **apophyllite**, **stibnite** and **cassiterite** at the stand of *DeTrin Minerals*.

Then there is one very new, and so far very enigmatic indeed, Chinese item: four specimens of **pyromorphite** from an undisclosed place in China, picked up by Chris Wright of *Wright's Rock Shop* at this summer's Ste-Marie-aux-Mines Show. Chris showed me the best of the four: a 5 x 6-cm, very dense cluster of subparallel elongated hexagonal prisms to 2.5 cm. The luster is medium-bright, and the color a medium apple-green with some tan areas. In other words, the specimen I saw does not yet represent anything like world-class pyromorphite, but by nature, by definition, is promising. Stay tuned.

Finally, let's resume tracking those *already* world-class "Hat Yai Province, Thailand" **mimetite** specimens which I first saw at, and reported on from, Tucson '98. In Springfield this year, to my surprise, it was an Englishman who had some—namely Ian Bruce of *Crystal Classics* (The Old Linmay, Woodcockshayes Farm, Halberton Road, Willand, Devon, England). Ian also had some new information about the locality: he says that it is an abandoned mine in a *tin* deposit (perhaps a greisen?) surrounded by an oxidized polymetallic skarn zone, where the mimetite happens. At any rate, the 15 miniature to small cabinet-sized specimens here were all flat plates of a weathered granite with coatings of lustrous deep black mammillary psilomelane, this black layer sprinkled with sharp, gemmy, vividly deep yellow hexagonal prisms of mimetite, uniformly around 4 or 5 mm. The only drawback to these specimens is that no really *large* mimetite crystals rise from the rabblement of small ones all over the matrix plates—but for brightness, sharpness, and color (including, in these pieces, the color contrast between gemmy yellow and underlying black), the specimens are extremely striking. Next big show, let's recall the scent, and resume the excited, snuffling chase . . . .

However, I have to say here, with a regretfulness that ought to be obvious, that I will *not* be making it to Denver this year. You see, this past June I did something wonderfully dumb: I tried to rescue my cat from being "stuck" on the roof of the house. And yes, I fell, and landed with a bare left foot on the concrete walkway, and cracked the heel bone straight through. I have been in a cast and on crutches for nine weeks now, and had to tour the Springfield Show in a wheelchair. Full recovery is expected by sometime in November, so I should be all right for Tucson at least. And do not ask "How was the cat?" On second thought, go ahead and ask this fatuous question, as I have grown rather fond of my stock reply, which is "delicious." ⊠





MINERAL STORIES

The Baron's Diamonds

by Jacques Jedwab

This story dates back about 20 years. Things have changed a lot since then: the hero is dead and South African apartheid is gone. But the risks of the trade (I mean diamond faking) are still there, and will be for a long time ahead.

We still have in Belgium a King and a flock of noblemen. I met at a party some 20 years ago such a gentleman, to whom I was introduced as a mineralogist. He was startled out of his natural politeness, and he soon told me the following story with much excitement.

He had recently been traveling on his own in a Land Rover across South Africa, when he was stopped by a hiker. After a ride of a few miles, and after asking where he was from, the hiker asked for a stop and went behind a bush. From there, he called in our baron, looking cautiously and anxiously all around. He opened wide his mouth and with index and thumb, he extracted a molar off his jaw. He turned the tooth upside down on his palm, and a small crystal fell out from the cavity He repeated that operation once again, and now two octahedral, colorless crystals shone in the sun.

He then said that he was a diamond miner, and although he was risking his life, he was ready to sell each crystal for R. 100.-, well under its value. Very excited, the baron gave him R 200.-, the man asked to be left on the roadside (probably to catch another fish, this was a fine day), and the buyer went ahead.

Here enters the mineralogist at the party. The baron asked me to look at his South African diamonds, which I agreed to do. (Now, you are probably as curious as I was then.) He gave me the diamonds, and the next morning, I went to the lab.

The diamonds had a low density (floating on bromoform), a low refractive index (no luster, index near 1.6) and were scratched by quartz: not diamond in any case. The crystal habit was that of octahedra with rounded faces, but the latter were dull and devoid of triangular pits or growth steps. I finally asked a colleague who was in the raw diamond business, and he told me that the crystals were "regular" fakes, i.e., made with the small cubes of crashed car windows. They are ground to octahedra and then put into hydrofluoric acid in order to smooth the faces from the grinding striae.

When I informed the baron about the results of my observations and the experienced opinion of my colleague, he actually seemed delighted by the prospect of having some more pepper to add to his travel stories.

Strained Friendship

by John Cooke

Do you ever feel, as I do, that life has a tendency to be a series of "if onlies" and missed opportunities? You know those days . . . if only I had set out to work five minutes earlier I would have missed this traffic jam. Don't you feel that mineralogy gives us great cause to say—if only? Most people will have a story to tell of the one that got away because there was someone closer to the outcrop, or when you buy an aesthetic mineral sample at a show only to be told that a better one was sold only a few minutes ago (and cheaper) by another dealer.

My story begins a few years ago when, together with a reluctant family, I set off to earn my fortune gold panning in the tributaries of the rivers cutting the gold-rich areas of Wales. I have to admit at the outset that gold panning may be a descriptive error—my trusty pan looked more like a frying pan. Undaunted by my lack of initial success, I dug dirt and gravel from the stream bed and, with each swirl of the pan, hoped to be blinded by a mass of gold nuggets. But it was not to be! The only success of the day was in providing my family with the entertainment of seeing me knee-deep in water with hope dwindling fast.

I returned to work the following Monday, where a dear friend asked about my success, or lack of it, in trying to find Welsh gold. I did try to explain that the search for gold was a little harder than I expected. My friend, who collects fossils rather than minerals, said that he had a free weekend and would welcome the opportunity to pan for gold if I could lend him all the detailed maps. Off he went with his own family in tow. Searching between the rocks in the same stream bed, yes, you guessed it: he found a small nugget. Now we're not talking Klondyke here, only a few grams, but it's the principle of the thing. There was an element of jealousy when he showed it to me; if only I had bothered to move that rock the spoils would have been mine.

I am pleased to say that we are still friends, but I'm not sure I will lend him any more maps!

The Lepidolite Boulder (II)

by Terry Szenics

I read with great interest the story of the lepidolite boulder in the May–June issue, in part because I was partly responsible for making that mine dump.

The mine referred to is obviously the Stewart Lithia mine, so famous for the typical pink rubellite crystals in massive lepidolite.

Back in the time period 1968 to 1970 I was operating the mine for the owner at the time, Ed Swoboda of Los Angeles. I can imagine the dumps have grown considerably and the property has changed quite a bit under later operators, but I can say that *we too* had our own boulder-rolling experiences there:

Better put, rather than being a victim of a near-hit, we were instigators of this great hobby-within-a-hobby of boulder-rolling. Mr. Swoboda would often visit the mine from his office in Los Angeles, and at times we spent many happy moments killing ourselves to unlodge a particularly unwieldy boulder from the top of the dump and send it crashing down below. (We did always check first to make sure nobody was in the valley below.) The physical location of this mine and its dumps were perfect for this sport: it sat up on the shoulder of a very steep hill, giving a straight shot to the very bottom: a mostly unused flat valley floor.

Once Ed and I had dislodged a particularly juicy boulder, all that was left was for the forces of nature to act themselves out, uncaringly and heartlessly oblivious to the whims or desires of their perpetrators. We watched with great glee and lots of shouting as it spun helplessly downward, crashing into and at times careening off of other rocks, all the time gaining more and more speed.

When the jeep road was bulldozed from the Stewart mine to the Tourmaline Queen mine some time before the latter was reopened, we repeated this game with the peculiarly rounded boulders of diorite country rock the machine pushed to the roadside. I remember once, not by our own hand, but when the bulldozer was directly above the Stewart mine base camp, the machine's blade accidently let loose a pile of rubble that cascaded downwards. One fairly large boulder just missed hitting the pride and joy of our mine, the air compressor, by inches. I can still so clearly remember the moment I watched that rock just miss that machine: my heart was in my throat.

To the untrained eye, boulder-rolling seems to be a sport for two crazy kids rather than two grown men. But not so! Boulder-rolling does definitely have a subtle connection with mineralogy and mineral collecting. Boulders, of course, are composed of rocks, which are made up of minerals. . . . It wouldn't have been so rich in meaning nor so psychologically satisfying if, for example, we had chosen some form of plant life to roll, such as a nasty old monstrous tree trunk.

And a final word to the writer of "Lepidolite Boulder #1," and others who have had near-misses with boulders: Do like we did, *you schmucks*; park your vehicles on *top* of the mine dump, not down below! Boulders are known to roll *downwards*. In the annals of science it still has never been proven that they can roll *upwards*.

Rock-Rolling (III)

by Wendell E. Wilson

Terry Szenics' notes on rock-rolling brought back fond memories of my own from 1969. I was then taking part in the University of Minnesota's Wasatch-Uinta Summer Geology Field Camp in the Utah Rockies, a six-week ritual which all geology students had to complete before graduating. We stayed in a ski lodge and ventured out each day, about 150 of us from various universities, with our instructors pointing and arm-waving at the fabulous geologic structures all around. Then we would be turned loose to go out on mapping projects and learn what it was like to be real field geologists. While we labored, the staff of instructors went off on their own to drink coffee, play poker, or whatever, leaving us to our own devices in the field.

One of those "devices," strictly forbidden by the faculty, was the rock-rolling competition. Any sizeable rock found perched near any hill or precipice did not last long. We would cease our geologic mapping for however long it took to work that rock over the edge, even if it required the combined efforts of every student in our seven-man mapping team. Then we would all stand transfixed with awe as it rolled down the slope, slowly at first, then bounding in high leaps, and finally crashing in a spectacular impact, fragmenting into several sections which kept on going. It was like watching fireworks. We cheered and "oooo'd" and "aaah'd" in great pleasure and satisfaction at the violence unleashed. It must have been a testosterone-driven "guy thing." I never heard of the few female students getting involved.

Of course, our instructors would often get wind that mapping teams were rolling rocks, and they'd turn apoplectic, haranguing the whole student body in the evenings when we all met back at the lodge. Being level-headed adults (and probably worried about being held responsible for our misdeeds), they could only think of such annoying possibilities as massive property damage, the danger to life and limb for any persons caught downhill from the offenders, and so on. Naturally, being young, we dismissed such quibbles.

Eventually, as the camp wore on, we got good enough to consider awarding ourselves PhD's in Rock Rolling. But for that we needed a really spectacular finale for our PhD "thesis." Many opportunities were nominated with the sudden cry of "Thesis rock!" But we waited until we found just the right one, a $4\frac{1}{2}$-foot boulder that had fallen loose on a dirt road high in the mountains. It must have weighed 2 or 3 tons, and we were all just barely able to slide it and lever it across the loose gravel a few inches to the edge, and over it went. It was glorious! It pulverized everything in its path, bounded high as it gathered speed, and at last plowed into a forest far below, by that time going over a hundred miles an hour, I'm sure. Microseconds after the boulder disappeared into the forest, crashing sounds were heard and huge 75-foot trees swayed violently as it bounced off trunks below the forest canopy. A herd of goats came running out in all directions, like the devil himself was after them!

We collapsed in ecstasy. There was no doubt that we had all earned our PhD's in Rock Rolling. Back at the lodge we compared notes with teams from other universities, and no one could beat our story. It was time to retire, but we will always have that memory.

The Mesolite Boulder

by Mike Groben

The mineral story entitled "The Lepidolite Boulder" by Rolf Luetcke in the May-June 1996 issue reminded me of a rather similar event that occurred 30 years ago.

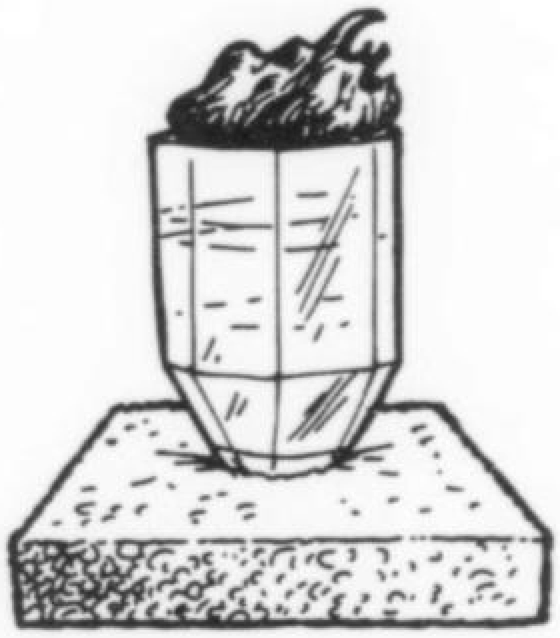
It was during the Fourth of July holidays that Al McGuinness and I had decided to go on a collecting trip in the general area of Ritter Hot Springs, Grant County, Oregon. There were rumors that some fine specimens of pseudomesolite (later discredited when it was determined to be mesolite) had been discovered in connection with some road improvement along the Middle Fork of the John Day River just east of Ritter Hot Springs.

The weather is pretty warm at that time of the year and we had been searching all day for the "pseudomesolite." It was during the later part of the afternoon, shortly before we had to leave for home, when we stopped to examine a fresh road cut which had also been worked back into the hillside as a small burrow-pit. Sure enough, we began to find some indications of the so-called pseudomesolite. We were encouraged, and began to explore the area more seriously. Damaged and dirty pieces with crystals to 2" in length were scattered throughout the pit. All we had to do was to find a good clean pocket to make our trip successful.

Al was searching on the side of the pit and I was higher up on the backside of the pit when I spied an opening about 6" wide with the "pseudomesolite" lining both the top and the bottom of the seam. In order to gain access to this pocket, I had to remove a boulder about 2 to 3 feet in diameter that was in the way. I was probably 30 feet above the floor of the pit and there was a talus slope reposing at an angle of approximately 45° between me and the bottom of the pit. Projecting out of this talus slope and about two-thirds of the way down to the floor of the pit was part of the original basalt flow. The basalt protruded out of the talus by possibly 10 to 12 inches, just about the size of a dinner plate.

I proceeded to move the boulder which was in my way and roll it down the slope so as to get it out of the way and get a better look into the pocket I'd found.

Believe it or not, that boulder rolled down that slope and hit that basalt protrusion head on. It broke into a dozen or more pieces and clattered on down to the bottom of the pit. To my astonishment, and almost as if somebody had carefully placed it, there on that 10–12 inch protrusion of basalt rested the most beautiful crystallized snow-white specimen of "pseudomesolite," 6 x 6 inches in size, sparkling in the sun! Al shook his head in disbelief (so did I!). The delicate 2-inch hairlike crystals on the specimen didn't have even one speck of dirt on them. Unbelievable! The specimen resides in my collection today, 30 years later; it's the best specimen of "pseudomesolite" (mesolite) we ever collected!



The Blue Topaz

by Bill Cordua

My mother was a great encouragement to me in my mineral hobby when I was a kid. She was not very knowledgeable, but she loved to go places and look for pretty stuff whether she knew what it was or not. Her favorite mode of cracking rocks was throwing them on the ground until they either split, or another collector would come running with a hammer to help. Anyway, my hobby eventually turned into a career as a University mineralogy professor and I am grateful for all of her support.

A few years ago she mentioned seeing a topaz pendant in a jewelry store. She had never really liked cut stones, but thought this was gorgeous, if too expensive. She told me about this on one of our weekly phone talks. (She lives in Maryland and I in Wisconsin.)

I was at the Tucson show soon afterwards and saw some lovely tawny matrixless topaz crystals. I bought one for Mom, mounted it in a clear plastic box with blue Min-Tack clay and mailed it to her with a note to the effect that here was a nice topaz for her. What I didn't know was that my mother had been looking at *blue* topaz. My packing was not as careful as it should have been because the topaz arrived loose in its little box. When my mother unwrapped the gift, she immediately assumed the Min-Tack was the topaz. She jammed the topaz, termination first, into the Styrofoam, leaving the Min-tack blob thrust into the air. This is what she showed her friends as the unusual blue topaz her mineralogist son had sent her from Tucson!

It wasn't until a few months later on my next visit to Maryland that I discovered the mistake. When I told my mother about it she said "I thought that stuff was a little soft." By the way, she did eventually get her blue topaz pendant.

Careless Culling

by Art Smith

Just about everyone in the hobby has probably done things when they first started collecting that still haunt them, and wish they could have another chance to do things differently.

In the summers of 1958 and 1959 when I was working nights on the clean-up crew at the food and gift concession building at the Mount Rushmore Memorial near Keystone, South Dakota, the days were available for roaming the Black Hills and collecting minerals in the numerous nearby pegmatites. At that time the Maywood Chemical Company of Maywood, New Jersey, was working the Etta pegmatite near Keystone for lithium. The primary ore was the gigantic spodumene "logs" that criss-crossed each other in the intermediate zone adjacent to the quartz core. One of my fellow workers, John Valdez, mentioned that his dad worked as a miner there, and suggested I pay him a visit and introduce myself because he was always finding interesting minerals. This I promptly did.

The Etta pegmatite was originally a prominent knoll but by then most of the upper part was an open cavity and it was being mined as a glory hole. My entrance to the mine was through a tunnel at the base of the knoll. Once inside the glory hole at the tunnel level there was an inclined shaft to climb down about 30 feet to a short adit that opened to the working area, which was the lowest level of the glory hole. Ore and rock were blasted from the sides and dropped to this level where they were sorted, cobbed, and hauled up the incline and then to the ore bin or the dump.

There was no office apparent, so climbing down to the working face was the only option. Here I was made welcome by Mr. Valdez and the other miners, but it was obvious that collecting in the working area with the tons of loose sliding rock was too dangerous to attempt even when they were not working. I had many questions and there was much talk about their mining, but after a little while I realized the miners were getting a little restless because I was definitely slowing down production and they were probably paid by the amount of ore produced.

As I started to leave I was told not to even try to collect in the working area, even when they were not mining, but they promised to save any pieces that they thought might be of interest to me. They would be put on a high ledge located in the lower adit.

In those days, when they quit for the day they did not even bother to lock things up. With plenty of summer daylight in the evenings, I would visit the mine, climb down to the lower level, sack up the specimens saved on the ledge and climb back out. There were lots of unusual spodumene pieces, stannite, beryl, albite (clevelandite), columbite, and other minerals. I also carted off several pieces of a late-forming albite that was not in distinct crystals but had cavities that were indications of former minerals now gone. They were all ugly, but different from the more common cleavelandite so I kept them.

By the time the summer was over I had quite a collection of minerals from here and elsewhere in the Black Hills which would have to be pared down so as not to overload my car for the trip back to Missouri. Several of the albites were pitched but three or four made the trip back.

In the late Fall of 1959, when I had finished my thesis, further reduction of specimens was needed for the trip back to New Jersey and only one of the albite specimens made the cut.

As a footnote, my next visit to Keystone and the Etta mine was in the late summer of 1962; by then the Etta mine was abandoned and the lower levels flooded. So collecting in the mine might be ended forever.

By the middle 1970's I was slowly relocating my minerals and library from my parents' basement in New Jersey to Houston, Texas. Since all of the material had to be shipped or flown in extra traveling cases, I had to be very selective of what specimens made the trip. The albite and other specimens from the Etta had no special value except for some fond memories, so most were always left behind. By that time, however, I was interested in microminerals so why not see if there were some microcrystals of interest inside some of those now dust infilled cavities of the albite specimen. What would a fresh break reveal? A chisel and hammer was applied to it and, zing, the first break exposed a beautiful, flat, pale purple fluorapatite crystal about 4 mm across—my first for the Etta! Naturally both pieces made the trip to Texas, and careful trimming exposed other microcrystals of fluorapatite. I still wonder; what else had I culled that I should have checked more carefully?

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1. **CALCITE**, Elmwood mine, Carthage, Smith County, TN. Glassy, transparent and symmetrical—this double-terminated twin is greatly superior to most of the huge crowd of Elmwood pieces. 6" across $2000

2. **RHODONITE**, Chiurucu mine, Dos de Mayo province, Huanuco department, Peru. An esthetic cluster of *thick*, bright-pink, terminated crystals growing in parallel. An excellent specimen from one of the best rhodonite localities. 2" across $5500

3. **FLUORITE** with **BARITE**. Okaruso mine, Namibia. A "mountain" of dark-blue fluorite crystals with minor white barite. 5" across $1000

4. **FLUORITE**, Nicolai mine, Dal'negorsk, Primorjski Kraj, Russia. A glassy, colorless, cubic crystal with beveled edges. 1½" across $1000

5. **RUTILE** with **HEMATITE**, Ibitiara, Bahia, Brazil. "Stars" of bright, golden rutile crystal aggregates growing epitaxially around glossy-black hematite blades. 2" across $2000

6. **ANDORITE**, San Jose mine, Oruro, Oruro department, Bolivia. A fine 1" cluster of metallic crystals growing in parallel. From the premier locality for andorite. $1000

7. **PYROMORPHITE**, Les Farges mine, Ussel, France. A richly crystallized druse of bright-green, hoppered crystals on matrix. 3" across. $2600

8. **SMITHSONITE**, Choix, Sinaloa, Mexico. A cute pair of rose-pink smithsonite spherules. The symmetrical, organized appearance distinguishes it from most. 3" across $850

9. **BARITE** with **MALACHITE**, Shangulowe, Katanga, Democratic Congo Republic (formerly Zaire). Rich druse of distinct, lustrous, free-standing, malachite-included barite crystals which are completely free of damage. 2¾" across $1500

10. **DIOPTASE** on **CALCITE**, Tsumeb, Namibia. One of the most highly sought after mineral combinations. Lustrous, perfect dioptase crystals to ⅝" on bright white calcite. 2" across $1500

11. **DIOPTASE** on **CALCITE**. Tsumeb, Namibia. Hundreds of lustrous dioptase crystals (<1/16") encrust a matrix of white rhombohedral calcite crystals. 3¾" across $700

12. **AQUAMARINE**, Xue Bao Diang mountain, north of Chengdu, Sichuan province, China. This locality has achieved fame for its fine crystals of *tabular* aquamarine. The shape and general esthetics of this contemporary classic make it a superb example. 5¼" across $2500

13. **CALCITE**, Dal'negorsk, Primorjski Kraj, Russia. A beautiful complex, ball-shaped, transparent, glassy twin with minor attached matrix. 5" across $2500

14. **NEPTUNITE** with **BENITOITE**, Dallas Gem mine, San Benito County, CA. This is possibly the finest neptunite thumbnail in existence. This esthetically composed piece was featured in several of "Classic Mineral Videos" advertisements. See "Rocks and Minerals" (vol. 72, no. 5, p. 321). 1¼" across $1500

15. **AZURITE**, Cole Shaft, Bisbee, Cochise County, AZ. This classic displays small, neon-blue crystals arranged to form bright rosettes. Mined between c. 1890–1910 .... $1800

16. **COPPER**, Lake Superior region, MI. An outstanding piece from the most prolific native copper locality on earth! A wonderful cluster of spinal twins with a clean, chocolate-brown patina. 3" across $5000

17. **INESITE**, Wessels mine, Kuruman, Northern Cape Province, South Africa. A plate of reddish-pink, bladed crystals. Very esthetic. 3" across $1300

18. **NEPTUNITE** with **BENITOITE**, Dallas Gem mine, San Benito County, CA. A double terminated, glossy-black neptunite crystal (1¾" long) on benitoite. 5" tall $3500

19. **CALCITE**, Egremont, Cumberland, England. A loose, transparent nailhead crystal with attractive hematite staining. 3" tall $1250

20. **SIDERITE**, Morro Velho mine, Minas Gerais, Brazil. Splendid, disc-shaped, greenish-brown crystals completely encrusting the matrix. 4" across $650

21. **BOLEITE**, Amelia mine, Santa Rosalia, Baja California Sur, Mexico. Two pseudocubic crystals (¼" on edge) of boleite on "mud" matrix. 3" across $800

22. **WULFENITE**, Toussit mine, Morocco. Bright yellow crystals to ⅝". 3½" across $1500

23. **CALCITE**, Nicolai mine, Dal'negorsk, Primorjski Kraj, Russia. A superb contemporary classic which one day may be more highly regarded than the finest English calcite specimens. Stubby, lustrous, nailhead crystal. 2¼" tall $600

24. **ELBAITE**, Himalaya mine, Mesa Grande, San Diego County, CA. Hot-pink, glassy crystals with green caps growing subparallel to each other. 1¾" tall $750

25. **CALCITE** with **COPPER**, Quincy mine, Hancock, Houghton County, MI. A jewel-like calcite crystal on a "sheet" of tarnished native copper. 1½" tall $750

26. **QUARTZ**, PC mine, Jefferson County, MT. A *lustrous*, heart-shaped Japan-law quartz twin (1⅛" across) on matrix. 3" across $750

27. **AQUAMARINE**, Dusso, Gilgit division, Pakistan. A fine, loose, glassy, barrel-shaped, sky-blue crystal which is ahead of most of the crowd. 3" tall $3500

28. **SMITHSONITE**, Tsumeb, Namibia. A plate covered with rose-pink crystals of smithsonite to ⅕" on edge. A very fine piece. 6" across .. $1950

29. **DATOLITE** with **ILVAITE**. Boron mine, Dal'negorsk, Primorjski Kraj, Russia. Hundreds of microscopic ilvaite crystals including glassy crystals of tabular datolite. 4" across $700

30. **PYROMORPHITE**, Kintore open cut, Broken Hill, New South Wales, Australia. A weird piece consisting of pale-brown, *very slender crystals* (~⅛" in diameter) to 1½" long. Some damage. 5" across $1700

31. **VIVIANITE**, Huanuni mine, Oruro department, Bolivia. A slender crystal of deep-green, lustrous vivianite on a sparing matrix of siderite. 3" tall $1500

32. **GALENA**, Great Mogul mine, Tipperary, Ireland. Much more than another odd locality piece. A group of bright, complex galena crystals. A very fine example of the species. 2½" across $1500

33. **COBALTOCALCITE**, Mashamba West mine, Mashamba, Democratic Congo Republic (formerly Zaire). A vibrant, hot-pink druse completely encrust the matrix. Scarce in this quality level. 3" across $1200

34. **SPESSARTINE** on **ORTHOCLASE**, Shengus, Gilgit district, Pakistan. Six bright, wine-red, gemmy, symmetrical crystals to ⅜" in diameter present themselves from an orthoclase matrix. A jewel. ⅝" across $2000

35. **FLUORITE**, Berbes mine, Asturias, Spain. Glassy, phantomed, intergrown cubes to 1" on edge cover a matrix of white crystallized barite. 3" across $750

36. **VIVIANITE**, Huanuni mine, Oruro department, Bolivia. Lustrous, chunky, emerald-green crystal with iridescent drusy pyrite. 2¾" tall $1000

37. **BOULANGERITE** on **RHODOCHROSITE**, Rosebury, Tasmania, Australia. One of the finest known specimens. Bright, acicular crystals on pink rhodochrosite. 6" across $1950

38. **AZURITE** with **ARSENTSUMEBITE**, Tsumeb, Namibia. Bright, neon-blue, 1" azurite crystal partly embedded in a matrix of grass-green arsentsumebite. Only removed from a single pocket—hence, a great rarity. 1½" across $1500

39. **HEMATITE** with **RUTILE**, Novo Horizonte, Bahia, Brazil. Most hematite crystals from this locality are wafer-thin. This crystal is *thick* with golden rutile needles penetrating the surface. 2½" tall $1200

40. **QUARTZ**, Dara Ismael Khan district, Waziristan, Pakistan. This faden crystal is so symmetrical that closer inspection may be required to reveal that it is indeed natural. 3½" tall $1200

41. **DIOPTASE** on **CALCITE**, Tsumeb, Namibia. A jewel-like cluster of stout, lustrous, separated dioptase crystals to ⅔" tall. 2" across $1800

42. **CERUSSITE**, Tsumeb, Namibia. Lustrous, translucent, elongated sixling. 2½" tall $650

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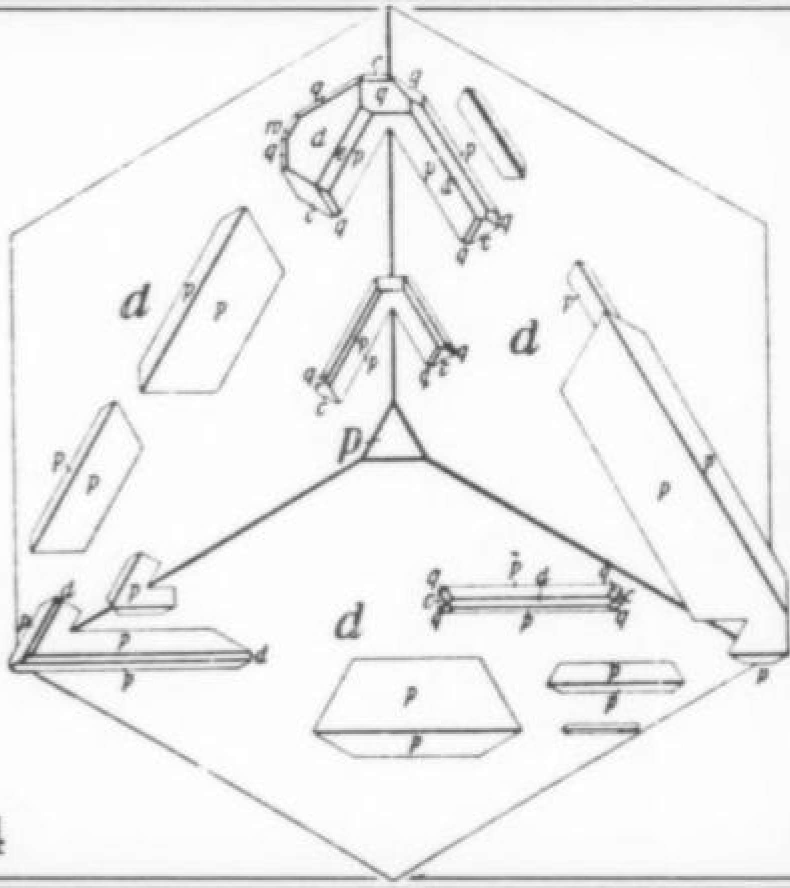

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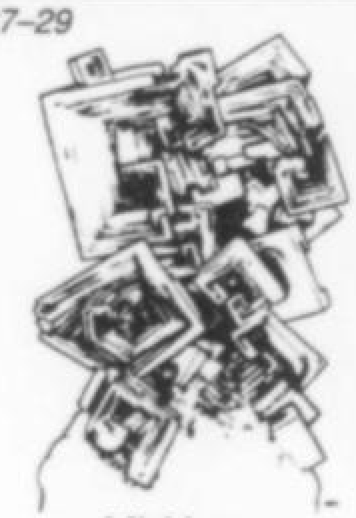

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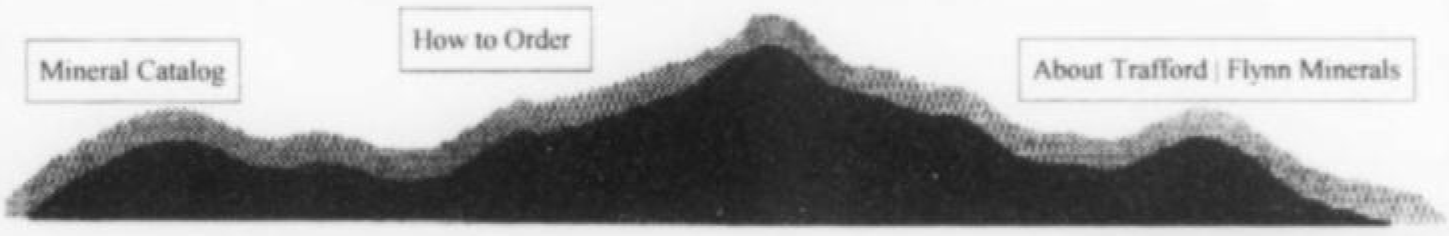
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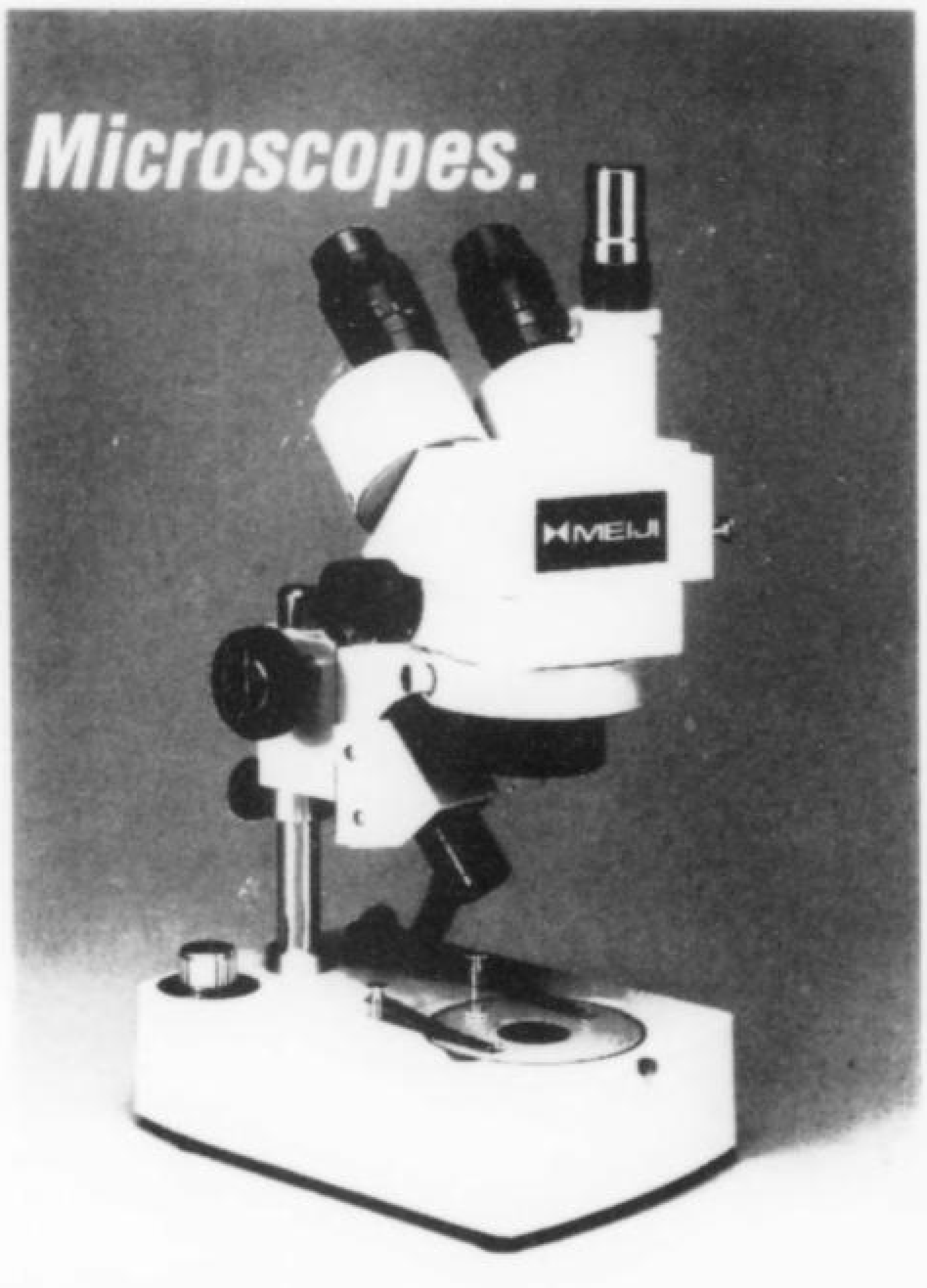

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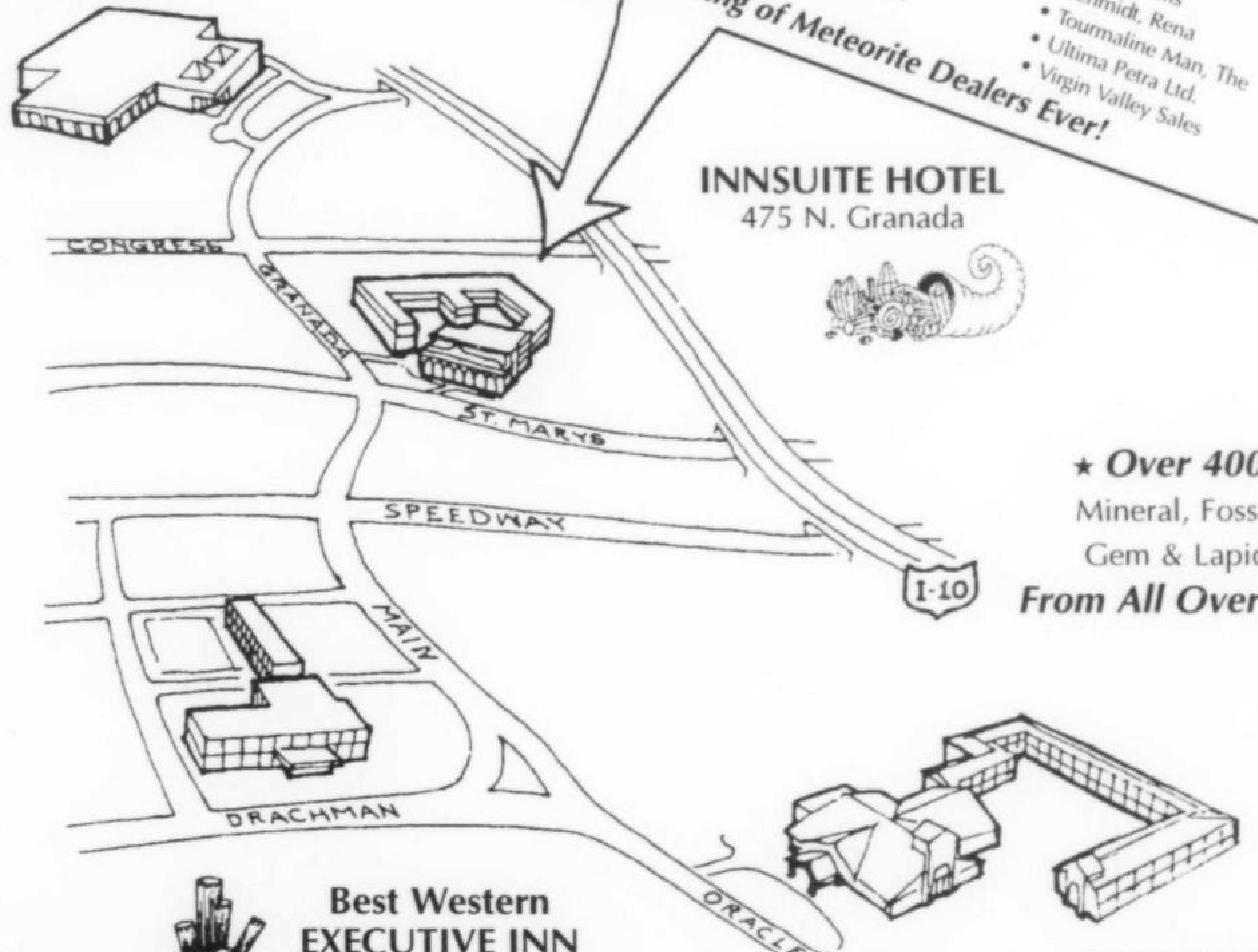

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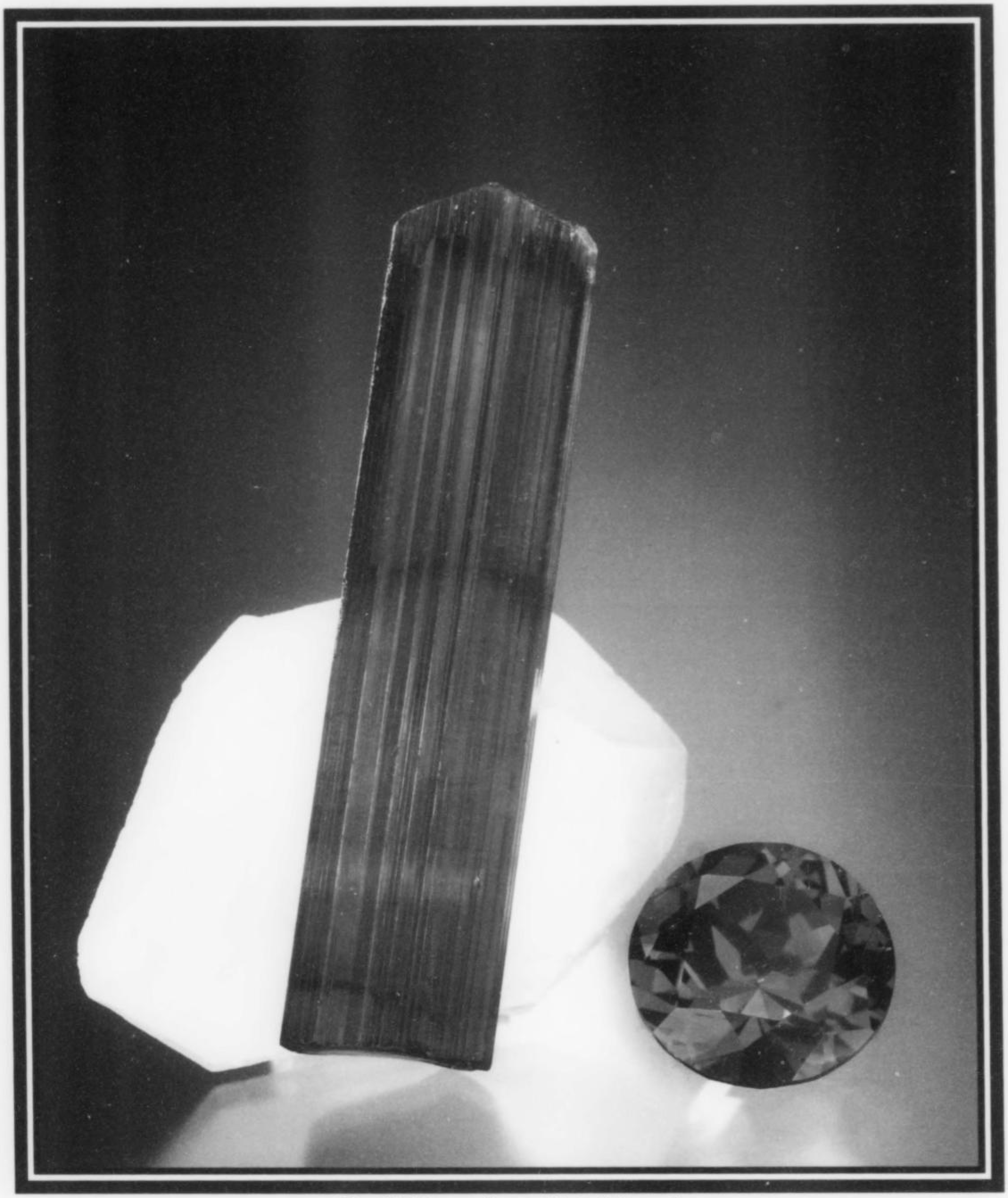

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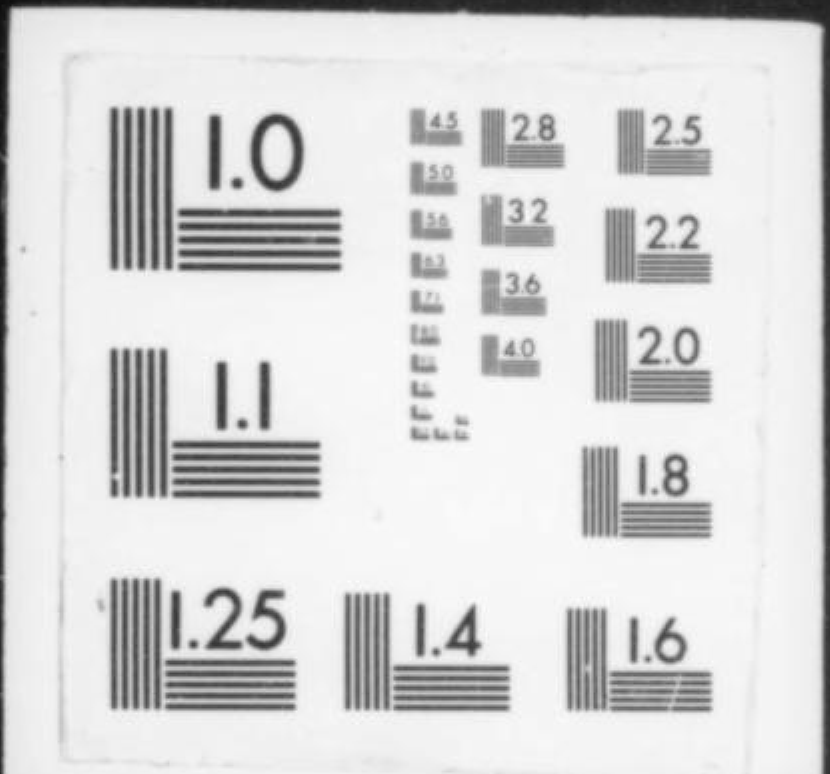
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