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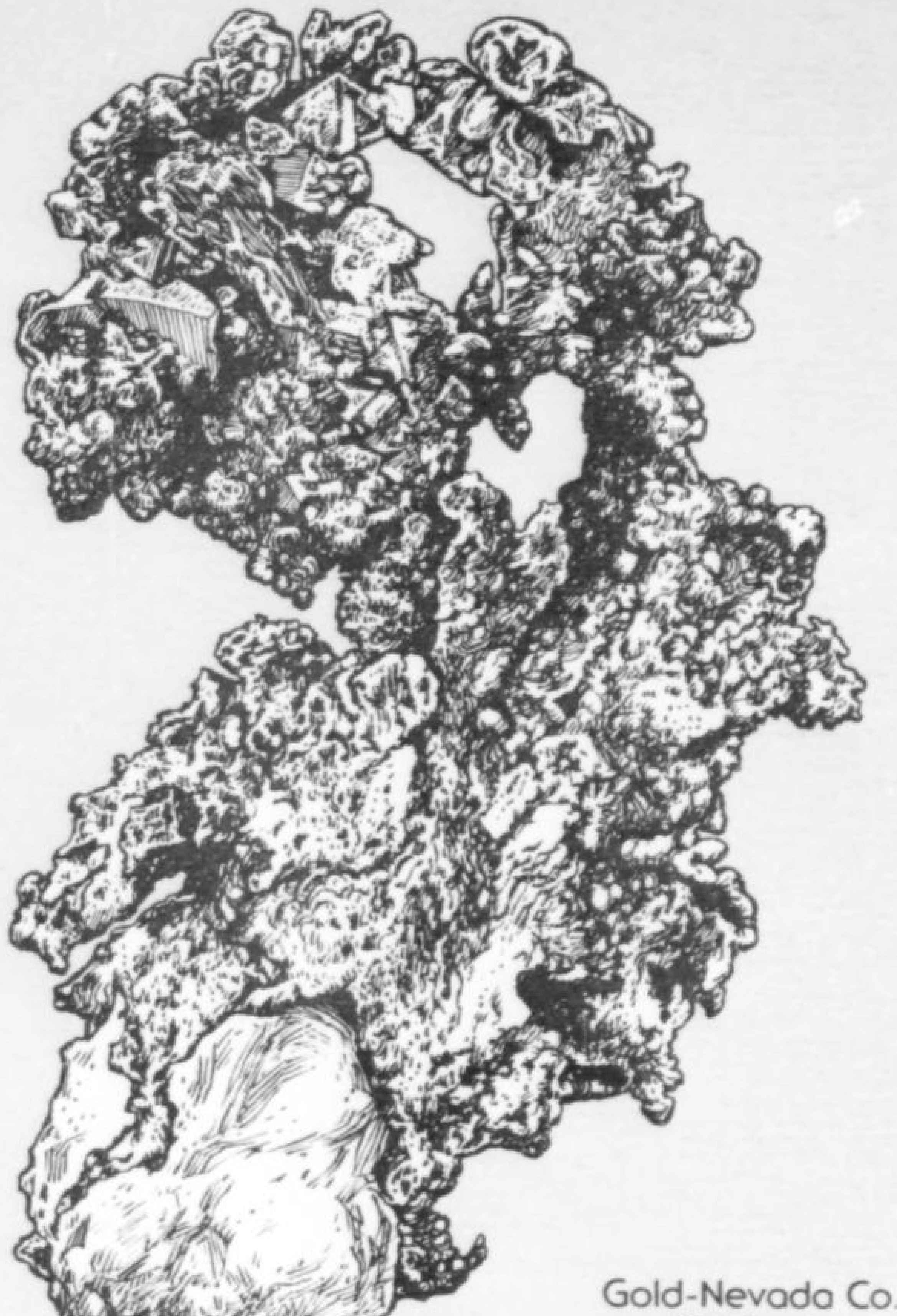

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Volume Ten, Number Five
September-October 1979

Articles

Departments

COVER: BERYL on rhyolite from the Violet #5 claim, Wah Wah Mountains, Beaver County, Utah. The crystal is about 1 cm in size. John Barlow specimen; photo by Harold and Erica Van Pelt.

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notes from the EDITOR

THE DISTRIBUTION PATTERN OF THE *RECORD*

Although not all mineral collectors subscribe to the *Record (gasp!),* it is probably safe to assume that significant differences do not exist in the *proportion* of mineral collectors who subscribe throughout the United States. Language barriers undoubtedly result in a lower proportion subscribing in the non-English-speaking countries, of course, especially those countries which have access to a local publication in the native tongue. On the other hand, some foreign countries (Germany, for instance) have a cultural disposition toward literature which probably increases the proportion of collectors who subscribe to one mineral magazine or another. Those qualifications aside, I think the following maps provide an interesting glimpse into the geographical distribution of mineral collectors, as inferred from the distribution of *Record* subscribers.

The first thing that strikes one's eye in Figure 1 is the low distribution through the center of the country. This area of apathy corresponds essentially to the states of the Louisiana Purchase, plus the central southern states. As shown in Figure 2, a remarkably large section of the central United States contains only a fifth of the U.S. subscribers. The eastern and west-southwestern states as (notably smaller) groups each contain two-fifths.

Local interests commonly reflect local geology, and the most likely explanation for this distribution is a combination of population distribution as a whole, superimposed on mineralogies of varying interest.

As indicated in the inset to Figure 2, foreign subscriptions account for nearly a fourth of *Record* readers. The foreign distribution is shown in more detail in Figure 3. The number of German subscribers, more than either the Australians or the British, is impressive considering the language barrier.

Of what use are these data? How can I shrug my shoulders in print? Perhaps advertisers or mineral show planners can plan their strategies with these distributions in mind. Or perhaps the clever graduating High School senior will keep the high states in mind when deciding which university to attend. (The more fellow collectors there are locally, the more enjoyable one's free time is liable to be. Furthermore, if my assumption is correct, the states with the most collectors will have the mineralogically most interesting geology to which formal study might be directed.) But for most readers I suspect the distributions will simply be interesting food for thought. Why, for example, all those collectors in sandy Florida?—Retirees who became interested while living elsewhere? Why so few in Idaho, with all of its mountains and mines? And what, pray tell, does the Louisiana Purchase have to do with all of this?

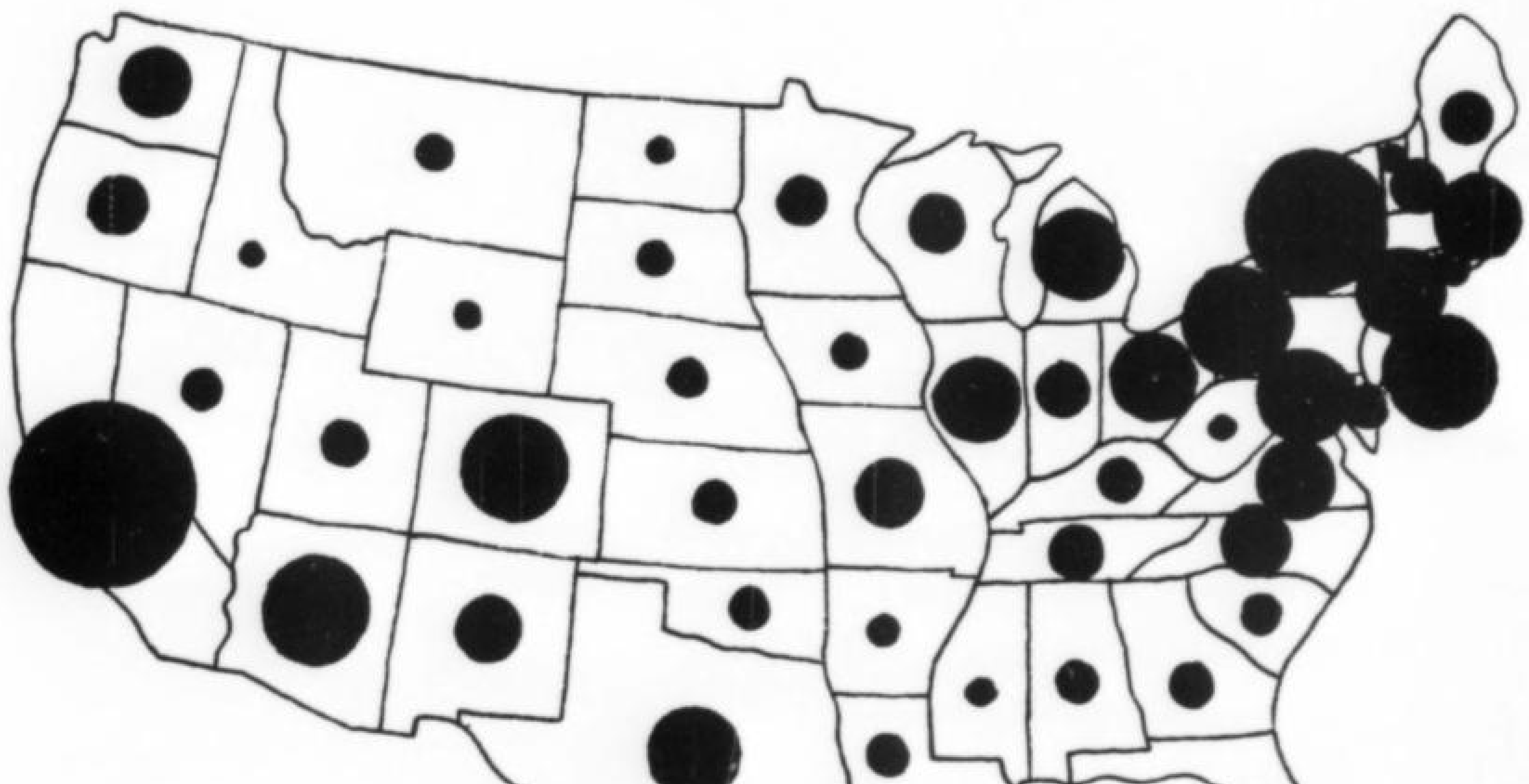

Figure 1. **The distribution of subscribers to the *Mineralogical Record* in the United States. The area of each circle is directly proportional to the number of subscribers in each state.**

Figure 3. **Proportional distribution of foreign subscriptions.**

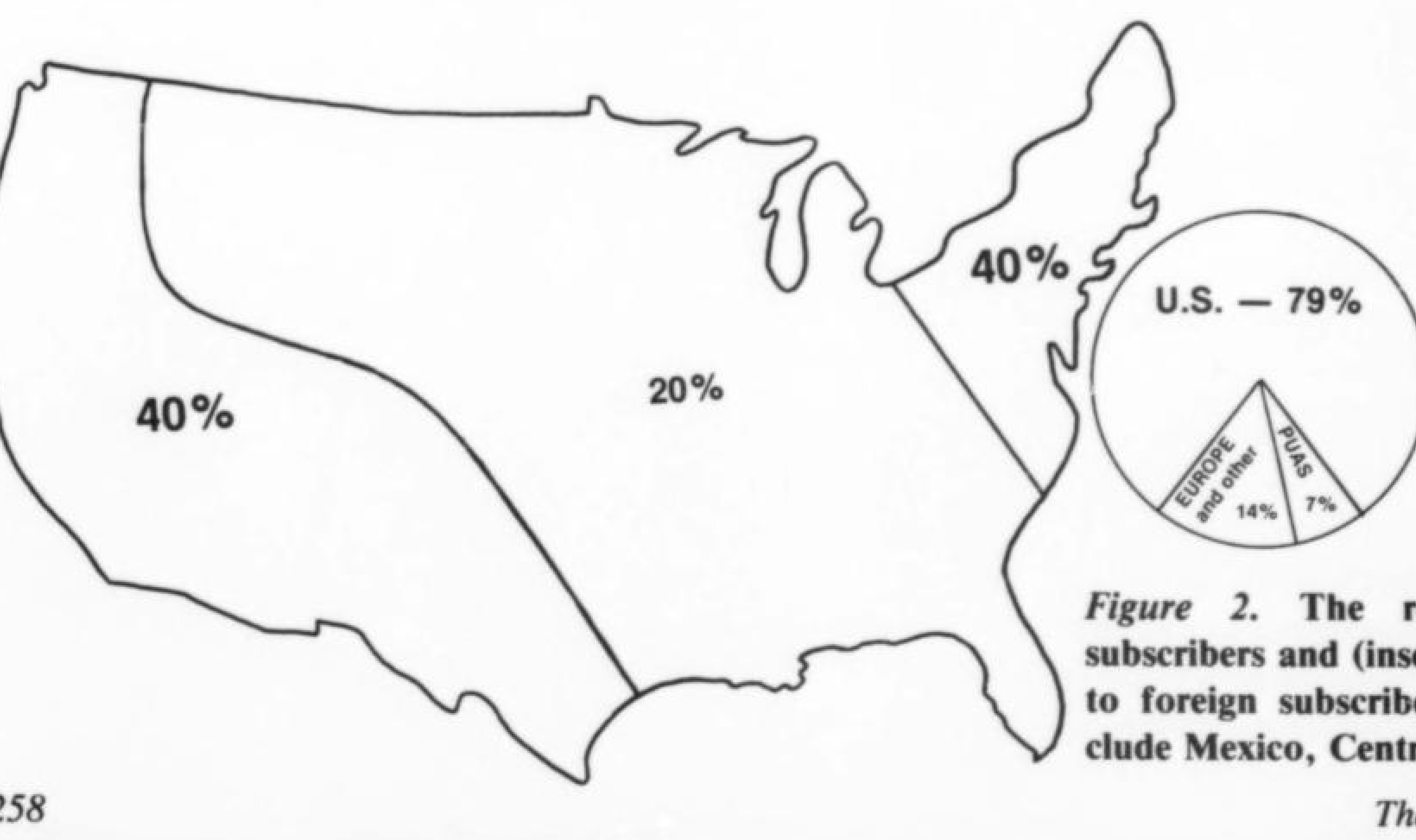

Figure 2. **The regional distribution of subscribers and (inset) the proportion of U.S. to foreign subscribers. (PUAS countries include Mexico, Central and South America.)**

The Thomas Range, Wah Wah Mountains, and vicinity, Western Utah

by **Lanny R. Ream**
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Sandpoint, Idaho 83864

The rhyolites of westcentral and southwestern Utah comprise one of North America's most interesting collecting regions. The areas are accessible without difficulty, are open nearly the year around, are not difficult to work, and contain a suite of at least ten minerals that vary from rare to common, including one gemstone. Superb and abundant sherry-brown topaz crystals and brilliant red beryl are the best known species.

INTRODUCTION

Henry Englemann probably made the first discovery of topaz in the area during an expedition in 1859 (Englemann, 1863), and Alling (1887) was the first to describe it. Maynard Bixby discovered the bixbyite (named in his honor) and red beryl which were described by Penfield and Foote (1897) and Hillebrand (1905) respectively. Later explorers and collectors discovered a much wider suite of minerals including pseudobrookite, garnet, hematite and quartz. The early collectors included Arthur Montgomery and Edwin Over. It was Edwin Over who made the first discovery of pseudobrookite (Montgomery, 1935, Palache 1934).

With the boom in the mineral collecting hobby, the range has become increasingly popular with collectors. This has led to recent discoveries that are as exciting as those of the 1800s. Mike and Sandra Sprunger and John Holfert have been responsible for many of these. The author has made some interesting discoveries,* mostly with the assistance of the Sprungers and Holfert. Recent finds include bigger and better quality crystals and some new minerals for the range.

The Thomas Range is not the only area in western Utah that produces these minerals. Similar occurrences have been known for many years in the Dugway Range, north of the Thomas Range, and in the Keg Mountains, 12 miles east of the Thomas Range (Fig. 1). Red beryl has been known for 20 years in the Wah Wah Mountains, 100 miles to the south. Recent work by the author has shown that similar rock types, with the same mineral suite, occur for at least 45 miles to the southwest of the Wah Wah Mountains.

The south end of the Thomas Range is located 45 miles northwest of Delta, Utah, and is reached by a paved road from that town. Good quality dirt roads provide access all around the range and a few passable vehicle trails extend into the mountains a few miles. The Thomas Range is 12 miles long, varies from four to eight miles across, and trends north-south. Spor Mountain lies to the west and appears almost to be part of the range. Antelope Ridge lies close to the southeastern part.

A semi-arid climate and high elevation (1398-meter valley floors and 2128-meter mountain tops) gives the area a cold desert vegetation type. A sparse sagebrush-juniper cover leaves the area open and barren in appearance. Summer temperatures are constantly in the 90's to 100's and winter temperatures in the 'teens. Collecting is possible the year around if one avoids the winter storms and hottest summer days.

The areas to the south are accessible from the towns of Cedar City and Milford. The Wah Wah Mountain locality is about 30 miles southwest of Milford and 45 miles northwest of Cedar City. From there, the area extends for about 45 miles to the southwest and is accessible by dirt roads from Modena and Cedar City.

Elevations in the Wah Wah Mountain area vary from 1581 m to over 2128 m. The climate is semi-arid, as at the Thomas Range, but precipitation is over 30 cm in the higher mountains. The cold desert vegetation of the valley floors changes to a more dense piñon-juniper cover in the mountains. Rock outcrops are less than 50% in the area as compared to 80% in the Thomas Range. Winter snow prevents access for two to four months of the year.

* This study was undertaken as a Friends of Mineralogy project (Pacific Northwest chapter).

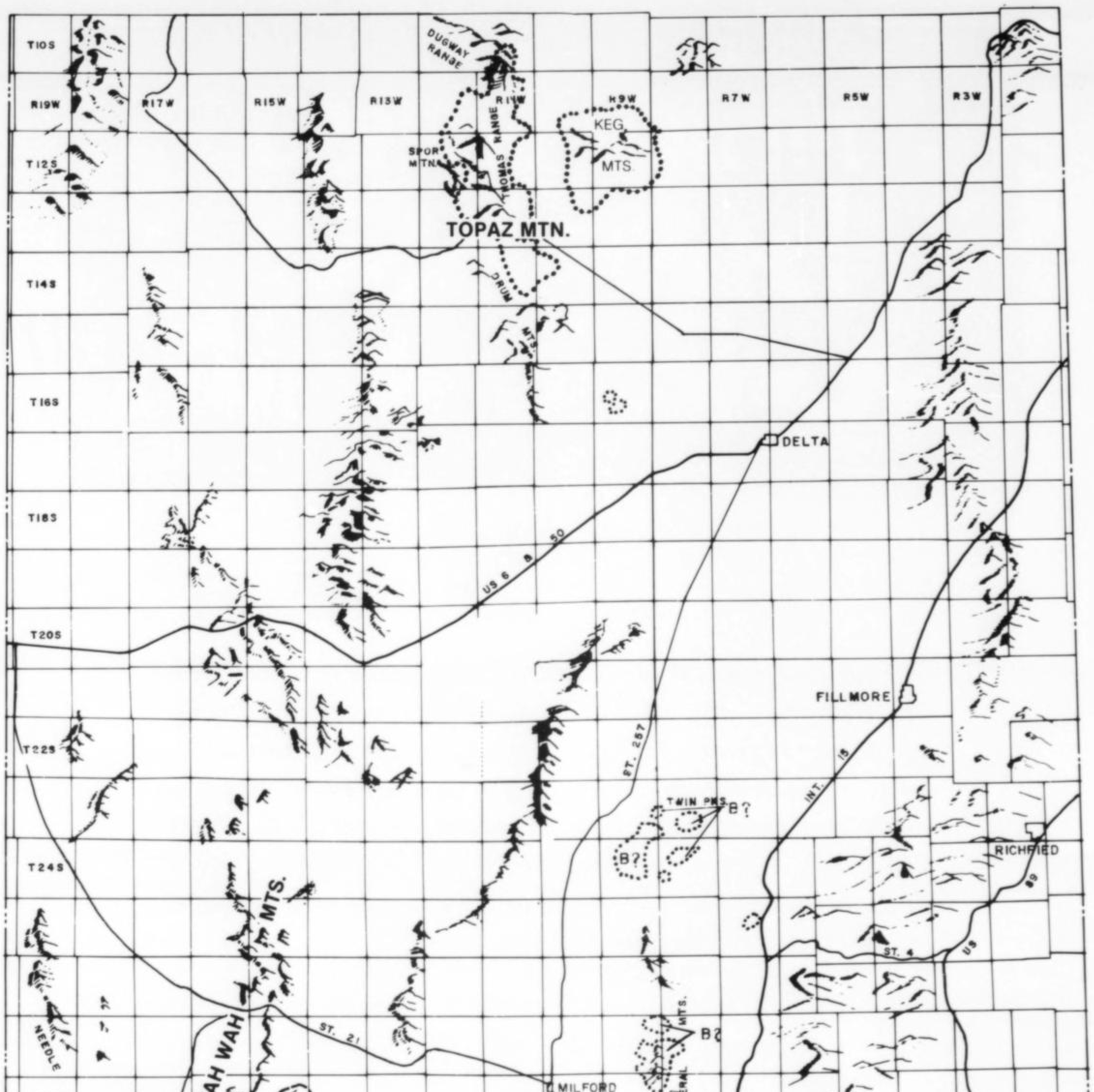

Figure 1. **TOPAZ RHYOLITE IN WESTERN UTAH**

T₂rf Late Tertiary rhyolite-dacite-quartz latite flows; some of which are Topaz-bearing rhyolites (approximated at Keg Mtns. and Drum Mtns.)

Known outcrops of gray and maroon Topaz-bearing rhyolites in the T₂rf group.

B T₂rf that does not contain Topaz-bearing rhyolites

Tvu Tertiary volcanics undifferentiated; contains some Topaz-bearing rhyolites of the T₂rf group.

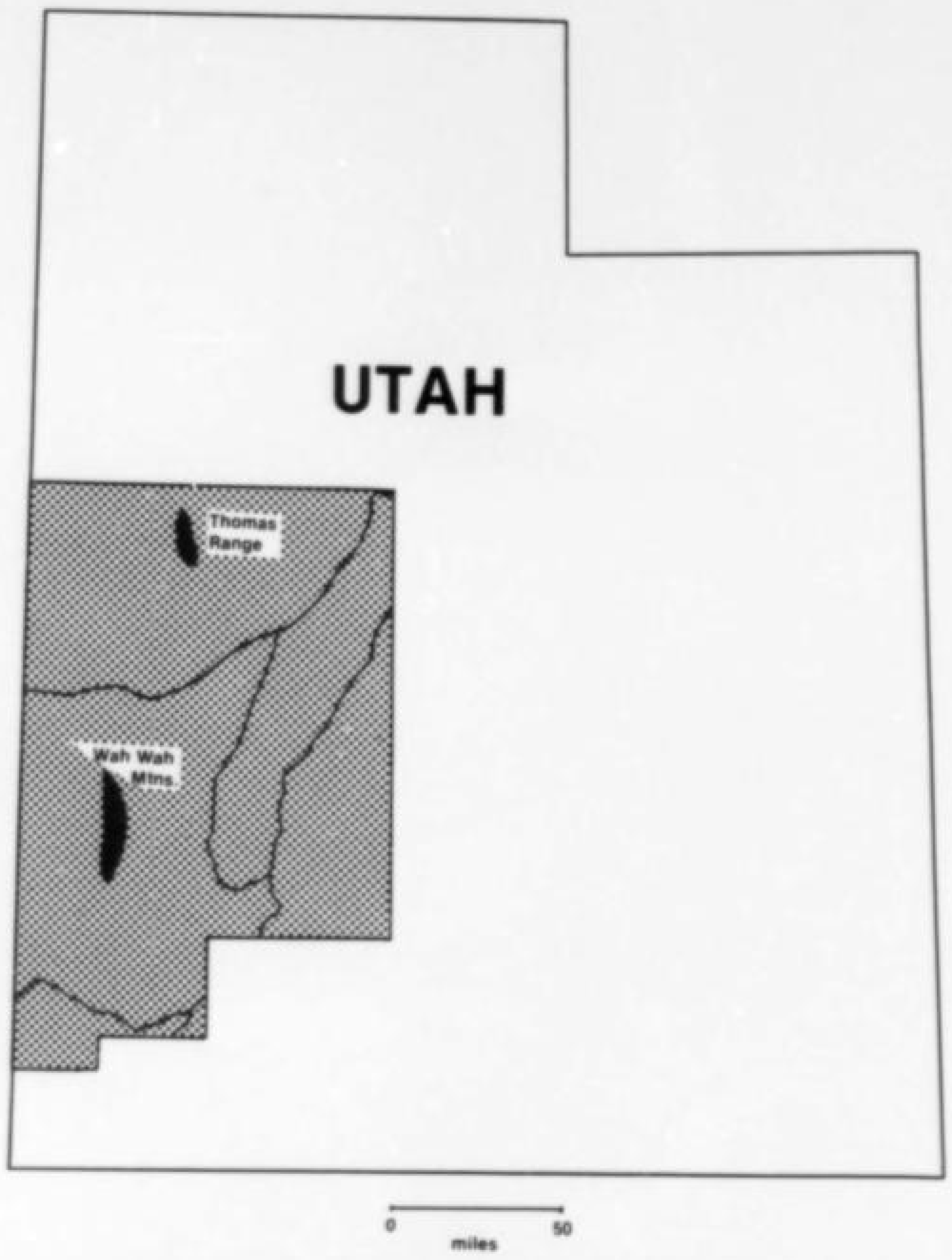

Figure 2. **Location map showing the Thomas Range and the Wah Wah Mountains within the map area shown in Figure 1 (shaded).**

The mineral producing area is in the southern portion of two north-south trending mountain ranges, the Wah Wah Mountains and the Needle Range. These ranges widen at their southern ends to close off the valley between them and to form a northeast-southwest trending range of hills which extends from the Wah Wah Mountains southwesterly through the southern Needle Range to the Paradise Hills and on into Nevada.

GEOLOGY

Tertiary rhyolites comprise most of the Thomas Range and contain the minerals of interest. There are some flows of rhyolite breccia and green obsidian underlying the rhyolites and exposed around the edges and central portions of the range. Paleozoic sediments crop out on Spor Mountain and presumably underlie the volcanic rocks in the Thomas Range. Staatz and Carr (1964) have described the rhyolites as occurring in five separate units. In any one unit the color varies from white to maroon, with light to dark gray being the most common.

Lithophysae and other cavities are rare to abundant. The lithophysae are characterized by numerous concentric layers or shells comprised of rhyolite and small quartz crystals. Shrinkage cracks and other fractures are locally common. The crystals of topaz occur in these various cavities or frozen in rhyolite. Crystals (if frozen in the rock) or lithophysae are commonly surrounded by a soft sandy layer of rhyolite. Lithophysae are commonly flattened and concentrated along flow banding (which consists of alternating gray and maroon layers).

The rhyolites form jagged to rounded peaks, ridges and knolls. Sometimes where lithophysae are abundant, centuries of weathering have enlarged the cavities, giving the rocks a honeycomb or frothy appearance. In other areas, differential weathering between gray and maroon layers has developed a ribbed or obviously layered appearance.

On the geologic map of northwestern Utah, Hintze (1963) used the Symbol T_2rf (described as "late Tertiary rhyolite-dacite-quartz latite flows") to designate these rhyolites (see Fig. 1). The same symbol is used for similar topaz-bearing rhyolites in the Dugway, Drum and Keg Mountains. Hintze (geologic map of southwestern Utah 1963) used the same symbol to designate volcanic rocks in the Wah Wah and Needle Ranges as well as at Three Knolls 12 miles northwest of Delta, around Twin Peaks 25 miles northeast of Milford, in the Mineral Mountains 10 miles east of Milford, in the Black Mountains 25 miles south-southeast of Milford and in the Bull Valley Mountains south and west of Cedar City.

The author determined through field investigations that the rocks in the Mineral Mountains contain perlite, obsidian and a devitrified gray rhyolite of a texture similar to the topaz-bearing units. No topaz or other minerals of interest were identified, except for some quartz in a few lithophysae. James Whelan, University of Utah (personal communication), reported small light pink topaz crystals in these rhyolites (or in tuffs?) in Wildhorse Canyon. The units in the Black Mountains are mostly basalt and gray to maroon rhyolites and trachytes. No rhyolites of the texture associated with minerals of interest were seen. Units near Enterprise in the Bull Valley Mountains consist of breccia, trachytes and ignimbrites. Topaz-bearing rhyolites were not seen.

The outcrops of T_2rf at Twin Peaks were not investigated, but hematite (as martite) has been reported as pseudo-octahedrons of excellent quality to 2.5 cm and poor quality to 12.5 cm. No investigation was made of the reported topaz occurrence at Three Knolls 12 miles west of Delta. This is near the site of the Japanese internment camp of World War II.

In the southern Wah Wah Mountains there is an area of volcanic rocks designated as Tvu (Tertiary volcanics undifferentiated) on the geologic map (Hintze, 1963). These include some light gray to maroon rhyolites which contain topaz and other minerals and probably should be included in the T_2rf classification.

The remainder of the rocks with the T_2rf designation include topaz-bearing rhyolites and lie in the southwest-northeast trending hills of the southern Wah Wah and Needle ranges. These rhyolites are similar to the Thomas Range rhyolites. They are light gray to maroon in color. The maroon flows consist of thin alternating bands of gray and maroon color. Lithophysae are locally abundant in the maroon unit and are rare in the gray unit. The cavities are generally flattened parallel to the color banding and vary from microscopic to at least 20 cm across. As the fracture surfaces and banding weather, the rhyolite takes on an easily recognizeable ribbed appearance, distinctly different from the other volcanic rocks of the area.

In most outcrops, the maroon rhyolite overlies a gray unit. Rarely, a gray unit overlies the maroon. It may be that erosion has removed the gray unit in most areas. The underlying gray rhyolite contains few cavities or fractures. Topaz sometimes occurs frozen in the rock or rarely in cavities with granular quartz and Feldspar.

Most often the maroon rhyolite caps ridges and knolls where it forms cliffs from 5 to 15 m high. The gray unit rarely forms low cliffs, but generally forms slopes and rounded ridges or knolls covered by soil and vegetation. It is of unknown thickness as its base is not visible.

The similarity of the rhyolites over this entire area suggests that they consist of no more than two or three large flows. This situation would be unusual because rhyolite flows are not normally extensive. The flows may have originally coalesced and covered the area as one (as the flows of the Thomas Range appear to do), but subsequentty were eroded into separate outcrops. Staatz and Carr (1964) have proposed a similar process for the Thomas Range rhyolites. They identified at least five vents for those flows.

MINERALOGY

The following descriptions cover the general characteristics of the various minerals of interest as they occur throughout both the northern and southern areas. Unique features characteristic of some localities will be fully described in the locality section.

Topaz

Topaz, most popular of all of the minerals of the rhyolites, is responsible for luring most collectors to the Thomas Range. This mineral occurs in beautiful gem quality crystals that are an attractive addition to any collection. Color varies from a light yellow to a dark amber or sherry wine color. In a few areas, the crystals are of a rose or pink color. Unfortunately the yellow to sherry color crystals are subject to fading to colorless if exposed to sunlight or heat. Direct sunlight can fade the crystals to colorless in a few days, but the color will last indefinitely if exposed only to normal levels of artificial light. Because of this fading, all crystals found weathered out of the rocks are colorless. It is necessary to break the rock to find the richly colored specimens.

The morphology of the crystals can be complex. Several faces have been identified (Alling 1887), including two prisms {110} and {120}, four pyramids {223}, {111}, {221} and {441}, a pinacoid {010}, a basal pinacoid {001} and two domes (prisms) {021} and {041}, and others. To some degree, it is possible to determine the locality of crystals, from a few of the localities, by their morphology.

Crystals occur as singles or clusters of intergrown crystals. Some are doubly terminated. They may occur as floaters or near floaters or may be attached to the rhyolite along one edge or base. The attachment may consist of the base being firmly attached, or, more commonly, the attachment consists of rhyolite and quartz inclusions grading into a granular rhyolite matrix. In such cases the inclusions may be in layers representing where the crystal grew through the multilayered lithophysae into the open cavity. This type of attachment is common and allows the crystal to readily become detached from the matrix. Good specimens of topaz on matrix are uncommon. Most of the best quality crystals occur in cavities concentrated along fractures.

Gem-quality crystals are abundant and can be found throughout the Thomas Range and less commonly in the southern ranges. Crystals average about 10 mm to 20 mm long and 4 mm to 6 mm across in the Thomas Range and one half that size in the southern occurrences. These can be collected by the hundreds in some localities. Larger crystals of gem quality, to 4 cm and more, occur rarely. Such occurrences exist over an area of only a few meters.

Much more common than fine quality crystals are gray "sandy" crystals. These are topaz with an abundance of inclusions. Penfield and Foote (1897) determined that the inclusions are microquartz crystals. The amount of quartz varies from a few percent to such a high percentage that it is not possible to see the topaz "matrix" of the crystal with the unaided eye. Such crystals have the topaz morphology and are commonly of the best euhedral quality, but most have poor terminations that display a ragged development. They occur as singles or clusters with an average size larger than the sherry-brown topaz. Specimens to 4 cm are common and they have been reported to 10 cm or more. In many areas, crystals in the 2 to 3 cm range can be picked up by the hundreds from the surface of the ground.

Sandy crystals are frozen in rhyolite and rarely occur in cavities. The rhyolite around the crystals is often of a soft sandy texture. It readily weathers away giving the exposed rock a cavity-filled appearance when in fact no cavities are present in unexposed rock.

Topaz may be found in combination with any of the other minerals that occur in the rhyolites. Crystals have been found with oriented bixbyite cubes attached, with red beryl attached or with pseudobrookite or hematite included or attached. Colorless to blue quartz commonly lines cavities containing topaz.

Bixbyite

The site of Maynard Bixby's original discovery of bixbyite was reported to be in the south end of the Dugway Range (Buranek, 1947) and in the northeast Thomas Range (Montgomery, 1934; and Staatz and Carr, 1964). The author believes the true location is in the northeastern Thomas Range at a location that is being worked commercially for topaz. Although known from several localities throughout the world, the finest specimens of bixbyite come from the Thomas Range.

This black manganese iron oxide crystallizes in the cubic system and has a submetallic luster. Crystals are almost always euhedral cubes which may be modified by the trapezohedron {211}, sometimes with octahedron faces {111}. Modifications are most common on the corners, but do occur along the edges of crystals from some localities. Interpenetration twinning on {111} is common.

***Figure 3*. A sherry-brown topaz crystal on rhyolite matrix from the Thomas Range. The crystal is 1.5 cm tall. Eric Offermann specimen and photo.**

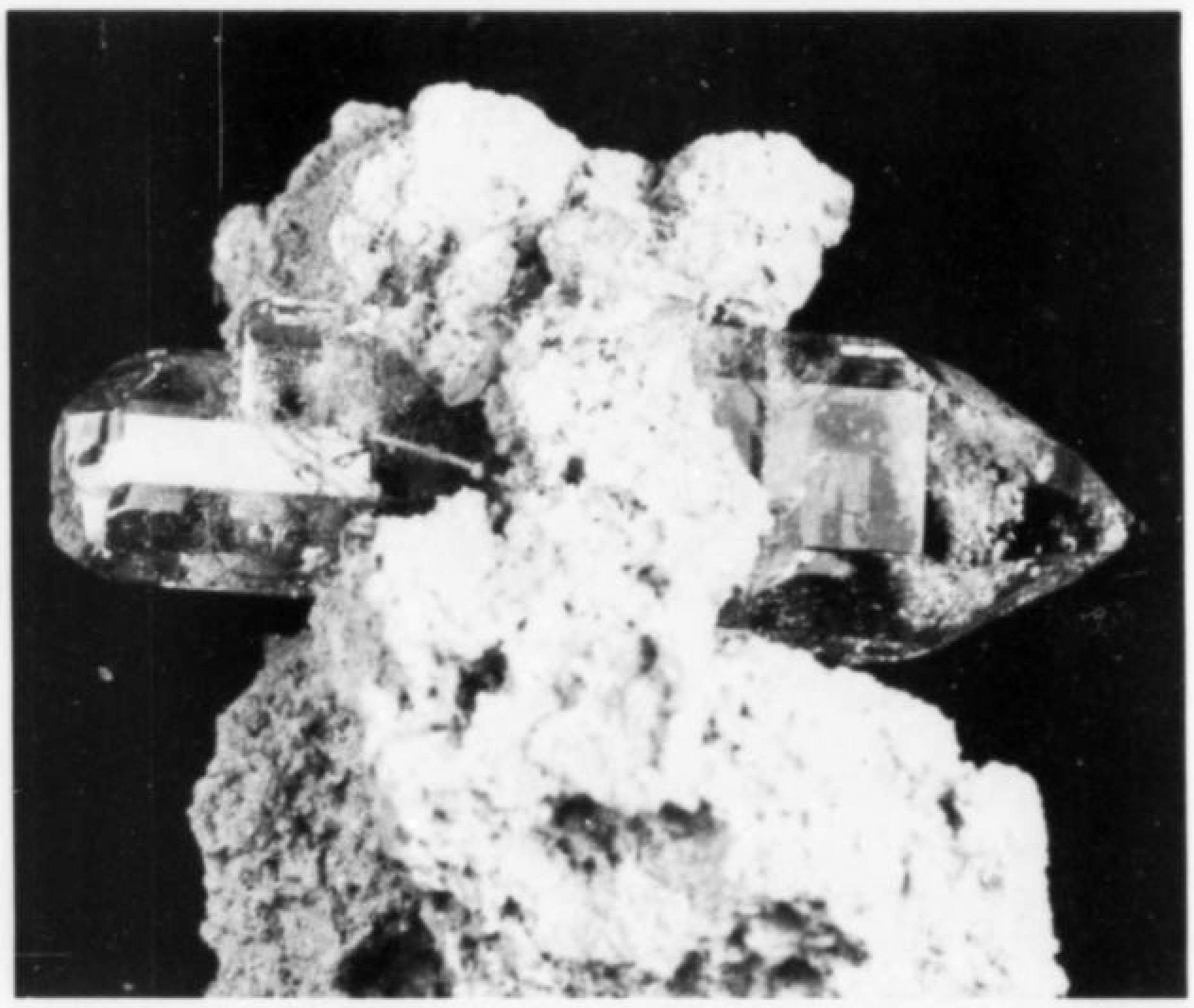

***Figure 4*. A doubly terminated, light sherry-colored topaz crystal piercing matrix from Topaz Valley in the Thomas Range. The crystal is 2.7 cm long. Specimen and photo: Lanny Ream.**

Figure 5. A blocky sherry-brown topaz crystal 1.2 cm across from Ponderosa Park. Specimen and photo: Lanny Ream.

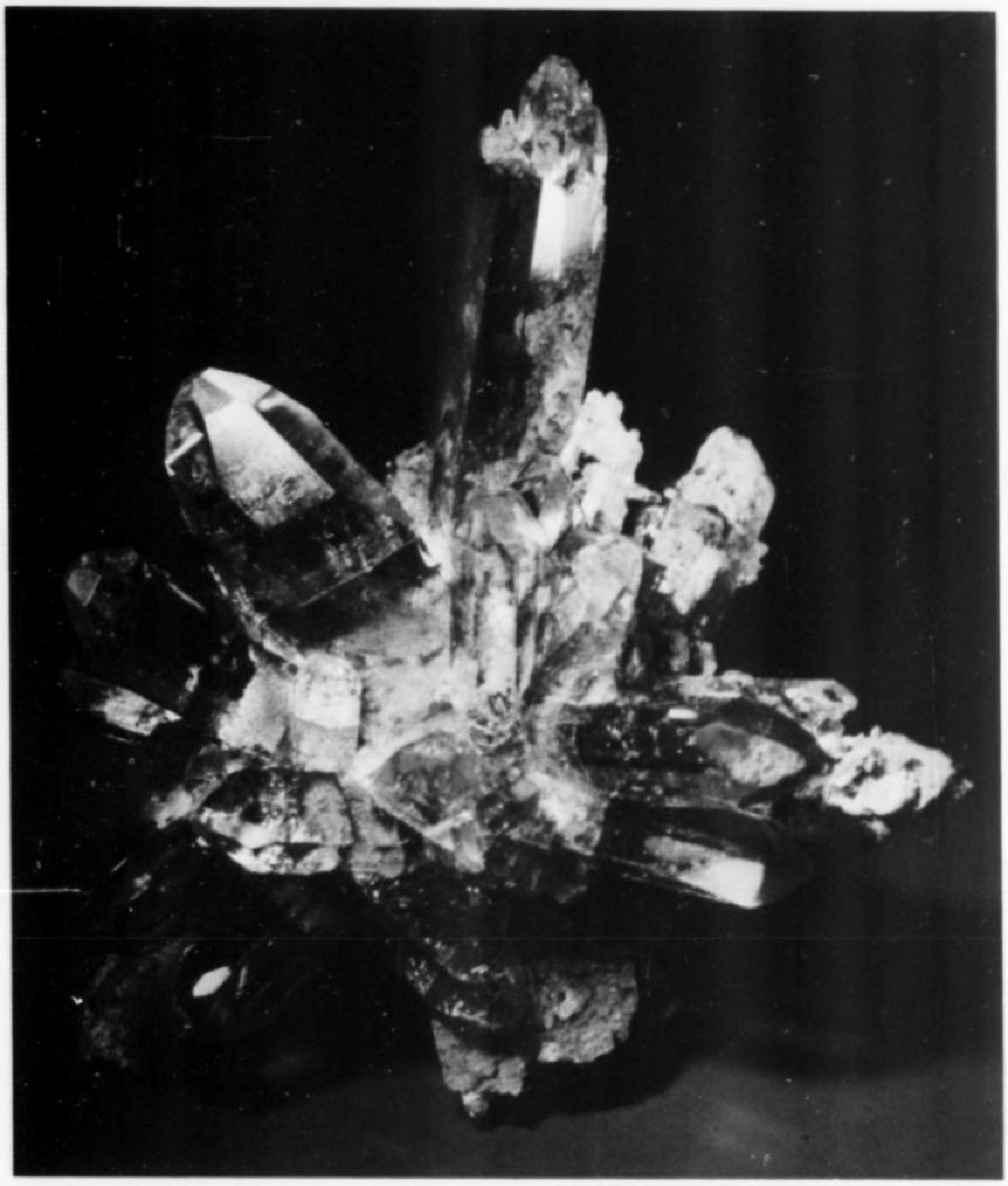

Figure 7. A superb group of topaz crystals on matrix from the Thomas Range. This group, measuring 2.5 cm tall, was collected by Ed Over. Smithsonian specimen.

Figure 6. Topaz crystals, the largest 2.9 cm tall, on matrix, from the Thomas Range. John Holfert specimen.

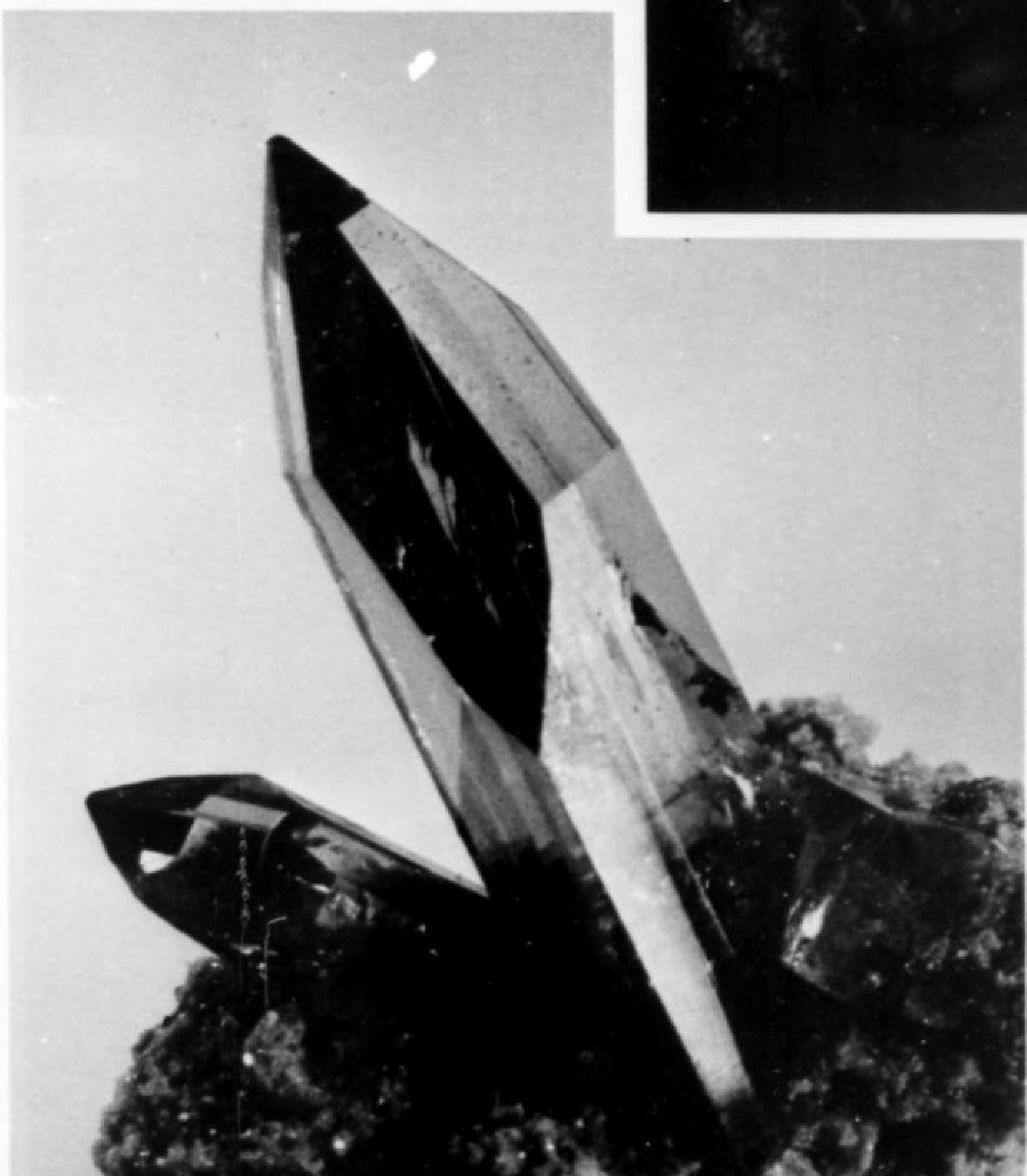

Figure 8. Sherry-brown topaz crystals to 1.4 cm from Modena Canyon. Specimen and photo: Lanny Ream.

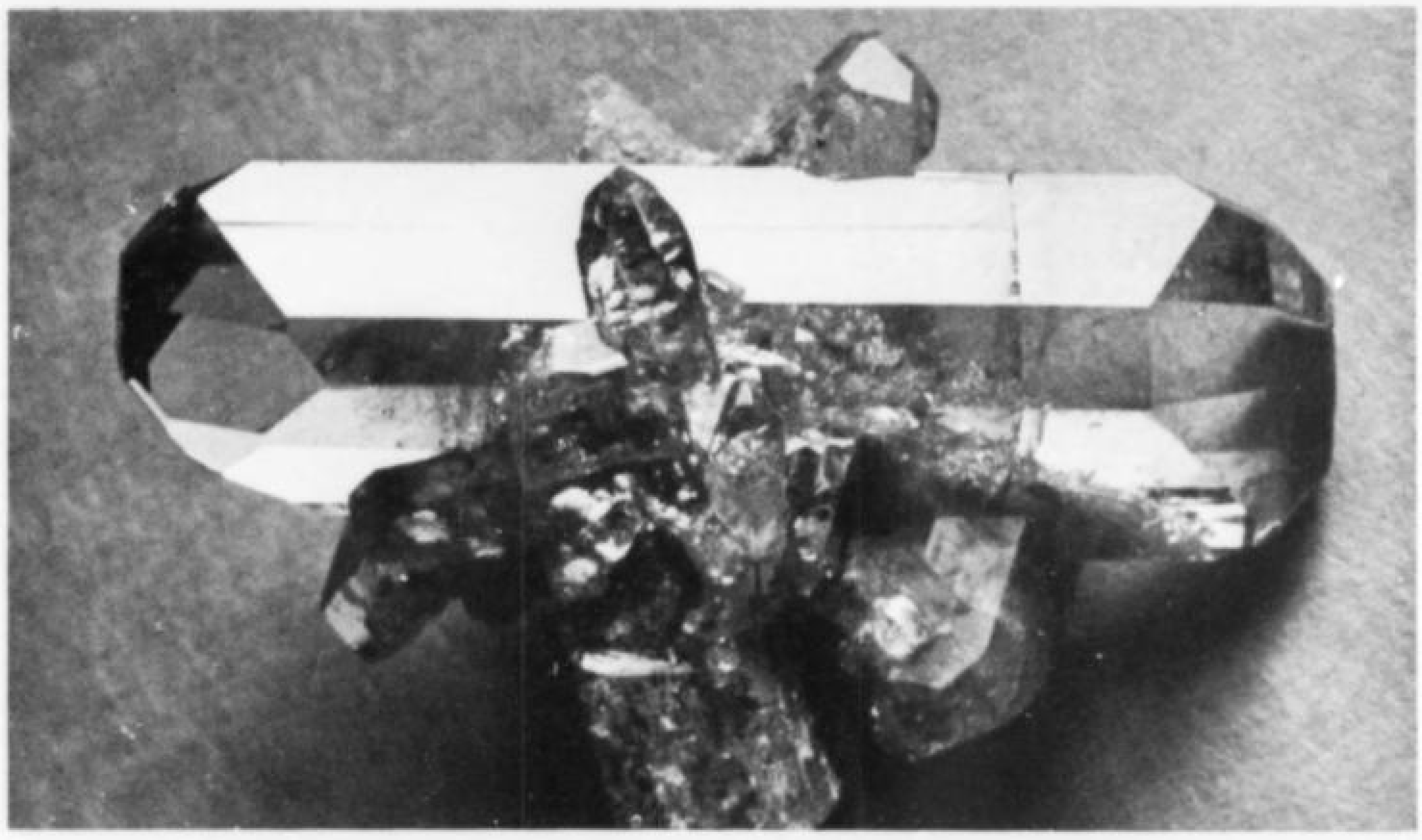

Figure 9. Large pale sherry-brown topaz crystal measuring 4.2 cm, from the Thomas Range. Specimen and photo: Lanny Ream.

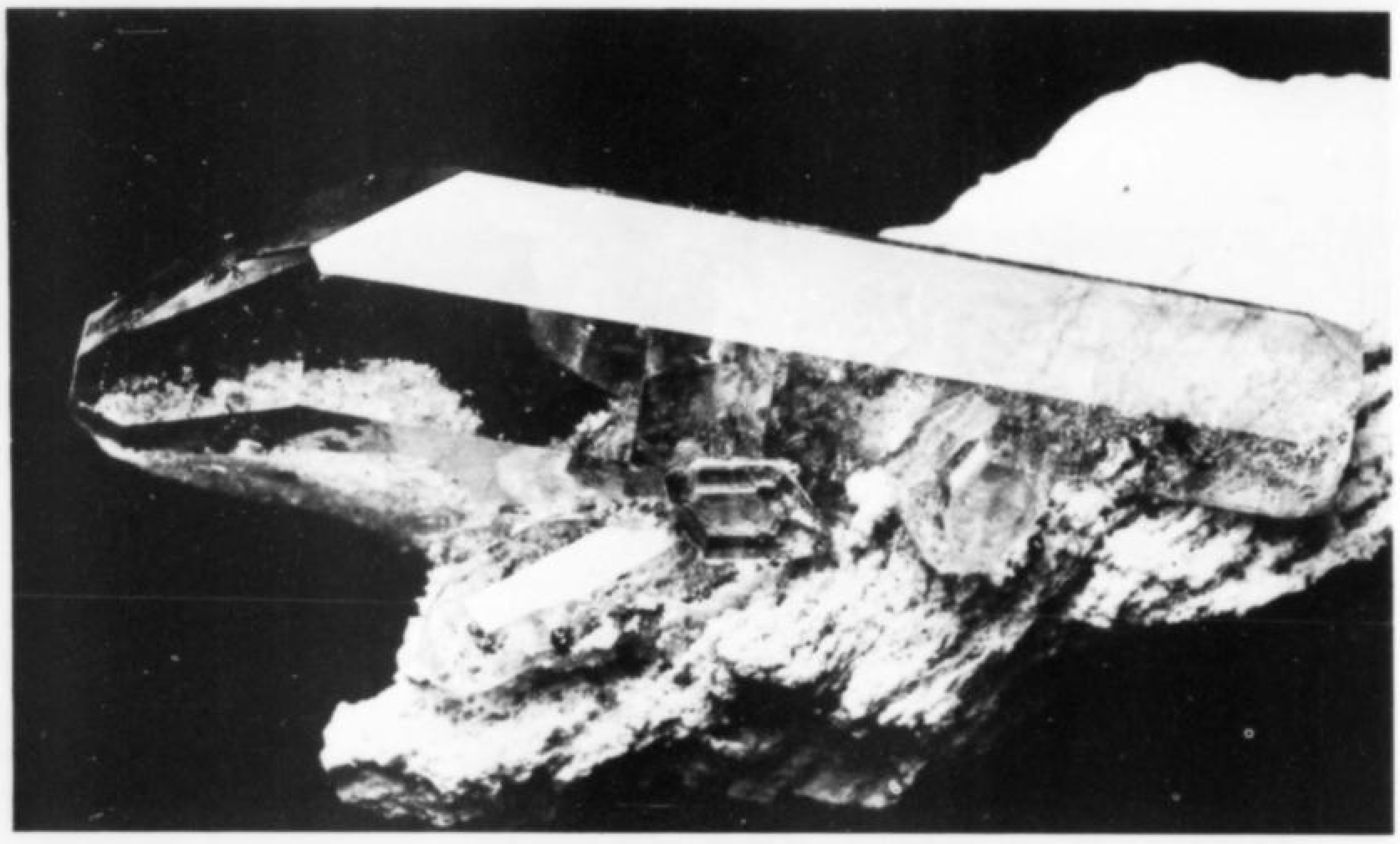

Figure 10. Large sherry-brown topaz crystal measuring 3.6 cm, from the Thomas Range. Specimen and photo: Lanny Ream.

Figure 11. The best topaz crystals from a single pocket in the Thomas Range. The crystal at center (seen in Fig. 9) is 4.2 cm. Specimen and photo: Lanny Ream.

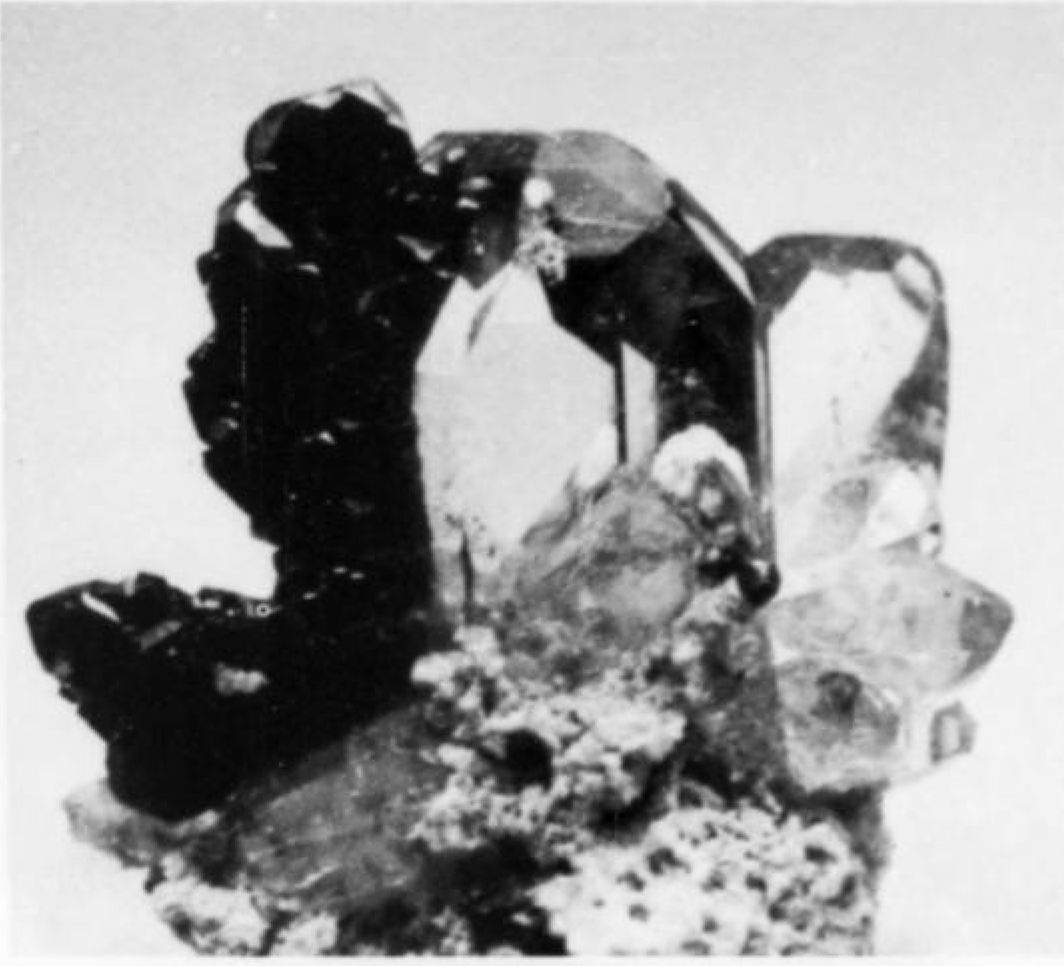

Figure 12. Tabular bixbyite 1.2 cm tall perched on topaz from the Thomas Range. Mike Sprunger specimen.

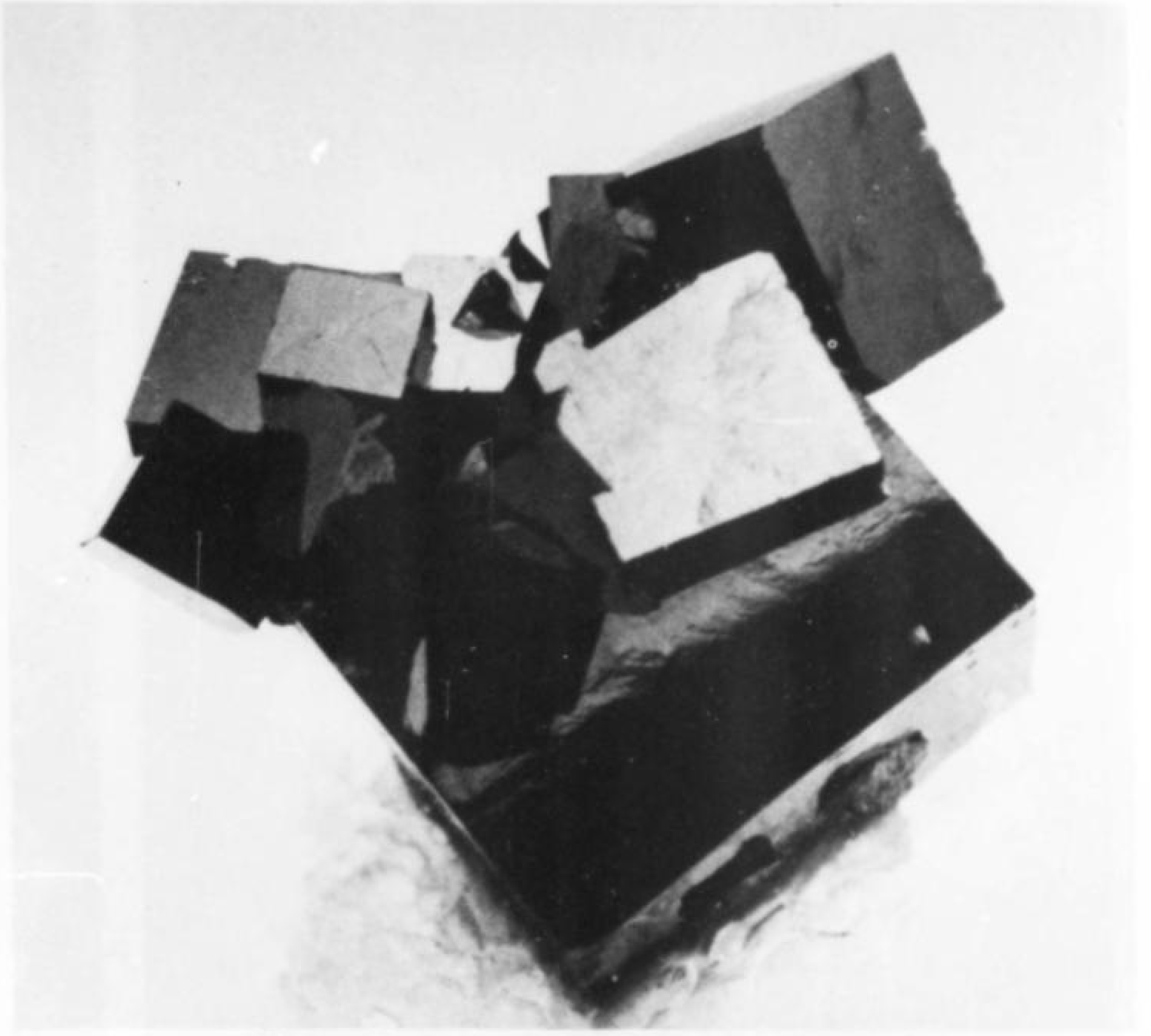

Figure 13. An extraordinary group of large bixbyite crystals, the largest crystal measuring 1.1 cm on edge. Ken and Betty Roberts specimen.

Figure 14. Two bixbyite crystals, the largest 5.5 mm, perched on a topaz crystal from the Thomas Range. Mike Sprunger specimen.

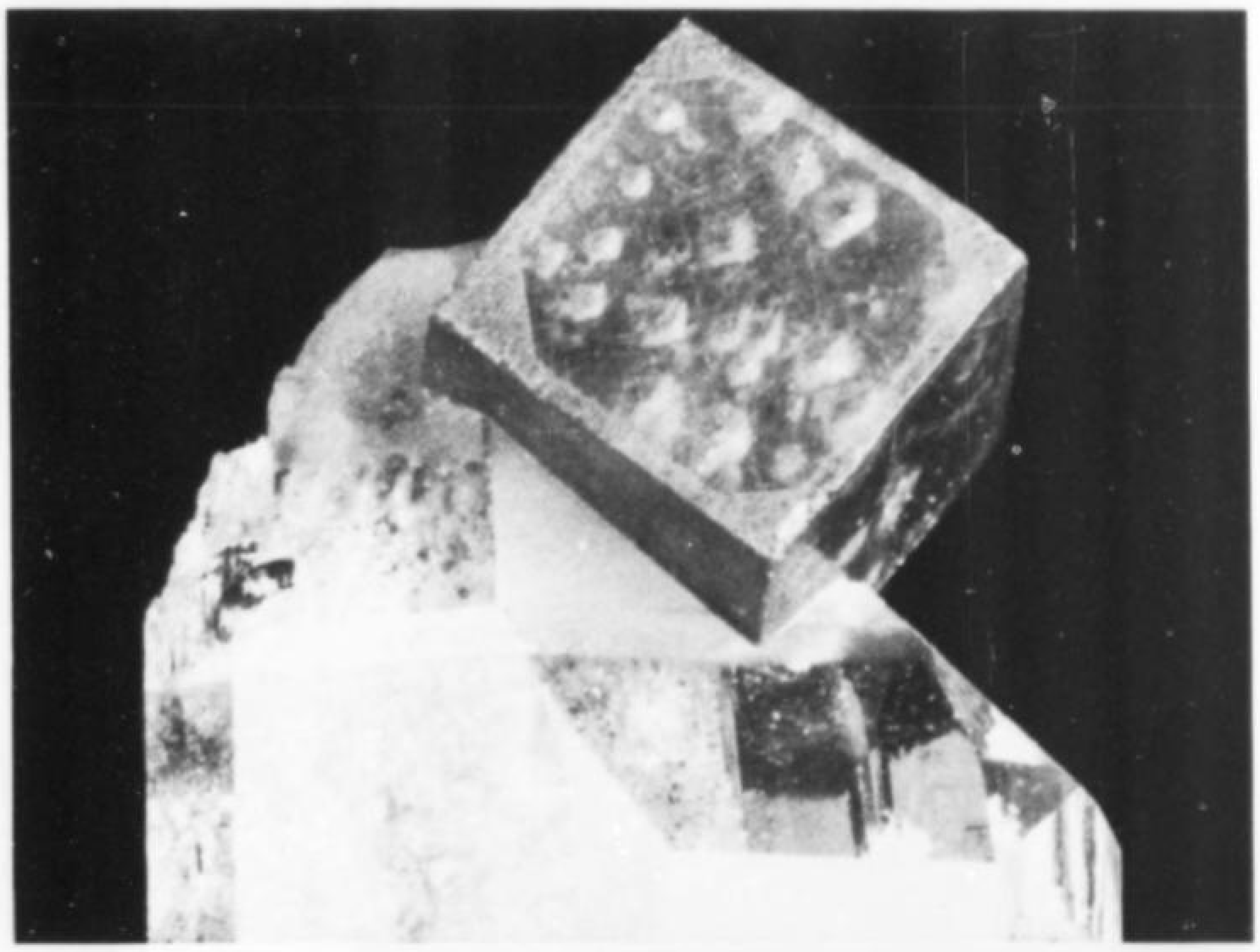

Figure 15. A 6.2-mm bixbyite crystal showing surface features, perched on a topaz crystal, from the Pismire Knolls. Specimen and photo: Lanny Ream.

Figure 16. An 8-mm bixbyite crystal showing surface features, from the Thomas Range. Specimen and photo: Lanny Ream.

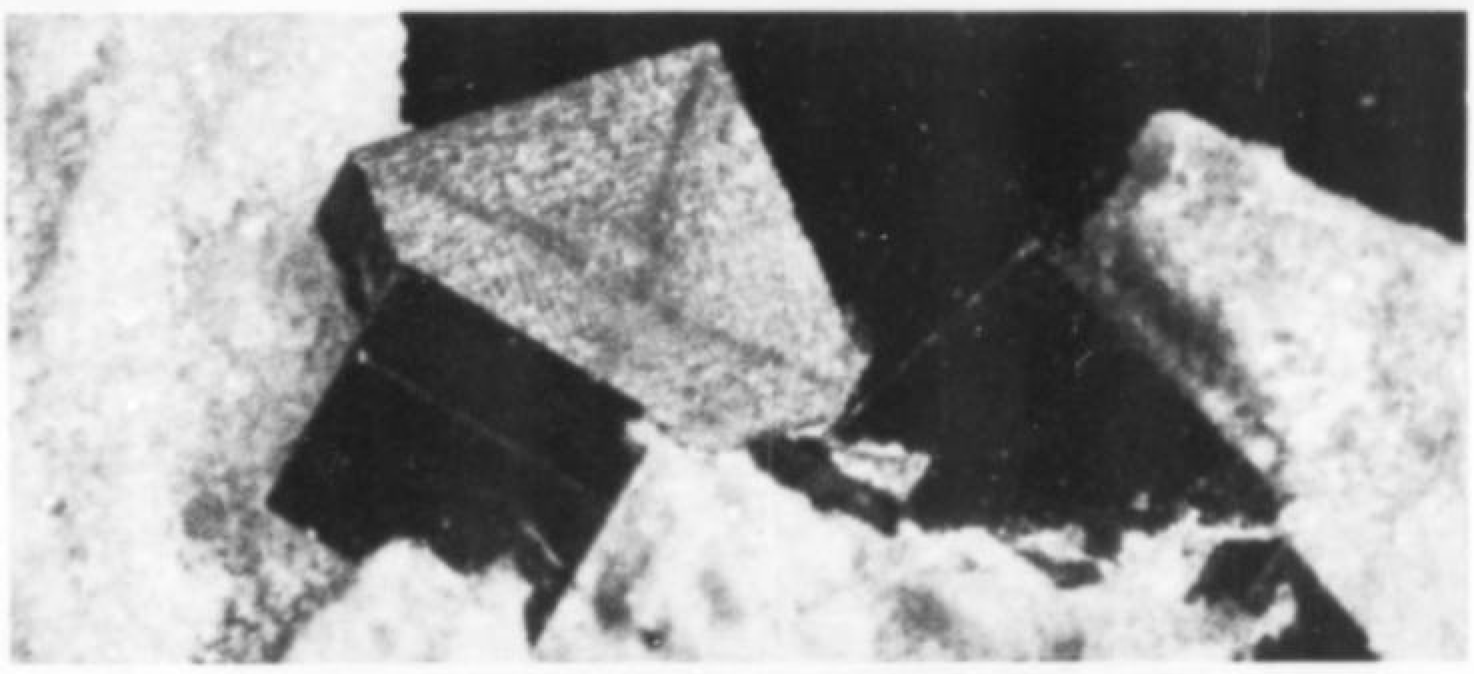

Figure 17. A bixbyite crystal displaying an "X" on the cube face. All faces of the cube show a similar feature. The crystal, 2.6 mm across, is from the Pismire Knolls. Specimen and photo: Lanny Ream.

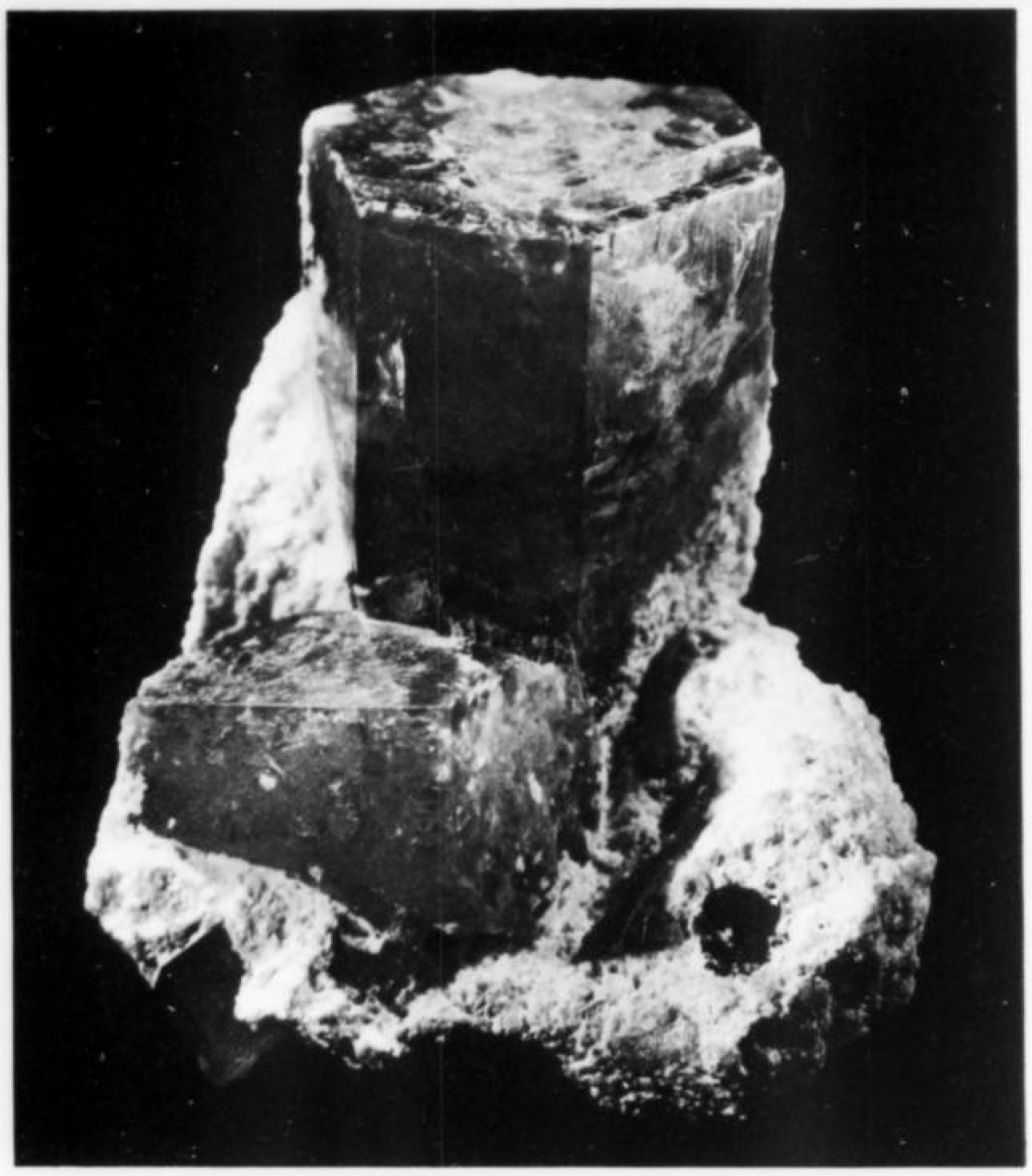

Figure 18. **Red beryl crystals with bixbyite on rhyolite matrix from the Wah Wah Mountains. The specimen is 2.7 cm tall. Gerhard Becker specimen; photo by Olaf Medenbach.**

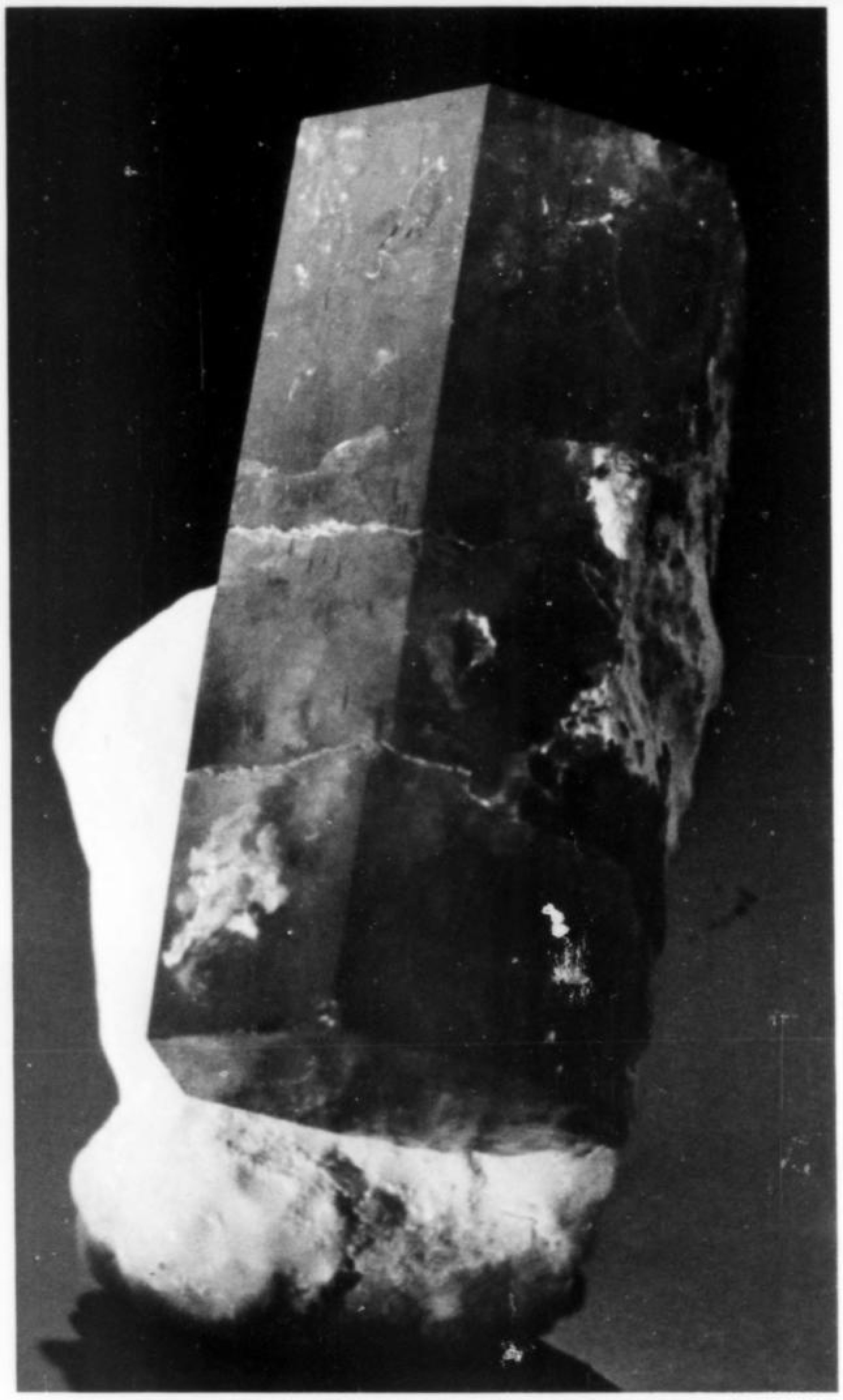

Figure 19. **A single, extraordinarily large crystal of red beryl 2.5 cm tall on matrix from the Violet claims in the Wah Wah Mountains. Harris specimen; photo by Dane Penland.**

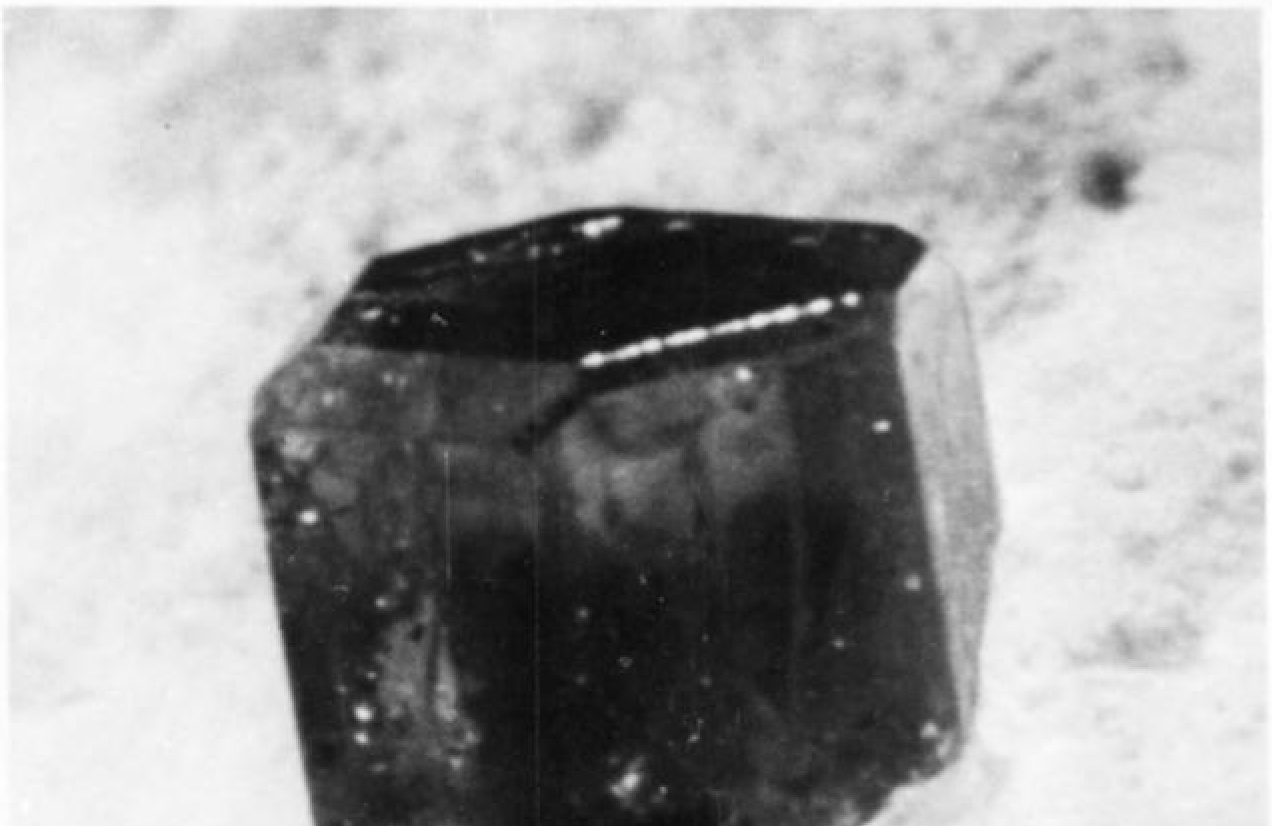

Figure 20. **A single, very gemmy crystal of red beryl on kaolinite matrix from the Violet claims, Wah Wah Mountains. The crystal measures about 5 mm. Harris specimen; photo by Dane Penland.**

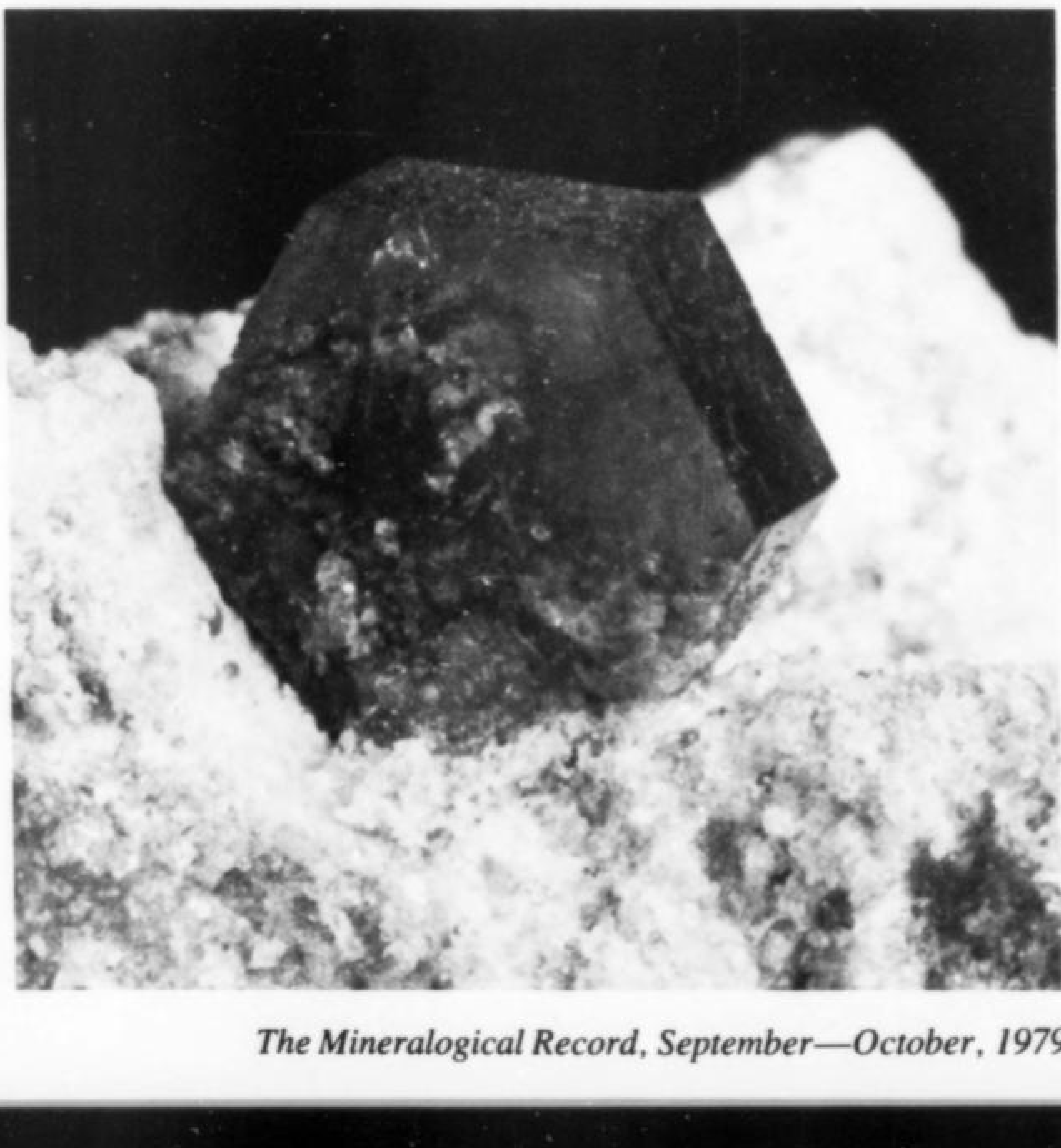

Figure 21. **A tabular red beryl crystal 6.5 mm across on rhyolite matrix from the west side of Topaz Valley in the Thomas Range. Specimen and photo: Lanny Ream.**

A few cubes from one locality display numerous flat-topped peaks on the faces and modifications along the edges. These peaks appear to be built up by vicinal faces terminated by cube faces. Other crystals from the same area display an "X" on each cube face, which may be due to twinning. At least one locality produces crystals that are tabular. Typically, several tabular crystals are combined forming a "chain".

At most localities, bixbyite crystals are less than 2 mm across and rarely 4 to 7 mm. One small deposit produces crystals to more than 12 mm. Generally it is rare to find a specimen with more than one cube over 4 mm across, but the one deposit produces specimens with several cubes over 7 mm on a small cabinet size matrix.

Bixbyite occurs on topaz, commonly oriented. The orientation is such that the topaz *c* axis is parallel to an imaginary line drawn from opposite corners across a cube face. Multiple oriented cubes with corners touching may form a "necklace" around a topaz prism. This mineral occurs with all of the other minerals and may be perched on beryl or be penetrated by pseudobrookite blades.

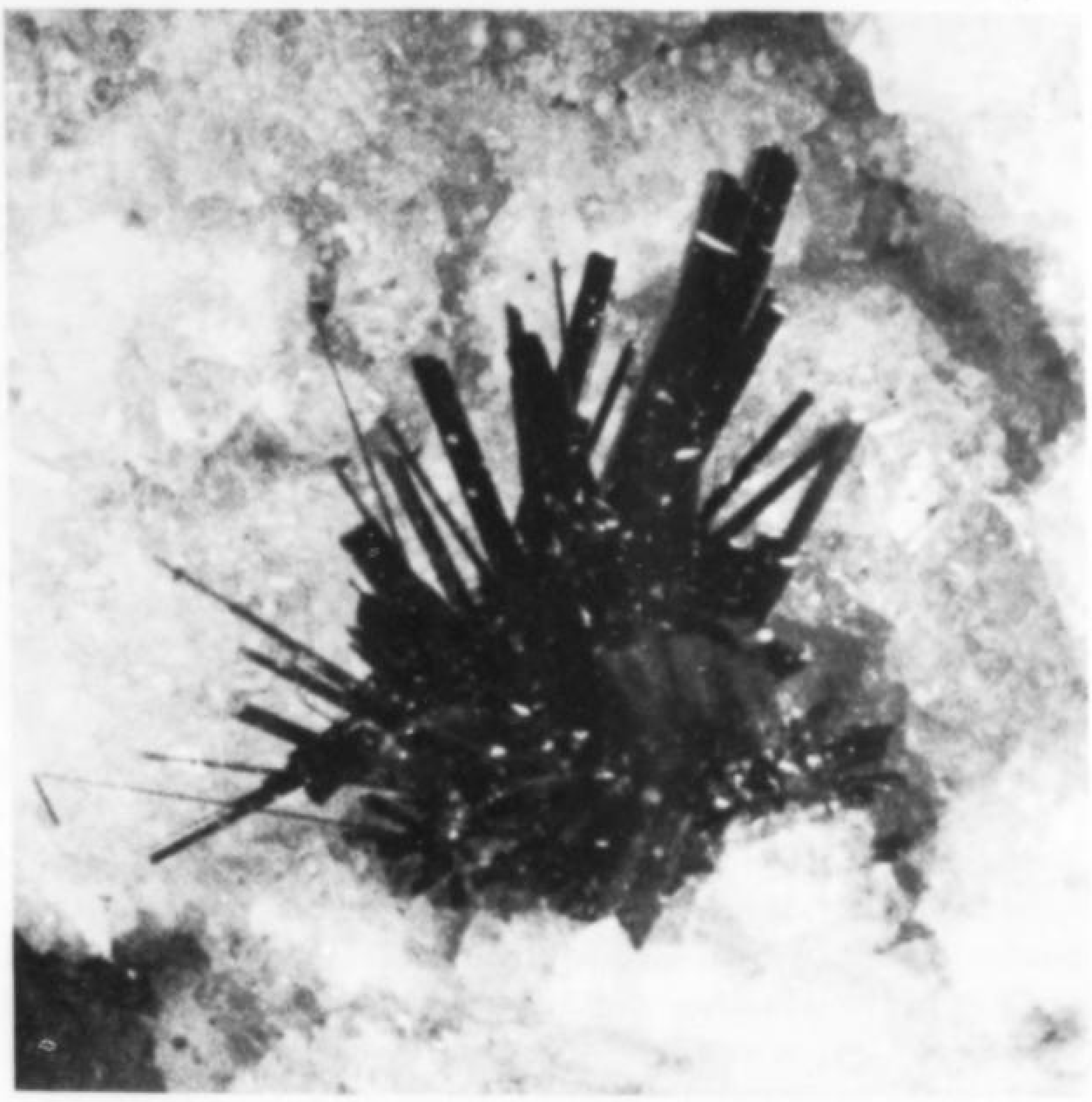

***Figure 22.* A typical cluster of pseudobrookite crystals 7 mm across from Topaz Valley in the Thomas Range. Specimen and photo: Lanny Ream.**

Beryl

The red beryl in the rhyolites of the Thomas and Wah Wah Ranges can be found at several localities. Beryl of any sort occurring in rhyolite is a rare type of occurrence. It has been reported from San Luis Potosi, Mexico, the Black Range, New Mexico, and East Grants Ridge, Valencia County, New Mexico (Johnstone, 1953).

Beryllium occurs on the southern and western flanks of Spor Mountain just west of the Thomas Range. The world's largest deposit of bertrandite occurs in the Tertiary sedimentary rocks of this small range. There are no other deposits of beryllium known near the Wah Wah Mountain red beryl occurrence. A few light blue-green beryl crystals have been found in pegmatites in granites in the Mineral Mountains 35 miles to the northeast.

Beryl crystals vary from a pink to bright red or raspberry red color. Most of the pink crystals have a sugary texture and quartz inclusions. A few crystals are of gem quality and have been cut into faceted stones. Such stones are pink to red, but usually lack brightness.

At most locations crystals are tablet shaped, that is the *c* dimension is shorter than the *a*. Crystals have a prismatic habit in the Wah Wah Range and at one location in the Thomas Range. They are simple and consist of only the basal pinacoid and the hexagonal prism. Tablet shaped crystals average less than 4 mm across, but have been found to more than 10 mm. A crystal 4 mm across the *c* face will be only about 1.5 mm along the *c* axis. Prismatic crystals average about 10 mm long in the Wah Wah Range and occur to 25 mm; in the Thomas Range they average about 4 mm long and occur to 20 mm.

The prismatic crystals, commonly in clusters, are concentrated along veins that are fracture-controlled, and the tabular crystals occur in vugs. The latter occur as singles or rarely clusters free-floating or on matrix. The tabular crystals are usually weakly attached, so that matrix specimens are relatively uncommon. Prismatic crystals occur with no other minerals, but tabular crystals may be in combination with any of the other minerals. Bixbyite or topaz may be perched on a beryl crystal or a beryl crystal may be perched on a topaz, garnet or bixbyite crystal.

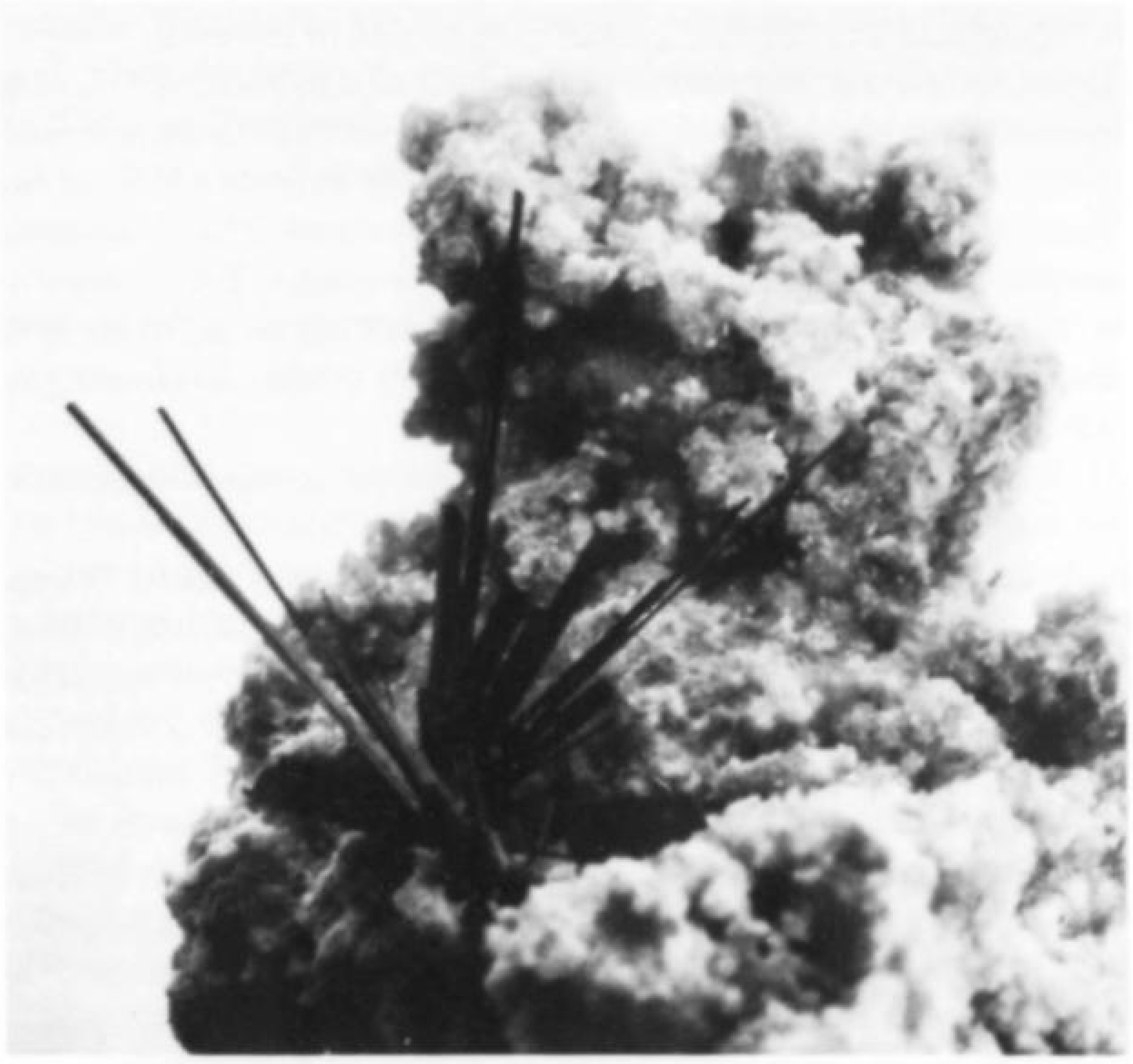

***Figure 23.* Pseudobrookite crystals, the longest 1.2 cm, from the Thomas Range. Mike Sprunger specimen.**

Pseudobrookite

This iron titanium oxide is common in the rhyolites of western Utah where it occurs as black crystals with a submetallic luster. Most crystals are elongated as slender, small blades and needles. They rarely reach a length of 10 mm and are usually less than 1 mm across. Crystals occur as singles or as groups radiating from a common point. The groups have been found to 5 cm across and extraordinarily large singles to 7 cm have been collected. The largest and most abundant occurrences are in cavities concentrated along fractures.

Pseudobrookite most commonly occurs as single crystals less than 4 mm long with topaz or as small radial groups. In the locations where the groups are numerous there may be some quartz, hematite or topaz, but rarely other minerals. It does occur with all of the other minerals, but is less common with red beryl and garnet. Topaz, bixbyite, hematite and red beryl are often penetrated by pseudobrookite.

Garnet

Anhedral to euhedral crystals of garnet are common in the rhyolites of the Thomas Range and occur in the Drum Mountains. The author did not identify any in the southern area, but Patton (1908) reported their occurrence near Gold Spring, Utah, in Lincoln County, Nevada. This is only a few miles west of the Modena, Utah, topaz area and may be in related rhyolites.

Crystals are most commonly rounded and poorly formed, but may be sharp euhedral crystals of trapezohedral habit, commonly with dodeca-

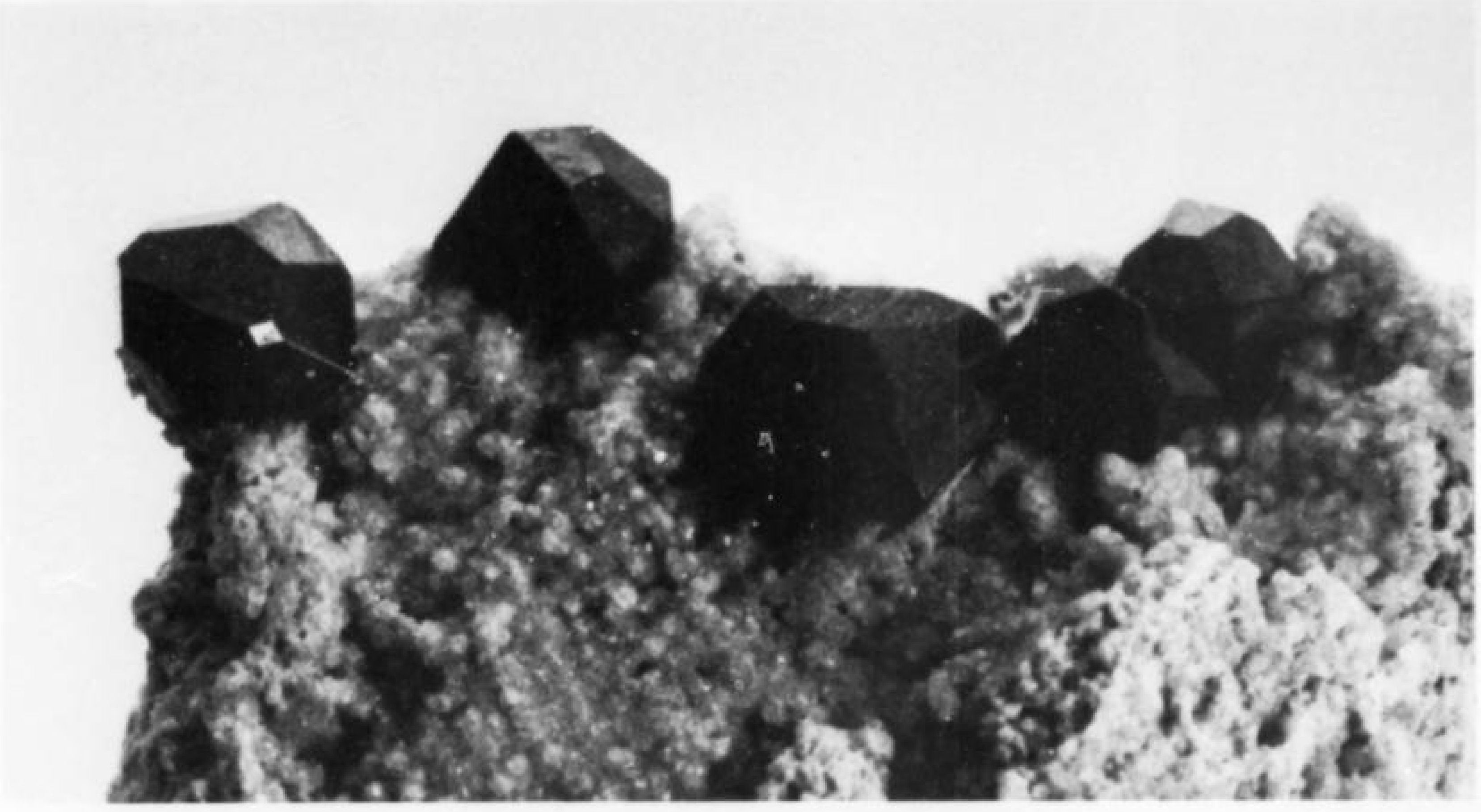

Figure 24. **Reddish black garnet crystals on matrix from the Thomas Range. The largest crystal is 7 mm. Mike Sprunger specimen.**

hedral modifications. Octahedrons to 6 mm have been found at three localities (John Holfert, pers. comm.). The euhedral crystals are dark reddish-brown color and are rarely translucent. They are common to 4 to 7 mm and have been reported to 3 cm as euhedral crystals. Anhedral crystals have been found to 6 cm or more as singles or clusters. They have either a semi-smooth round or irregular shape comprised of a sort of skeletal growth intergrown with the rhyolite matrix. These skeletal crystals can be rotated in the light so that a multitude of small faces will reflect light simultaneously revealing a trapezohedral face composed of the small faces. Other anhedral crystals have a pitted or irregular surface that does not show crystal forms.

At several localities the garnets are replaced or altered to bixbyite, topaz, quartz and manganese oxide (Penfield and Foote, 1897). The alteration may be only a surface crust or may involve the entire crystal. They are usually rounded and are a brownish to black color. In two locations, these altered garnets have an overgrowth of small topaz crystals. The topaz appears to be epitaxially oriented so that it is possible to identify the morphology of the garnet by studying the topaz. Bixbyite cubes occur as singles or multiples often nearly completely covering the altered garnets at two of the locations.

Garnets occur in lithophysae or other cavities or frozen in the rock. Crystals frozen in the rock are anhedral to subhedral.

Present day collectors and prveious writers generally call the Thomas Range garnets spessartine. Staatz and Carr (1964) studied the index of refraction and composition of Thomas Range garnet by spectrographic methods. From these studies, they suspect that the garnet is comprised of composition intermediate between spessartine and almandine.

At most locations, garnets occur as the primary mineral with little or no quartz, topaz or hematite. The altered garnets occur with epitaxial topaz overgrowths and/or bixbyite coatings and topaz and hematite. Red beryl has been reported as being rarely attached to garnets.

Hematite

Hematite is common in the rhyolites as paper-thin hexagonal or irregular plates or blades. They may occur in singles or groups, sometimes as fan-like growths. Most commonly the crystals are 3 to 4 mm across but have been reported to 20 mm or more. In a few locations they are thick enough so that rhombohedrons beveling the edge of the plate or blade can be seen with the unaided eye. Some hexagonal plates are skeletal. The crystals have a dull to submetallic luster and are black in color.

At some localities ilmenite is present in place of hematite. Such crystals have the same morphology as hematite and they can not be readily distinguished.

Hematite (and ilmenite) is very common and occurs with all minerals. It is often included in or on topaz and on altered garnets.

Quartz

Quartz lines lithophysal cavities in most areas. Crystals are stubby, often doubly terminated and are normally 2 to 3 mm long and rarely

Figure 25. **Dark red garnet crystal 1.0 cm across with topaz on matrix from the Thomas Range. Mike Sprunger specimen.**

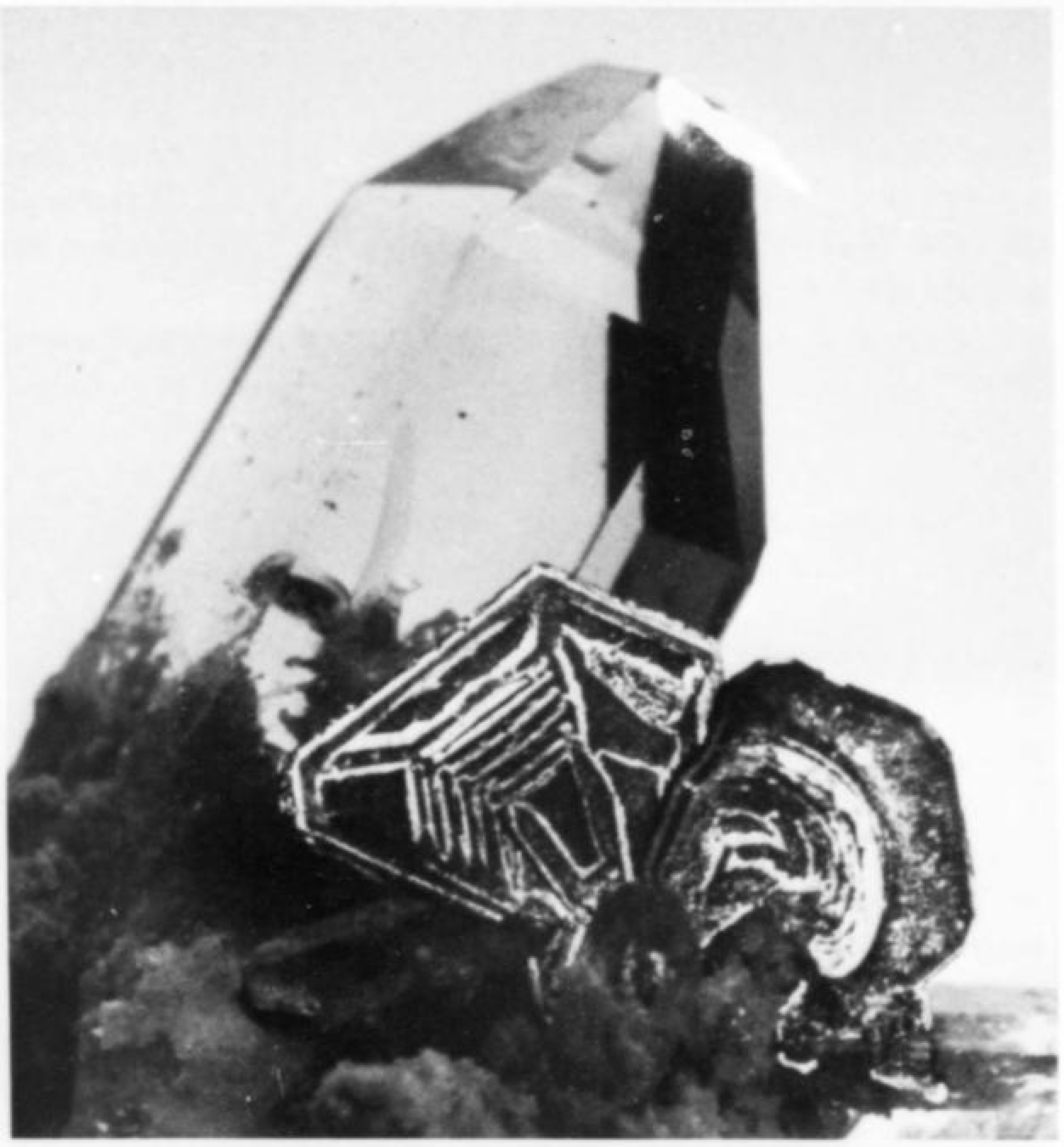

Figure 26. **Thin platy crystal of hematite with skeletal surface features, 1.2 cm across, with topaz from the Thomas Range. Mike Sprunger specimen.**

Figure 27. **Thin platy crystal of hematite 1.1 cm across on matrix from the Thomas Range. Mike Sprunger specimen.**

over 5 mm long. In most areas they are colorless to pale blue but are sometimes medium blue. They are associated with all of the other minerals and often provide excellent blue matrices for them.

Fluorite

Colorless, violet, and purple fluorite occur throughout the rhyolites, but has not been found in abundance at any locality in them. Economic deposits are known in carbonate rocks in the Spor Mountains. Small deposits of subeconomic size occur in carbonate rocks in the Wah Wah Mountains northwest of the topaz areas.

Fluorite is generally finely crystalline and forms a thin coating on other minerals or on rhyolite. Rarely, individual crystals reach 2 mm or more in size and can be distinguished with the unaided eye. Buranek (1947) reported that a few green specimens were found in Topaz Valley south of Topaz Mountain.

Orthoclase

Small sanidine crystals rarely occur in cavities with topaz and quartz. Generally they are well formed and either colorless or white. A few specimens of a light bluish-gray color have been collected. Most are less than 3 mm long and are abundant in the cavities in which they occur.

Calcite

White calcite occurs in a few localities as small rhombohedral crystals or irregular masses. It coats the other minerals or fills cavities.

Opal

Opal (hyalite) is common as thin botryoidal crusts or masses on other minerals. Although normally colorless, it does grade into milky or white opal. Under an ultraviolet light, specimens fluoresce green.

Crusts of white opal (or chalcedony in some areas) are locally common in fractures. These crusts are 2 to 15 mm thick and have a rough irregular surface. They also fluoresce green.

Weeksite

The rare uranium silicate, weeksite, occurs at a small prospect, the Autunite No. 8 claim, on the east side of Topaz Mountain. It is not related to the minerals described (except that uranium is probably the activator in the fluorescent opal) but does occur in the volcanic rocks adjacent to topaz bearing rhyolites. Many collectors will be interested in this mineral and may want to collect some specimens. The Autunite No. 8 claim is one of the type localities for weeksite (Outerbridge, *et al.*, 1960).

Weeksite occurs as rosettes of yellow needle-like crystals averaging about 1 mm across. They are generally coated with a clear to bluish opal. The occurrence is in a brown porphyritic rhyolite along joints and fractures. Locally it is abundant, but good specimens are not easy to find. Rhombehedral crystals of white calcite and colorless to purple fluorite crystals occur sparingly in the fractures.

PARAGENESIS

Most of the minerals were deposited throughout much of the mineralization period. They are often intergrown and deposited on each other so that a precise paragenetic sequence can not be readily determined. Table I shows the approximate paragenetic sequence.

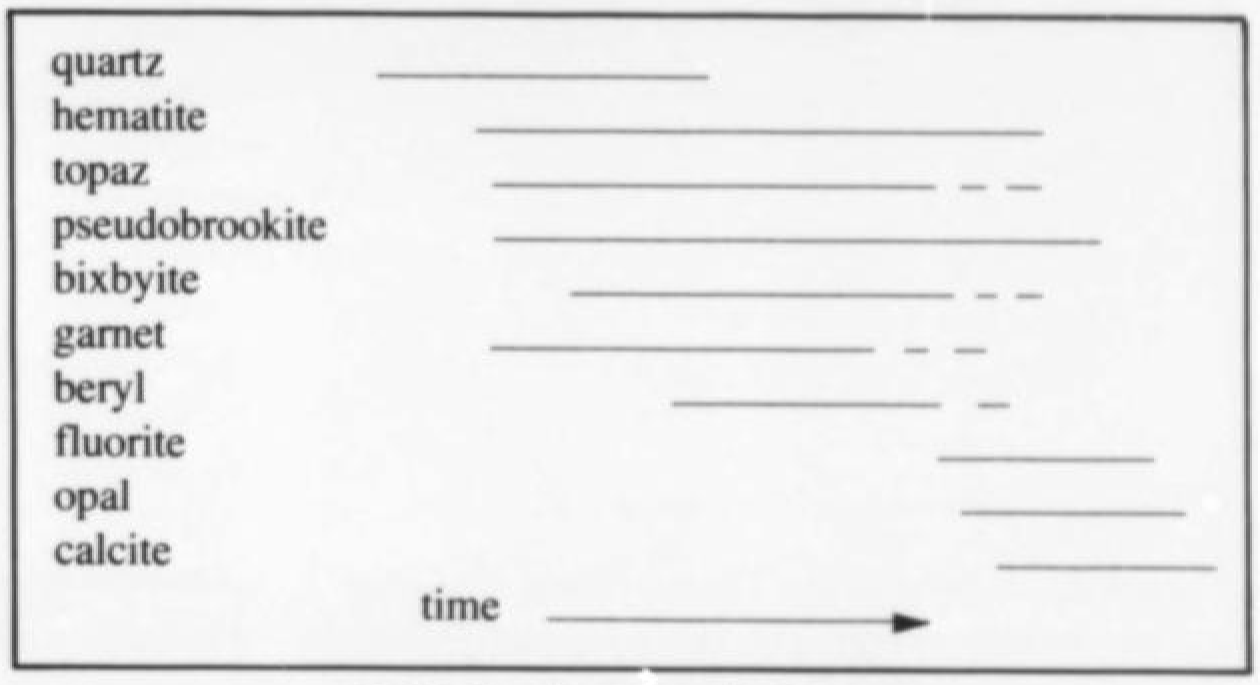

Table I. Paragenetic Sequence

LOCALITIES AND OCCURRENCES—NORTHERN RANGES

Thomas Range

The Thomas Range contains the best localities and produces the best quality specimens, with the exception of red beryl. There are several specific locations in the range which produce specimens of a quality much better than the average. Unfortunately for the field collector, most of these are on mining claims which are being worked commercially. The author was allowed to visit, in most instances was guided to, these locations to obtain data for this article.

Most of the best localities are on the edges of the range. This is not due to actual occurrence, but is only because of the difficulties of access. There are areas with topaz or other minerals exposed on the surface in remote regions. It is expected that some of these could produce specimens of quality and quantity equal to those of the best known locations. It requires either a long walk or very expensive road construction to get to these. The economic return will not allow such an investment and the long hike, coupled with the difficulty of producing a quantity of specimens by hand, prevents the interior locations from competing with those on the edges of the range. They will produce a few crystals for the satisfaction of self-collecting.

By far the single best area in the range is Topaz Mountain. This highest and southernmost mountain of the range is easily accessible from the paved road from Delta. The collecting area is a broad valley on the south side of the mountain. To most collectors familiar with it, it is known as Topaz Valley or "The Cove" (Fig. 29). It is an area of sparse vegetation as is most of the Thomas Range. Steep ridges with near vertical cliffs form the sides of the valley.

The west side of the valley consists of a curving northwesterly to northerly-trending wall. It rises quite steeply from the valley floor. There are five excellent areas on the wall that produce crystals. All of them are accessible by a trail from the end of the road and are in the NE¼ Sec 17 and SW¼SE¼ Sec 18, T13S, R11W. The best locations are three prominent pits that have been worked for topaz, bixbyite and red beryl. The most southerly pit is about 150 m above the valley floor. The other two pits are approximately 100 and 200 m to the north at the same elevation.

Topaz crystals to 3 cm or more can be found in lithophysae in the first pit. They are usually of the finest quality and darkest color. Most are good gem quality in part. The non-gem part contains quartz and rhyolite inclusions where the crystal is loosely attached to the cavity wall. Few crystals can be collected on matrix. Cavities occur throughout the rock but are concentrated along two sets of fractures. The largest of which

Figure 28. **A view of the Thomas Range looking approximately north. The bowl-shaped depression occupying the right side of the range is Topaz Valley, sometimes known by collectors as "The Cove." Photo by Richard W. Thomssen.**

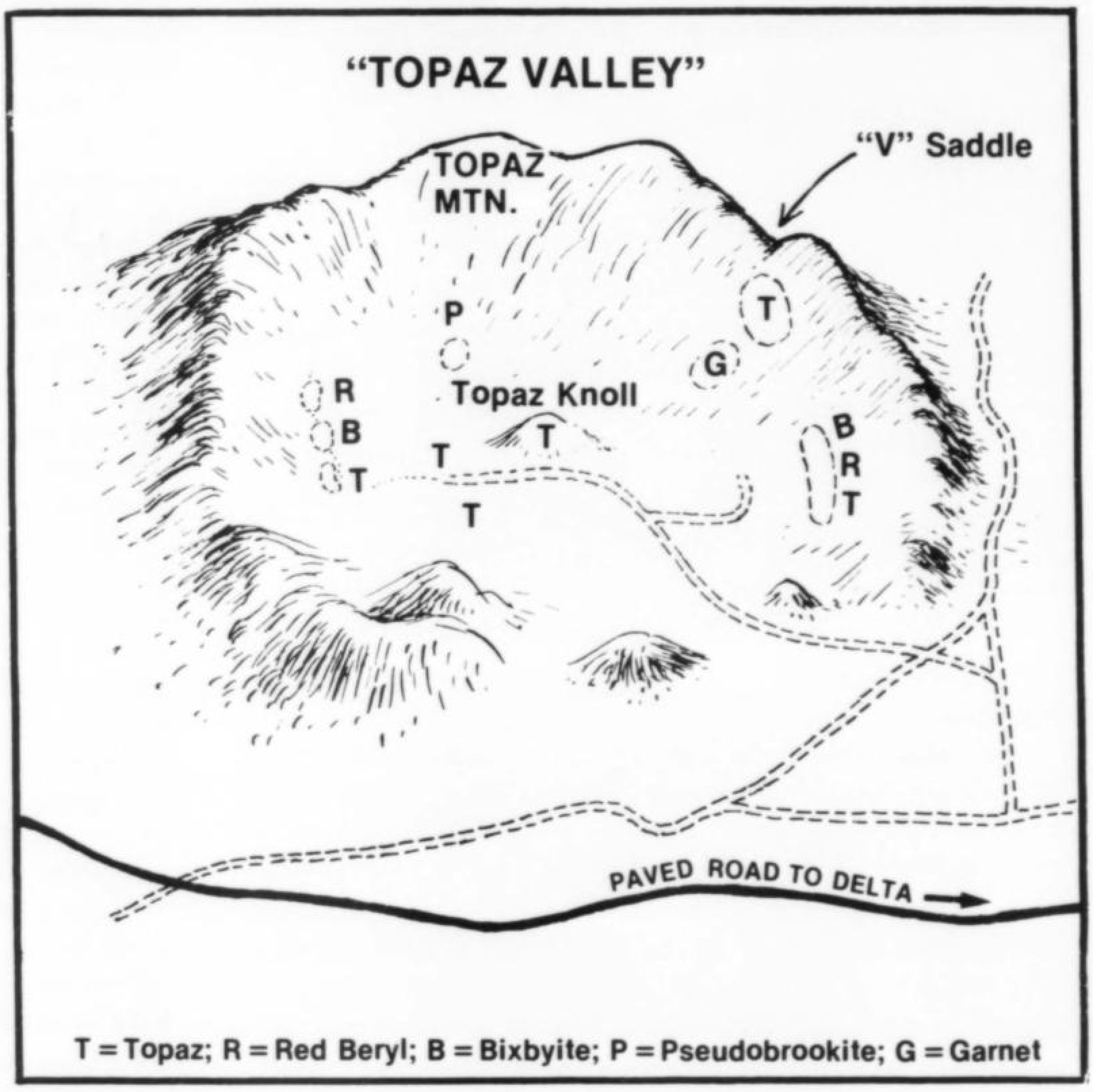

Figure 29. **Topaz Valley occurrences in the Thomas Range.**

roughly parallels the wall and steeply dips into it; the other is approximately at right angles to it.

When first discovered by the author in October, 1975, this locality had not been worked before. After being initially opened up, other collectors have worked it intensely, including the use of blasting. Presently there is a pit about 10 m across and 5 m deep. It is possible to collect a large number of crystals in this pit in a day's time. Due to the reactivation of old mining claims, this pit is currently closed to collectors. However, the Bureau of Land Management is currently investigating the validity of those claims.

The next pit to the north has been worked for bixbyite for many years. It is about 10 m long and 7 m deep. In the past, crystals to 6 mm were found, but presently most are less than 2 mm across. They occur on topaz frequently as "necklaces" of oriented cubes. The topaz is mostly of the sandy or partially sandy type. Lithophysae are abundant as are specimens.

Red beryl is most numerous in the pit to the north. Crystals occur on rhyolite or rarely on topaz. Most of these tabular crystals will be less than 3 mm across, but they have been collected to 8 mm. The color varies from pink, sugary with quartz inclusions, to bright red. They occur in lithophysae or small irregular cavities, sometimes concentrated along fractures. When a crystal is found a careful search along any fractures or cavity zones will generally produce more.

The red beryl zone extends in a layer from 5 to 15 m thick from the pit southward to the other two pits and to the end of the ridge. The author has collected beryl at two other spots along this zone and knows of one pocket which produced 43 crystals. The pit has been the most consistent producer of fine specimens.

A small canyon lies just north of the beryl pit. In the canyon, on the same level as the pit, is a white zone of rhyolite that contains excellent pseudobrookite. Lithophysae are not abundant, but most do contain

Figure 30. **A view of the west wall of Topaz Valley. Topaz pit at the left (1), bixbyite pit (2), beryl pit (3), and pseudobrookite workings (4) in light rhyolite can be seen. Photo by Lanny Ream.**

clusters of crystals. Radiating groups from 10 to 15 mm across can be found.

Garnets occur in the first small canyon just beyond the end of the road on the trail to the topaz pit. They are mostly anhedral and occur as singles or groups to 2 cm or more.

North of the road on the west side of the valley there is a prominent white knoll. Some of the largest topaz crystals collected in Topaz Valley have come from here. The rock is hard and cavities scarce, but the crystals are a good dark sherry color and much thicker than other topaz crystals in the range. In this location a 3 cm crystal is often 10 mm wide and 7 to 10 mm thick, about twice as thick as an average crystal.

North of the knoll, on the north wall of the valley (south side of Topaz Mountain) there is a large white zone that produces excellent pseudobrookite. Lithophysae are abundant in some places often concentrated along a fracture. Radial groups to 2.5 cm across can be collected. Small topaz crystals are associated. Hematite plates are rare to abundant. Some of the plates are in fan-like clusters with individual plates to 1.5 mm across.

On the east side of the valley, topaz occurs in several areas. Specimens of topaz and red beryl or bixbyite occur below the dark cliff scattered over a wide area (SW¼SE¼, Sec.9, T.13S., R.11W.). Some very good combination specimens have come from here. Sandy topaz is abundant in several zones under the cliff.

There is a sharp "V"-shaped saddle in the ridge at the northeast corner of the valley. Topaz crystals can be collected in abundance both below, to the south, and above, to the northwest, of the saddle. In both locations, lithophysae are numerous. Topaz occurs with micro quartz of a colorless to light blue color. Most of the topaz crystals are less than 2 cm long. They are often firmly attached so that matrix specimens can be collected.

Garnets have been reported by Buranek (1947) in an area about halfway between the knoll in the center of the valley and the "V" saddle, and also below the saddle, to the northwest. They occur in lithophysae as sharp euhedral crystals.

Pink sandy topaz can be collected about one mile north of the Pismire Knolls (NE¼ Sec.17, T.12S., R.11W.). The crystals occur weathered out of the rhyolite and are abundant on the surface of the low outcrops just above the valley floor. Most crystals are less than 1.5 cm long and are sandy with translucent pink areas. Similar crystals have been reported elsewhere in the range.

Excellent euhedral garnet crystals are uncommon about 1.5 miles southwest of the Pismire Knolls. Good specimens can also be collected in the central portion of Antelope Ridge which is 4 miles east of Topaz Mountain.

The best garnet specimens have been collected at Garnet Basin (NE¼ Sec 11, T13S, R12W) in the southwestern part of the range. This locality is east of the Bell Hill fluorspar mine situated at the end of the paved road. A good vehicle trail can be followed easterly up a small canyon to the bottom of the basin.

Crystals occur alone or with topaz in the moderately steep slopes below the vertical cliffs. Topaz crystals to 3 cm occur near the base of the vertical cliffs towards the point on the southern part of the basin. Most garnets are less than 1 cm in diameter, but a few fine crystals to 2.5 cm have been reported. Combinations of garnets on topaz are rare. Subhedral crystals less than 6 mm across are common and are a good indication of a garnet zone which may produce euhedral crystals.

Pseudobrookite specimens of the finest quality have been collected at

Figure 31. **A view of Topaz Valley looking east from the west wall shown in the previous figure. The knob containing topaz is in the center, "V" saddle at left. Photo by Lanny Ream.**

two localities, one on the east and one on the west side of the range. At both localities, the mineral is in cavities that are concentrated along prominent fractures. The rhyolite is altered and bleached to a white color with yellowish-brown iron oxide stain in places. The quartz lining the cavities is of a pale bluish color. Groups of radiating crystals of pseudobrookite to 3 cm across and single needles to 7 cm occur, but groups averaging 1 cm across are most common. The long crystals are quite thin and very fragile. Specimens with several groups on a cabinet size matrix can be obtained but only with difficulty.

Some of the best topaz crystals occur in sand-filled cavities along two fractures at one locality on the east side of the range. The cavities are sand- or sand-and-clay-filled and occur as areas of widening in the vein, or as small pockets along the walls of the vein. Rarely, the cavities contain no sand or clay. In these, a few topaz crystals project inward from the walls. Generally the crystals occur as floaters or loosely attached crystals and crystal groups in the sand- or clay-filled cavities. They occur as singles or clusters many of them doubly terminated.

Those crystals that are attached to the matrix have a morphology similar to topaz from most other localities, but the floaters tend to be of a better quality with a distinctly different termination in which the basal pinacoid is prominent. This gives the crystals a stubby termination, somewhat rounded in appearance. These are often the best gem quality crystals displaying a color and clarity unsurpassed by crystals of any other locality.

In the pockets which contain an abundance of hematite flakes, the topaz often contains hematite inclusions and some have a smoky color. Sandy topaz crystals to 10 cm have been collected, but gem quality crystals rarely exceed 4 cm and are most common in the 1.5 to 3 cm range.

Small, rounded, altered garnets to 4 mm may be attached to topaz crystals in the hematite-rich cavities or may occur as clusters of 2 to 3 mm crystals. Rarely, bixbyite cubes to 3 mm are attached to the garnets or topaz.

Near the vein topaz locality described above is an excellent bixbyite locality. Bixbyite, topaz and altered garnets occur in small open fractures and sand filled cavities over an area about 15 by 20 m. The garnets are generally less than 4 mm in diameter and may occur in clusters of several crystals. They are gray-brown in color and often have an overgrowth of oriented topaz. Bixbyite may be attached as very sharp cubes. These can be so abundant as to nearly cover the garnet. Most of the bixbyite occurs on the garnets but the largest crystals (to 7 mm) are usually on topaz or rhyolite. Some cubes have a dull luster; these display an "X" on the faces. Other crystals have flat topped peaks on the faces, as previously described. Red beryl has been reported.

Another locality produces fine quality tabular bixbyite on topaz. The bixbyite has a brilliant submetallic luster and several crystals are commonly joined edge-to-edge. Most are less than 3 mm across but may be up to 6 mm and the "chains" of joined crystals may be 15 mm long. They are commonly aligned on the topaz parallel to the *c* axis or in other orientations. The topaz varies from sandy to fine gem quality crystals as singles or clusters. In the outcrops just below this occurrence a few altered garnet-bixbyite combinations similar to those from the previous locality have been collected.

Whereas most bixbyite crystals are less than 6 mm across and rarely exceed 4 mm, one locality in the northern part of the range produces them to 16 mm. Cubes to 6 mm are abundant and those 6 to 10 mm across are numerous. They commonly occur with two or more crystals to 6 mm on a small cabinet specimen. Small topaz of a pink color, less than 12 mm long, pseudobrookite to 10 mm, fluorite as purple crusts and poor quality calcite occur with the bixbyite. Some very good combination specimens have been collected.

The crystals occur in an altered rhyolite that is quite soft in some areas. Lithophysae are not present, but the minerals are in shrinkage cracks and other fractures. A yellowish-brown iron stain coats many of the fractures.

Bixbyite cubes are mostly modified by trapezohedron and octahedron faces. Small cubes, less than 4 mm, are often unmodified. The trapezohedrons generally have a dull luster and may be the dominant form of some specimens. Groups of intergrown cubes, sometimes with topaz or pseudobrookite are also present.

The author has recently learned of bixbyite crystals over 3 cm being found. They are reported to be in small cavities so that crystals are subhedral at best, but the potential exists for fine specimens to over 2.5 cm.

At one locality in the north part of the range, near Wildhorse Spring, the red beryl crystals have a prismatic habit normal for beryl. They are a pink to bright red color and up to 20 mm long by 8 mm wide. Most crystals have the darkest color in the center and pink color at the terminations. Rarely, they have a sugary texture on one side.

Beryl crystals are locally abundant along six kaolinized veins in an outcrop without cavities or other minerals. Some concentrations are so great that a few centimeters of the vein will produce hundreds of crystals, mostly less than 4 mm long, with a few of greater size. Even with the zones of high concentrations, it is necessary to mine a large volume of rock to obtain very many fine quality specimens.

The veins consist of a fracture with a yellowish-white kaolinite filling, 5 to 20 mm thick. Along the vein, outward for several centimeters, the rhyolite is altered and is soft when wet. When collected, it is easy to clean and expose crystals by scraping away this soft rhyolite. After a specimen has dried, the altered rhyolite becomes nearly as hard as fresh rhyolite.

These veins are believed to be hydrothermal in origin (John Holfert, personal communication). The beryl crystals show no point of attachment and are free-floating phenocrysts frozen in rhyolite. A few do have a "corner" that has a yellowish color and is sugary grained as if partially a point of attachment. The red beryl crystals in the Wah Wah Mountains have a point of attachment and are believed to be pneumatolytic in origin as are most of the other minerals of the rhyolites.

A garnet locality in Searle Canyon has produced several octahedrons, less than 6 mm across. These occur with trapezohedral crystals to 15 mm, in irregular cavities. Some of the crystals have a tarnished metallic appearance due to alteration of the surface to biotite (John Holfert, pers. comm.).

The author has been informed of several other localities in the Thomas Range and has made trips to a few and seen specimens from others. One locality has produced an abundance of topaz to 6 cm. The zone is quite limited and may cover only a few square meters. A nearby red beryl zone has produced excellent tabular crystals, some to 1 cm across and occasionally in clusters. Another area contains thousands of topaz clusters on blue quartz. These occur in lithophysae that are locally abundant. Most of the topaz crystals are less than 15 mm long, but some beautiful matrix specimens can be collected. Blood red topaz of small size (color due to microscopic hematite inclusions?) occur in one difficultly accessible area. Near this locality there is a small deposit of red beryl on intergrown (almost reticulated) topaz crystals. Another remote location contains an abundance of small topaz with hematite phantoms.

The above data on the Thomas Range was gathered during numerous field trips of several days each and from discussions with other collectors. A study of the range (indeed, of the entire topaz producing area) will never be complete. New information, and crystals showing new characteristics were discovered on almost every exploratory trip.

Dugway Range

The southwestern part of the Dugway Range is comprised of topaz-bearing rhyolites. Only a quick reconnaissance of this area was made. During discussions with other collectors, it was learned that topaz and other minerals do occur there, but not in the quality of those from the Thomas Range. This does not mean that a collector who enjoys prospecting or studying geology or mineralogy should ignore the rhyolites of the Dugway Mountains. Some very good mineral occurrences, yet undiscovered, may exist in these mountains.

Keg Mountains

Rhyolites similar to those of the Thomas Range crop out in the western part of the Keg Mountains, 12 miles east of the Thomas Range. The author did not make any field trips to these mountains. Collectors have reported that topaz does occur there with hematite. At least one hematite plate 7 cm across was reported. As in the Dugway Range, a prospecting trip to the Keg Mountains could be rewarding.

Drum Mountains

The topaz-bearing units extend to the southeast into the northeastern part of the Drum Mountains. During two investigations in a limited area of these mountains, topaz, garnets, hematite and quartz were found. The general indications were that the crystal potential is about as good as in the poorer areas of the Thomas Range. It appears that the fringe of rhyolite occurrences (the Dugway, Keg and Drum Mountains) are less mineralized than the Thomas Range.

In the northeasternmost portion of the Drum Mountains, some fine hematite clusters were found. Some of the plates are up to 2 mm thick. Clusters of blades (similar to the shape of a pen knife blade) and plates were common in a small area containing topaz and quartz. Some of these plates have prominent rhombohedral faces beveling the edges.

About one mile southeast of this locality on an east trending ridge (approximately in the NW¼ Sec 8, T14S, R10W) some large subhedral garnets were collected. These crystals, to 4.9 cm, were discovered where they lay, weathered out on the ridge top. The smallest crystal was 1.8 cm. They have a dimpled surface, with edges rounded and a dull to glassy luster. The color is reddish-brown to almost black. Crystal faces can be seen on most specimens.

LOCALITIES AND OCCURRENCES—SOUTHERN RANGES

Wah Wah Mountains

Red beryl was discovered in the Wah Wah Mountains nearly 20 years ago by Larry Walker of Beaver, Utah. The mining claims (known as the Violet claims 1–8, Sec 19–30, T29S, R14W) remained inactive until recently when they were purchased by Ed, Rex and Bob Harris of Delta. A limited supply of fine specimens is being produced from claims no. 3 and no. 5. Collecting at this locality has been described by Barlow (1979).

The prismatic crystals occur in a gray rhyolite on a knoll on the end of a ridge. In this area the rhyolite is light to medium gray and contains few cavities. Two separate occurrences are being worked, each has distinct characteristics. The beryl is pink to dark raspberry red and bright red.

The first area worked is on the top of the ridge where a pit 15 m long by 7 m wide by 5 m deep has been cut across the crest. Beryl occurs in two veins similar to those of the prismatic beryl deposit of the Thomas Range. The veins cut across the ridge, are roughly parallel and dip steeply. There is an irregular seam of yellowish-gray kaolinite in the veins. Both veins terminate against a cross cutting fracture.

Doubly terminated beryl crystals occur frozen in the rock within a few centimeters of the kaolinite seam. Crystals generally are scattered along the vein but are locally concentrated. Most are over 1 cm long, and they have been found to over 2 cm. They have a yellowish or dark core surrounded by dark pink to red or raspberry-red beryl, sometimes of gem quality. Even though they are frozen in matrix, when freed they paradoxically appear to have had an area of attachment, usually at one end.

Small flesh-colored topaz crystals occur rarely in irregular cavities. Small black specks of manganese oxide(?) are common throughout the rock. There is often a finely granular mass of the oxide in and around a pink anhedral beryl crystal.

The second beryl occurrence is about 50 m below the pit, on the end of the ridge. Crystals occur in a zone of irregular cavities, some of them possibly shrinkage cracks. These are often filled with a yellowish- to

Figure 32. **The upper beryl pit of the Violet claims which, with the neighboring pit, is known as the Violet mine. These two pits on the Violet claims have produced most of the red beryl of the best color and size. Photo by Lanny Ream.**

greenish-white talc-like mineral. Beryl crystals are commonly covered by this massive material.

Better quality crystals occur in this zone than in the pit. They are often of a brighter red color and do not have a dark core. Larger crystals, to 2.5 cm, are more common and a few specimens consisting of several crystals on matrix have been collected. These occur projecting into the cavities and are singly terminated or have one poorly formed termination where attached. Topaz and manganese oxide specks are absent.

Crystals of beryl are uncommon and much rock must be moved to locate them in both occurrences. It is necessary to break the rock by hand into small pieces to locate specimens. The veins can be followed in the upper pit, but there is no apparent control of the cavities in the lower pit. Zones are encountered where cavities, and sometimes crystals, are numerous.

Beryl is known to occur elsewhere on the ridge, but the other veins or zones have not been explored. It is possible that several other good zones may occur. There have been reports of other red beryl occurrences within several miles of this one.

About 100 m north of the red beryl deposit, there is a knoll of similar gray rhyolite which contains topaz. The crystals are flesh-colored to opaque dark gray (due to inclusions). They are up to 2 cm long and occur frozen in the rock. No other minerals were seen.

Gray rhyolite crops out below and to the south of the red beryl deposit for about one half mile. No other beryl or topaz occurrences have been located there. Above the beryl zone, in a gray to maroon rhyolite, topaz, quartz, bixbyite and hematite occur in lithophysae.

Rhyolite crops out as cliffs and ledges about 300 m west of the pit. Lithophysal cavities are nearly round in gray zones and ellipsoidal (flattened parallel to the color banding) in the maroon zones. A black vesicular basalt caps the rhyolite.

The lithophysae are lined with colorless to pale blue quartz and most contain topaz and hematite. Topaz crystals average about 5 mm long by 2 mm across and reach a maximum size of at least 15 mm by 4 mm. Their color is pale amber. Hematite plates are common to about 3 mm across.

Lithophysae in the light gray rhyolite contain bixbyite with quartz and some topaz. Quartz crystals are colorless and up to 6 mm long, and topaz is generally less than 10 mm long. Bixbyite cubes are highly modified by trapezohedral and octahedral faces. They average about 1 mm across.

Both the gray and maroon units crop out in several areas along Four Mile Wash, only a few were investigated. In all outcrops the gray rhyolite was overlain by the maroon. In the SW¼, Sec 30, T31S, R15W, the gray rhyolite locally contains translucent light amber to sandy gray topaz in sandy pockets. Crystals were found to 20 mm and the occurrence was spotty. The maroon rhyolite contains the topaz on quartz, the same as all the maroon rhyolites of the area.

Similar outcrops in the SW¼NW¼, NW¼SW¼, Sec 31, T31S, R15W, and the SE¼NE¼, NE¼SE¼ Sec 36, T31S, R16W are not as productive. The one in the NE¼SE¼ Sec 36 does contain bixbyite crystals of less than 1 mm on sandy topaz. The gray rhyolite is apparently barren and topaz and quartz is smaller and less common in the maroon unit in this area.

Both rhyolites crop out on several hills and ridges from two miles

Figure 33. **Maroon-colored topaz-bearing rhyolite capping a ridge northwest of Mountain Spring Peak. Light gray rhyolite forms a knob on the left end of the ridge and overlies the maroon rhyolite. Photo by Lanny Ream.**

northeasterly to two miles northwesterly of Mountain Spring Peak (Sugarloaf Peak on some maps). The Four Mile Wash locality is three to four miles northeasterly of the peak.

One of the most interesting localities is in the NE¼NW¼NE¼ Sec 12, T32S, R16W. There is a knoll of light gray rhyolite in a saddle between two hills capped by the maroon rhyolite (poor topaz producer). In the saddle, about 60 m to the south of the knoll, sandy topaz occurs in the gray rhyolite. There is a small outcrop of rock which barely reaches above the surface of the low sparsely brush covered saddle.

Sandy topaz crystals litter the ground over a wide area. It is possible to pick up a handful of crystals in a few minutes. These are mostly 10 to 15 mm long, opaque gray to partially colorless translucent. Bixbyite cubes to 1.5 mm are attached to a few specimens.

The small outcrop contains similar topaz crystals in sand-filled cavities. Seams of black manganese oxide are common, and crystals of bixbyite to 2 mm are less common. Most bixbyite is modified by the trapezohedron. Fluorite occurs as purple microcrystals forming crusts or scattered grains attached to other minerals. Pseudobrookite crystals to 2 mm long and 0.5 mm wide are somewhat more common than bixbyite. This is the only occurrence of pseudobrookite found outside of the Thomas Range.

Another outcrop of interest lies about one mile to the west in the SE¼NE¼SW¼ Sec 2, T32S, R16W. Maroon rhyolite forms prominent cliffs as a ridge cap, about 5 to 10 m high. The underlying gray rhyolite is covered by soil and sparse vegetation; to the west it is exposed and barren. Overlying the maroon rhyolite on the north end of the ridge is a remnant of a gray rhyolite flow. It forms a cap about 5 to 7 m high. No cavities or crystals are known although it is eroded into an irregular shape with small caves, arches and domes, giving the appearance of Thomas Range rhyolites.

The maroon rhyolite contains the largest, most abundant and best quality translucent topaz in this area. They are up to 1.5 cm long on quartz and hematite. Locally, crusts of fluorite cubes to 2 mm are sparse to abundant.

The rhyolite extends about one mile to the northwest where it forms cliffs alongside the road north of Meadow Spring. Topaz is locally abundant as colorless crystals to 5 mm in length. Shrinkage cracks are the most common cavities and contain topaz with quartz and hematite as microcrystals.

Ridges and hills to the northeast of this area are capped with rocks that from a distance have the same appearance as the maroon unit. There are no roads into the area and, because of time restrictions, the area was not explored for this report.

Needle Range

From one to eight miles to the west of the Mountain Spring Peak area, in the southern Needle Range, there are four areas mapped by Hintze (1963) as T_2rf volcanics. The north central portion of the largest area was examined.

Samples were taken and the rhyolites investigated along the road up Sawmill Canyon through Ponderosa Park, a distance of about two and one quarter miles. Sandy topaz litters the ground from the mouth of the canyon in the SW¼ Sec 14, T13S, R17W almost continuously through the NW¼ Sec 23, S½ Sec 22, NW¼ Sec 27, NE¼ Sec 28 and SE¼ Sec 21. Translucent topaz occurs in the maroon rhyolite and sandy topaz in the gray. Locally, the sandy topaz is abundant, even sparkling in the road.

Excellent quality topaz of small size was collected in gray to maroon rhyolite at the west end of Ponderosa Park in the SW¼SE¼SE¼ Sec 21, T31S, R17W. The rhyolite forms a cliff about 20 m long and 8 m high on the north side of the canyon where it narrows and turns northwesterly. There is a grove of willows in the canyon at this location. Topaz occurs in lithophysae which are locally abundant in the outcrop. Crystals to 15 mm by 7 mm were collected. Their color is medium sherry. They are often of gem quality, and though smaller, resemble those of the Thomas Range. Quartz lines the cavities, but no other minerals were found.

Paradise Hills

One of the better occurrences of topaz in the southern area is in Modena Canyon about five and one half to six miles north of Modena in the SW¼ Sec 25, NE¼ Sec 35 and NW¼ Sec 36, T33S, R19W. The maroon unit caps several ridges in this area.

The best outcrop sampled is in the SW¼SW¼ Sec 25. Cliffs there are up to 15 m high. Topaz was found throughout the area and is locally abundant. A matrix specimen with 34 crystals was removed with difficulty and one good doubly terminated crystal 18 mm long was collected. Quartz and hematite occur here in crystals less than 2 mm long. As is typical of topaz in these southern rhyolites, they often break off from the shock of breaking the rock; matrix specimens at this locality are thus difficult to obtain.

Volcanic rocks of the T_2rf group extend for eight miles to the west to the state line and an unknown distance into Nevada. About one mile west of Modena Canyon in the SW¼ Sec 27, T33S, R19W in a road cut where the road crosses a small wash there are a few sandy topaz crystals in gray rhyolite. A reconnaissance survey of the remainder of the area failed to locate any of the maroon rhyolite or any other topaz localities.

PRESENT COLLECTING SITUATION

Topaz Valley in the Thomas Range is by far the single best locality open to collectors. Excellent specimens of all of the minerals can be collected there. Most of the valley and the Thomas Range in general is

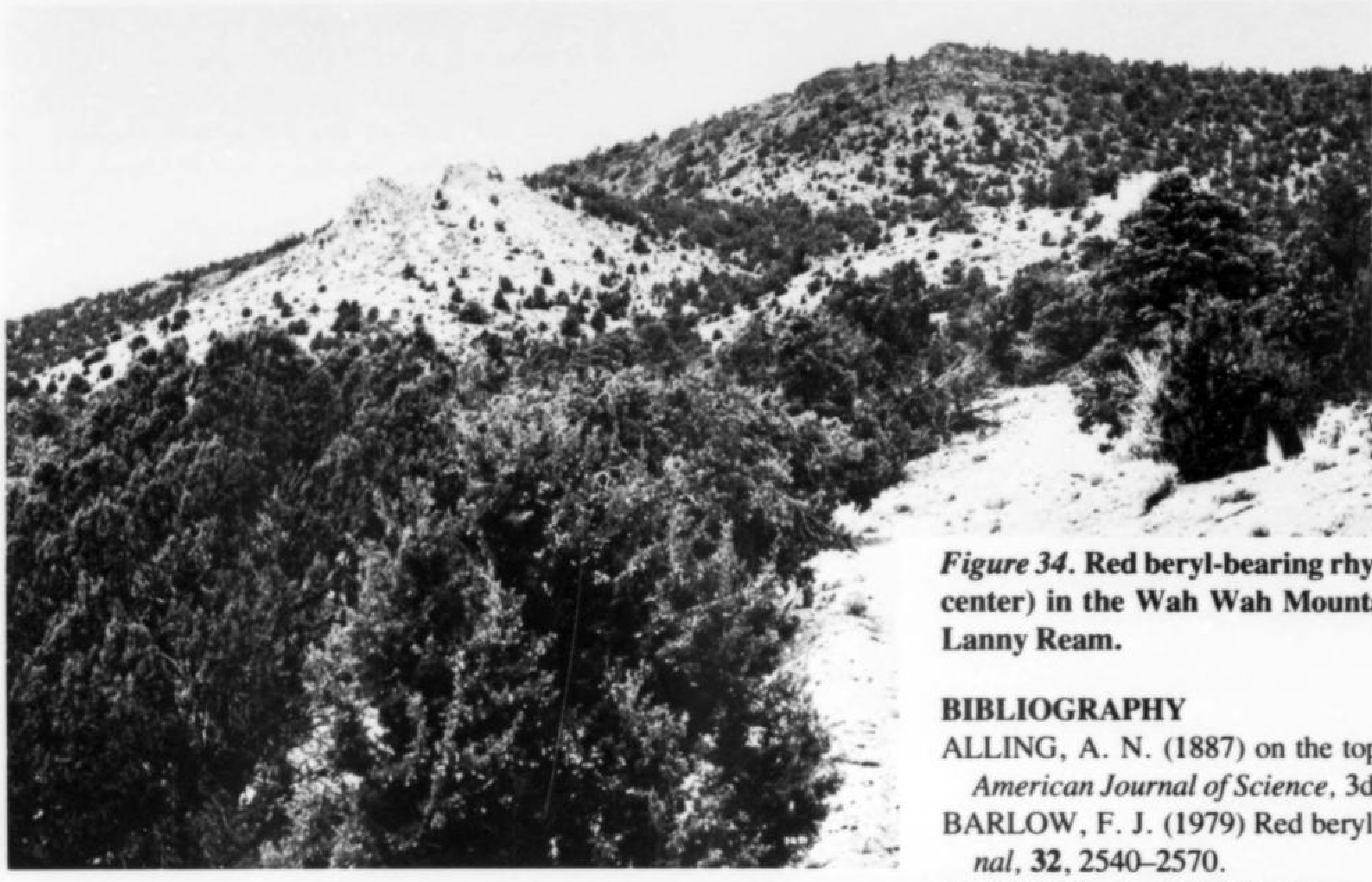

Figure 34. **Red beryl-bearing rhyolite knob (left center) in the Wah Wah Mountains. Photo by Lanny Ream.**

land administered by the U.S. Bureau of Land Management, the rest by the State of Utah. Most of the area is open to prospecting, collecting and mining. Topaz Valley is administered as a "rockhound area" by the Bureau of Land Management. Mining claims can not be staked and power tools and blasting are not allowed in this area (unfortunately for the rapport between collectors and the BLM, some individuals do use power equipment and explosives). The Mineralogical Society of Utah maintains old mining claims and leases on the knoll in the center of the valley. And, as mentioned previously some old claims on the west side of the valley have been reactivated, closing those areas to collectors.

The remainder of the range is open to collecting, but it takes much prospecting to learn the characteristics of the rhyolites and locate good crystal-producing areas. All areas described in the text, with the location given, were open to collectors when last investigated during the fall of 1978. Those which are described but have no location given are mining claims or leases and are closed to collectors. Much of the range is being prospected for uranium, primarily along the edges, and hundreds of claims are being staked. Technically all locatable minerals belong to the claimant, including topaz, bixbyite, etc., so it is illegal for a collector to remove the minerals from mining claims. Mining companies exploring for uranium deposits generally are not interested in the topaz and other minerals and are not concerned with the hobby collector entering their claims. Collectors should be aware of this conflict in the Thomas Range (and at most other mineral localities, especially around known mining districts) and investigate before collecting.

The Dugway, Keg and Drum Mountains have an unknown though probably low potential for producing fine mineral specimens. These ranges are open to exploring and collecting, and are well worth prospecting by those who would like to find specimens from localities other than the Thomas Range.

In the Wah Wah Mountains the red beryl locality is the only one on claims that are specifically located as mining claims. All of the other areas appear to be open to collecting.

ACKNOWLEDGEMENTS

The author would like to thank Mike and Sandra Sprunger and John Holfert for the information that they furnished on the Thomas Range and for the tours and collecting privileges at their claims. Information furnished by Bob Harris and his partners on the Wah Wah Mountains red beryl occurrence during visits to their mine is also greatly appreciated. Special thanks to Mike Groben for suggesting this article as a Friends of Mineralogy project.

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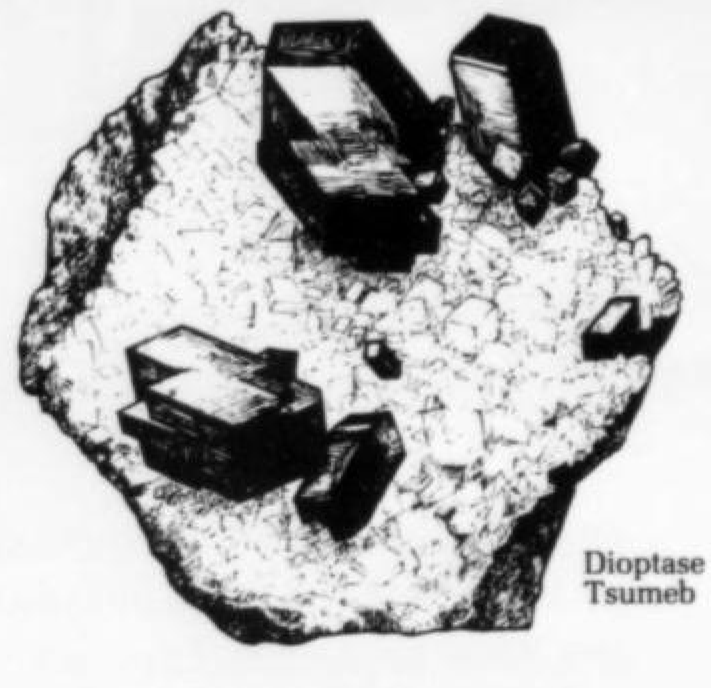

the Niccioleta and Boccheggiano pyrite mines, Tuscany

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Near the ancient Tuscan mining town of Massa Marittima, by the villages of Niccioleta and Beccheggiano, are two of Italy's most well known pyrite mines. A variety of other attractive minerals including blue celestine, clear gypsum, sulfur and amethystine quartz occur there as well.

INTRODUCTION

The area can be reached via highway 441 which leads from Massa Marittima to Siena. Five km past Massa Marittima is the turnoff for the Niccioleta district and the main shafts which lie about 1 km from highway 441. Continuing on highway 441 for 13 more km will bring the visitor to the remains of the old flotation mill of the Boccheggiano mine well off to the left side of the road, and a little further along on the right is the turnoff for the village of Boccheggiano. The Boccheggiano mine shafts are on the right and left sides of the highway.

In former years these deposits were intensively mined for mixed sulfide ore, especially argentiferous galena, but those workings do not extend into the pyrite bodies which were at that time considered worthless. Today pyrite mined from these deposits is processed at the nearby Scarlino plant for the manufacture of sulfuric acid. The pyrite is roasted in a special furnace to liberate SO_2, which is then hydrated and oxidized into H_2SO_4. The remaining ashes are reduced with naphtha and then magnetically concentrated to produce iron.

Within the last ten years these mines have yielded a whole suite of minerals which, for beauty and exceptional size, deserve to be more widely known and appreciated. Up until a few years ago, only the most conspicuous such as pyrite, gypsum and quartz were saved as specimens. However, with the increasing popularity of mineral collecting, and the accompanying demand, numerous other species including stibnite, celestine and sulfur have been collected. As is commonly the case in mining regions which produce good specimens, the local area abounds in private collections, some belonging to the miners themselves, and nearly every collection contains at least two or three exceptional pieces.

HISTORY OF THE AREA

The nearby area around Massa Marittima was mined extensively in ancient times, and many of these old workings are still in evidence. Several different deposits were exploited for mixed sulfides including argentiferous galena, tetrahedrite and copper ores. The earliest workings date back to the time of the Etruscans, a people who dominated central Italy before Roman times.

Intensive mining continued into the Middle Ages, when articles of mining were first drawn up to govern operations in the district. Those first articles, entitled *In nomine Domini, amen. Infrascripta sunt ordinamentafacta arte fossarum ramerie et argenterie civitatus Masse* (dated 1325) are still preserved in the town of Massa Marittima, and are considered to be the first European mining regulations.

Mining was, in those days, very profitable due to the high price of copper and silver, and the low cost of manual labor. A subsequent drop in the price of these metals, and the sweep of the Plague through Europe, caused the mines to be abandoned, and it was not until the 1700's that mining was resumed.

In the 18th century new explorations located the old mixed sulfide veins, but few produced operations as profitable as those at Beccheggiano and Fenice Capanne (still operating today).

When technical advancements made pyrite an important ore of sulfur for sulfuric acid production, many firms located the old ore bodies and long-known but disregarded pyrite lodes. Mining for pyrite continues today at the Gavorrano, Niccioleta and Boccheggiano mines.

PYRITE MINERALIZATION AT NICCIOLETA

Pyrite emplacements occur along the contact between schist and

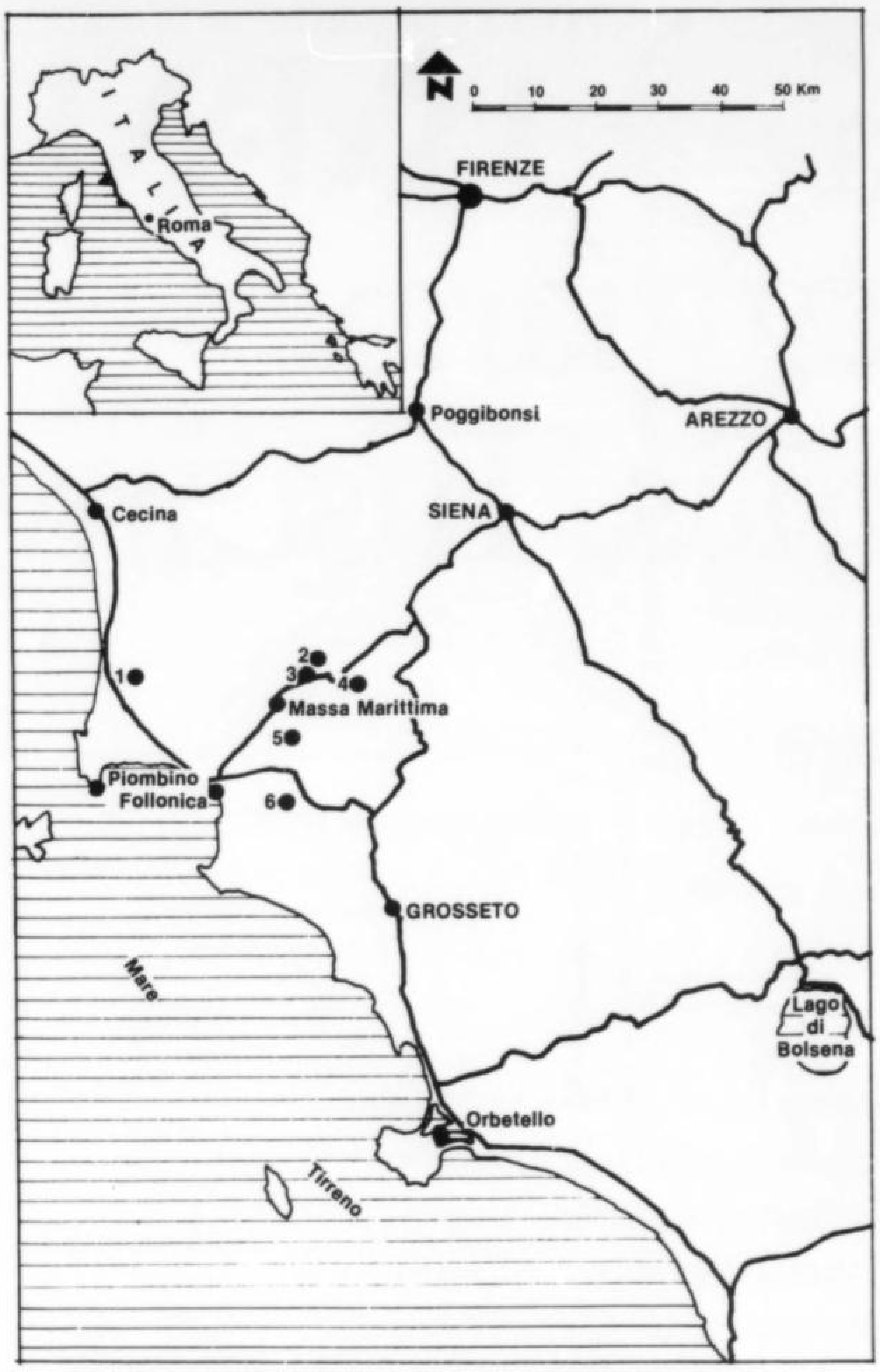

Figure 1. **Location map showing the location of important mines: (1) Campiglia Marittima (Pb, Zn, Cu); (2) Ritorto (pyrite); (3) Niccioleta (pyrite); (4) Boccheggiano and Campiano (pyrite, Pb, Zn, Cu); (5) Fenice Capanne (Pb, Zn, Cu); and (6) Gavorrano (pyrite).**

cavernous limestone units which crop out in an area facing Niccioleta village. The rocks have an anticlinal structure with a north-northwest/south-southeast axis. The anticline is cut on the eastern side by a series of faults paralleling the anticlinal axis. Pyrite also occurs in the faults and in the surrounding rock units. The pyrite occurring along the contact between schist and limestone is usually massive, crystalline, and associated with calcareous gangue minerals as well as moderate amounts of sphalerite, galena, and chalcopyrite in small veins in the pyrite.

Pyrite lenses in the schist contain medium-grained silicates such as pyroxene and garnet, or fine-grained silicates including epidote, pyroxene and chlorite. The pyrite itself is compact and crystalline, forming large masses of nearly pure material with minor calcareous gangue minerals extending into the schist and other rocks.

Current opinion attributes the Niccioleta pyrite to pneumatolitic hydrothermal action replacing carboniferous and sulfate-rich evaporite rocks. Mineralizing solutions infiltrated along numerous fissures and faults, particularly along the anticlinal axis.

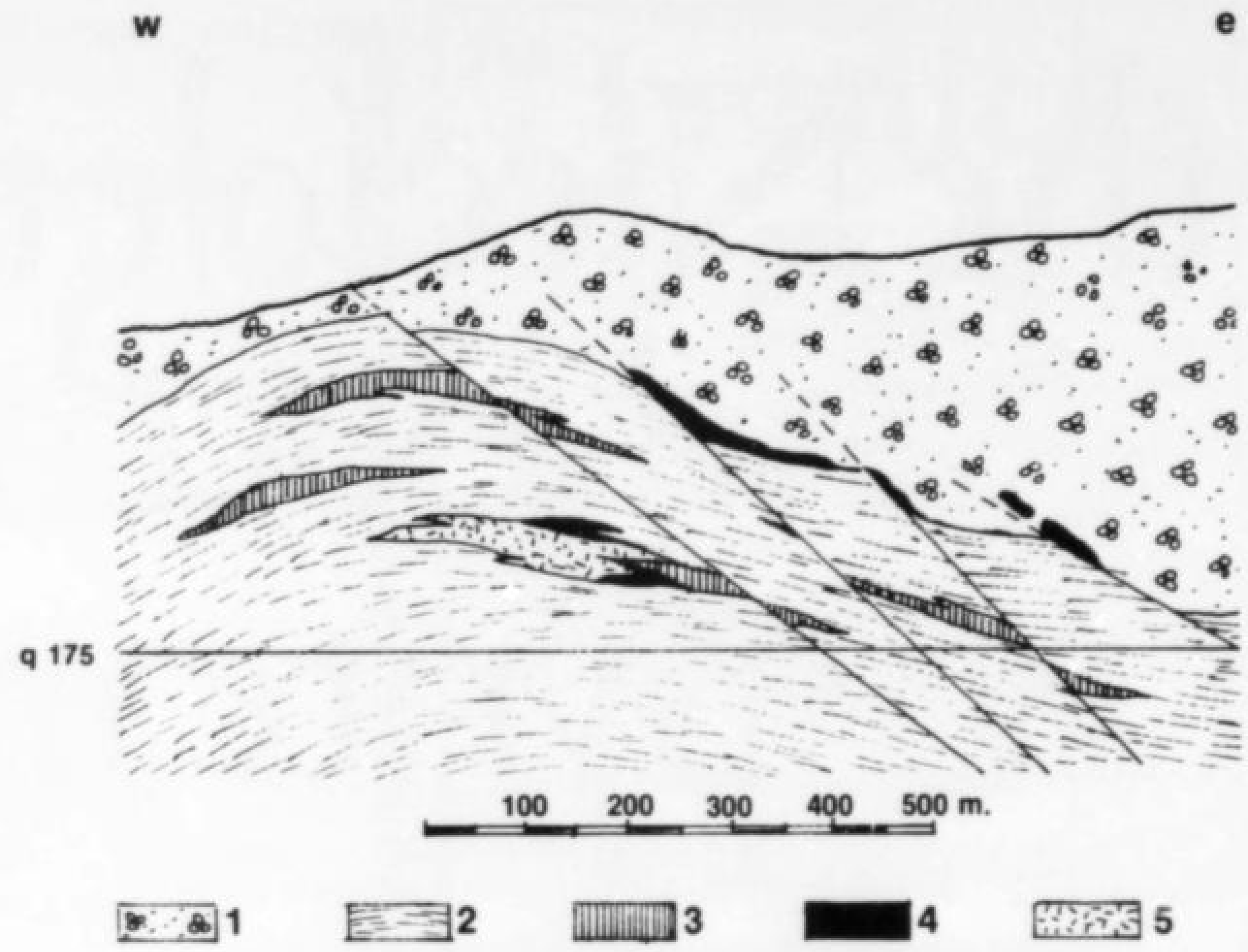

Figure 2. **Generalized geology at the Niccioleta and Boccheggiano mines. (1) cavernous limestone; (2) schist; (3) lenses of anhydrite and dolomite; (4) pyrite concentrations; (5) silicate deposits.**

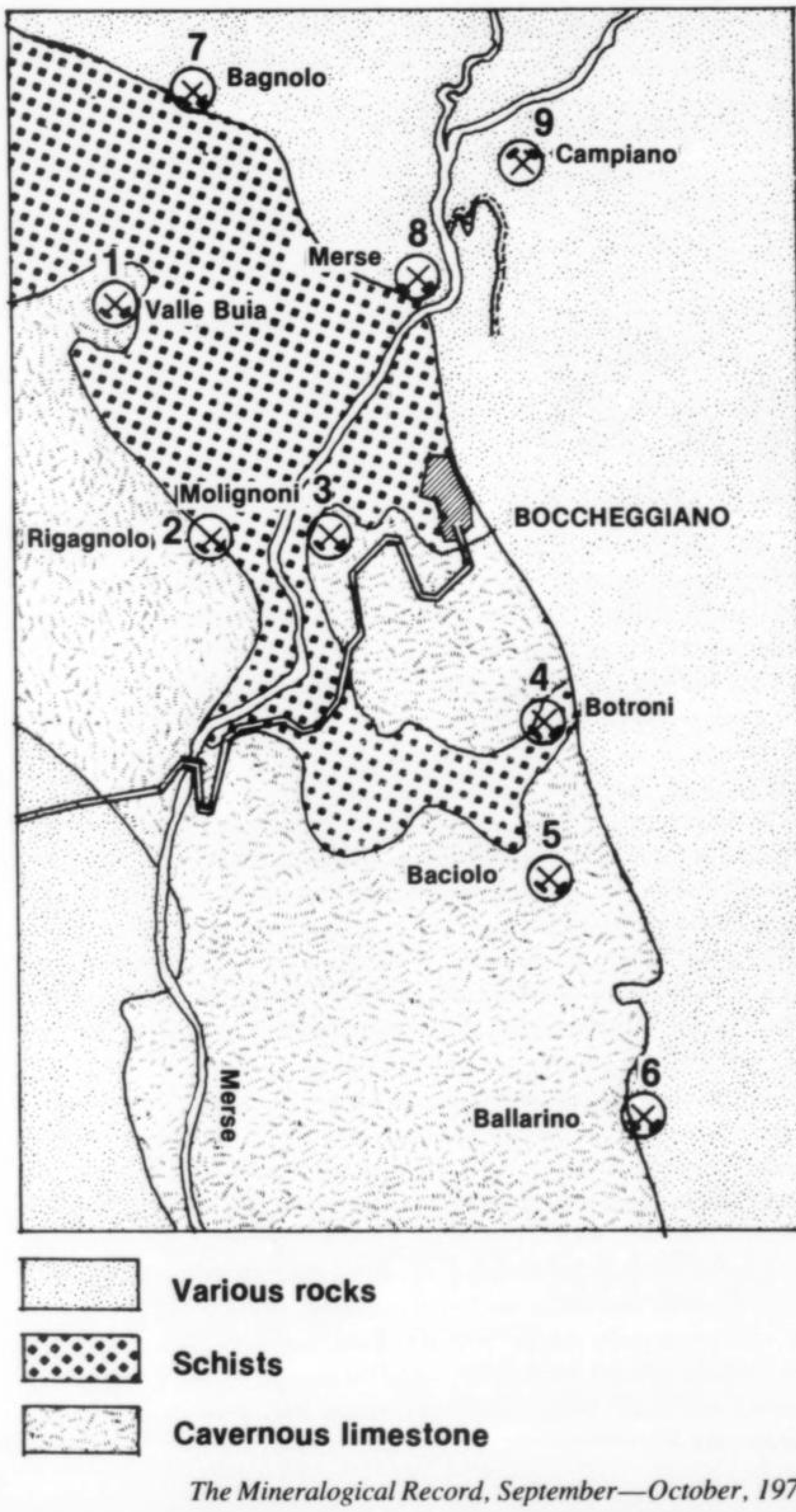

Figure 3. **Mines in the Boccheggiano area. Mines 1, 2, 3, 4, 5 and 6 are located on worked out pyrite deposits; 7 and 8 are exhausted copper-bearing pyrite deposits; 9 is a mine currently in the developmental stage which will be worked for Cu, Pb and Zn.**

It must be remembered that the secondary formation of metamorphic aureoles around pyrite lenses profoundly altered the surrounding rocks. Gypsum is characteristically formed by the reaction of limestone with sulfuric acid liberated from oxidizing sulfides. Considering the pyrite-sulfides-silicate association within the up-thrust anticline, it seems likely that both the structure and the mineralization are the result of middle-depth intrusions like those known to outcrop at many Tuscan localities (Elba, Gavorrano, Campiglia Marittima).

The Niccioleta mine has one ore shaft, one manway shaft, and three ventilation shafts, one of which is a remarkable 7-km tunnel used partially for drainage.

The mine ceased operating, for the most part, about 20 years ago because of a decreasing amount of extractable ore and also because of difficulties caused by a heavy flow of underground water. Only one of the shafts (Ballarino) continued to be mined up until a few years ago.

During the inactive period much exploration was undertaken, some by core drilling in the surrounding area, and a new ore body was subsequently discovered. This new deposit, the Campiano body, is a richly mineralized zone containing mixed sulfides and pyrite. Thus far ore reserves of 25 million tons have been located. The deposit is located north of Boccheggiano but on the same seam.

Site preparation at the new deposit is already underway and should, in a few years, allow modern exploitation of this ore body to begin, utilizing a descending spiral tunnel system. Unfortunately a variety of technical problems, including a heavy flow of ground water, have delayed progress and the mineralized zone has yet to be reached. Consequently no mineral specimens have as yet been produced. The drill cores, however, show a different type of mineralization from that at Boccheggiano; the percentage of mixed sulfides exceeds that of pyrite, and remarkable pyrrhotite concentrations have appeared which are unknown at Boccheggiano.

Figure 4. **The Niccioleta mine, north zone, in 1977. Photo by P. B. Scortecci.**

Figure 5. **The Boccheggiano mine, abandoned installations, in 1977. Photo by P. B. Scortecci.**

PYRITE MINERALIZATION AT BOCCHEGGIANO

The geology of the Boccheggiano mine is very similar to that of the Niccioleta mine area. Large pyrite lenses occur at the contact between schist and cavernous limestone but, unlike Niccioleta, mixed sulfide ores are very common. The Boccheggiano lode is connected to a fault which puts the schist and cavernous limestone in contact with a limestone-marl *flysch*.

About 2 km north of the village of Boccheggiano the fault contains an impressive lode of pyrite and chalcopyrite in a largely quartzose matrix. This lode has grown by replacement of the flysch carbonate rocks and a connected breccia zone.

The metalliferous minerals include pyrite, chalcopyrite, and traces of other sulfides. The pyrite, sometimes copper-bearing, is contained in lenses of small size evenly distributed through the fault zone.

MINERALS

Many interesting species have been found at these two mines. Pyrite, the main ore mineral, is among the most beautiful and spectacular. Few private and public collections in Italy do not possess at least one such

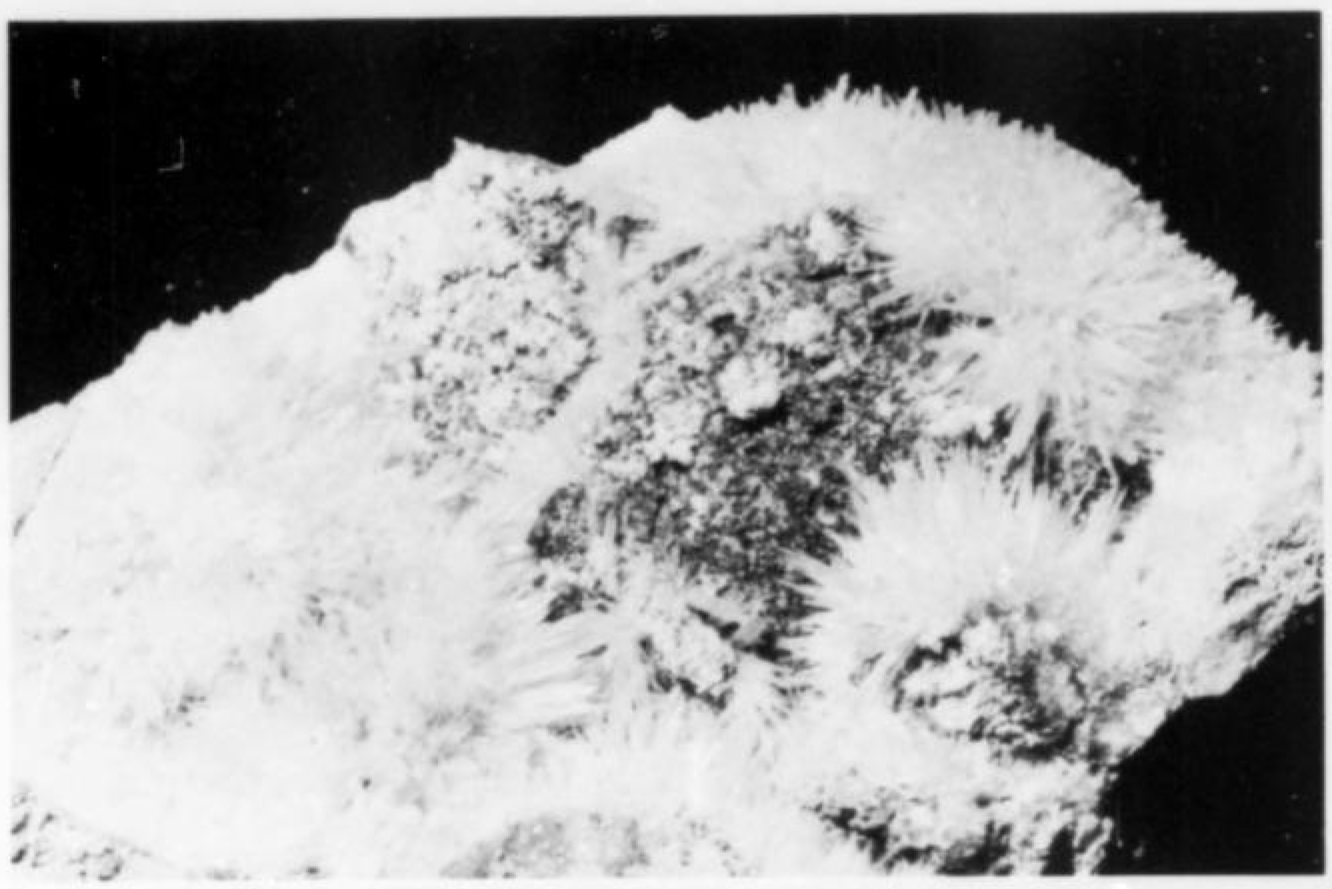

Figure 6. **Pale green acicular crystals orf aragonite from the Boccheggiano mine. The specimen is 13 cm across. Specimen and photo: P. B. Scortecci.**

Figure 7. **Cream-colored dolomite crystals on pyrite from the Niccioleta mine. The specimen is 8 cm across. Specimen and photo: P. B. Scortecci.**

Figure 8. **Gypsum crystals to 8 cm on pyrite from the Niccioleta mine. Specimen and photo: P. B. Scortecci.**

specimen from these mines, although they often bear indefinite or incorrect locality designations. A large number of good specimens come from the Gavorrano area too, but they are hardly as beautiful as those from Niccioleta and Boccheggiano; and specimens coming from the ore deposits on the isle of Elba (now bottoming out) are different because the pyrite crystals are almost exclusively pyritohedrons.

For many years now dealing in collector mineral specimens has flourished at Massa Marittima, stimulated by the beauty of the minerals and the proximity of the Tuscan seacoast which annually attracts hundreds of thousands of tourists from all over Europe. Because of this demand the miners themselves mine most of the specimens and sell them directly or to local dealers.

Allophane occurs especially in the upper portion of the Niccioleta deposit as colorless to greenish white crusts and blebs.

Aragonite is not particularly common, but occurs in nice specimens in the Boccheggiano mine. It forms acicular crystals to 4 or 5 mm in length. The color ranges from white to light green, pale pink and brown. Like calcite (see below) it fluoresces red under both longwave and shortwave ultraviolet light.

Azurite and **malachite** crystals are common, especially in the outcrop of the Boccheggiano mine ore body, where they have formed by the alteration of copper sulfides. The crystals are often beautiful and bright but do not reach large sizes; they are limited to a few mm and form large druses which are esthetically quite interesting.

Boulangerite and **jamesonite** have been found, in recent years, in the Niccioleta mine. Nearly all of the specimens were collected at the 175 level in the north zone. The crystals are usually very thin, forming aggregates on a matrix of small pyrite and sphalerite crystals or white and grayish calcite crystals. The dark gray crystals are typically dull, but some specimens have been found bright and fresh.

Calcite is very common in both mines. It forms concretions and crystals (scalenohedrons mostly) from 1 to 4 cm in size. A few white to pearly gray scalenohedrons were recently found (on the 175 level) which measure 7 cm. In general the color varies from white to gray and green. The specimens from Boccheggiano especially fluoresce a bright red under both longwave and shortwave ultraviolet light.

Chalcocite was mentioned in the earlier literature as an occasional associate of chalcopyrite in the quartz seam at Boccheggiano.

Celestine is common at both mines. It occurs most commonly as tabular, very transparent, white, gray or sky-blue crystals in sizes from a few mm to 2 cm. Prismatic crystals to 4 cm and associated with sulfur crystals were found recently at the 175 level of the Niccioleta mine. Other specimens recently found are very beautiful as well, consisting of crystals covered by colloidal pyrite (called *melnikovite*) which is bright and sometimes iridescent.

Chalcopyrite was formerly rather common in stopes in the quartz lode at the Boccheggiano mine, but has become increasingly rare in recent years. It occurs in crystals under 2 cm, commonly of sphenoidal

***Figure 9*. Sulfur crystals to 1 cm on pyrite from the Niccioleta mine. Specimen and photo: P. B. Scortecci.**

***Figure 10*. A gypsum crystal 8 cm tall, with included sulfur crystals from the Niccioleta mine. L. Fazzini specimen; P. B. Scortecci photo.**

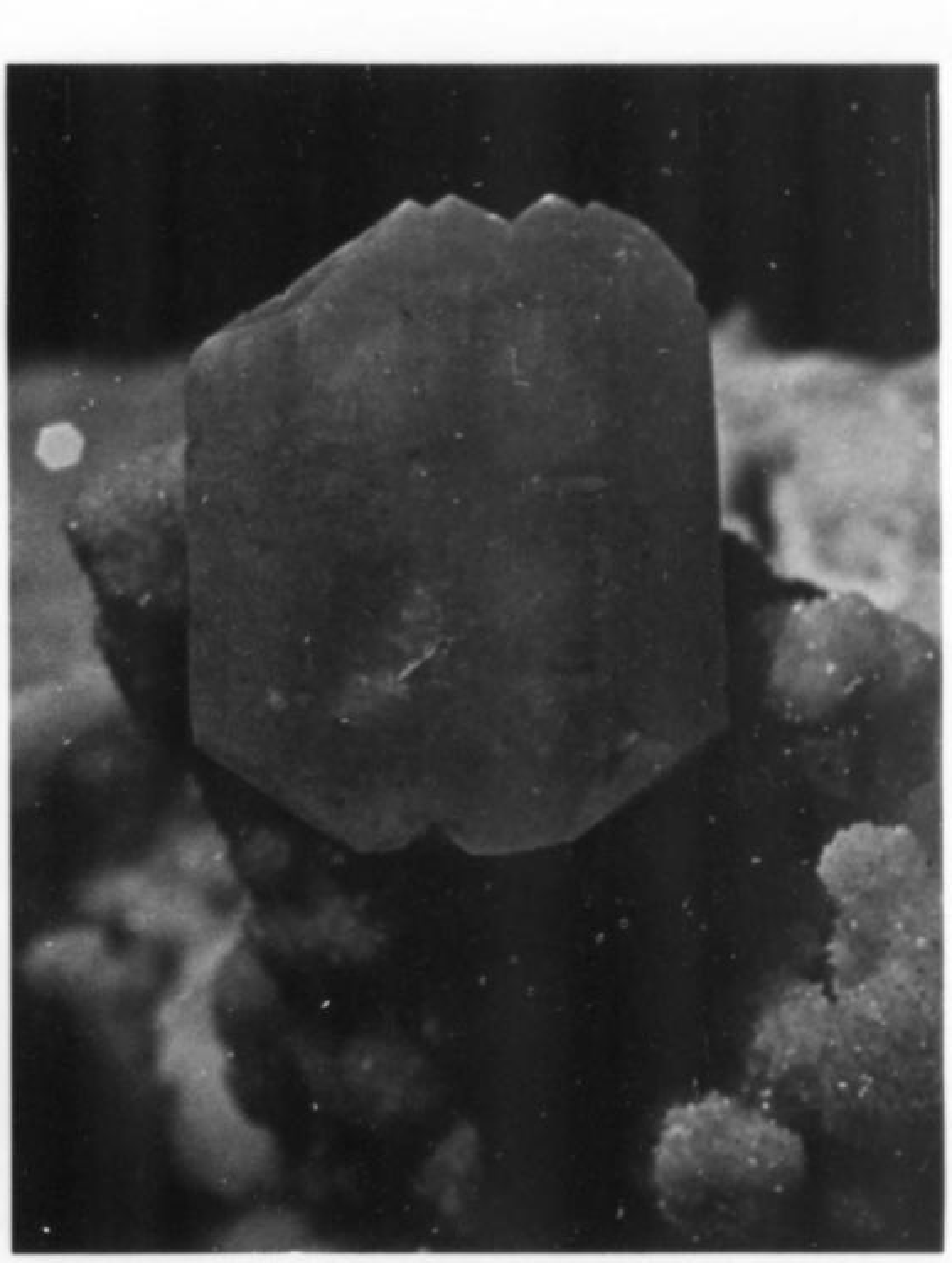

***Figure 11*. A tabular, 2-cm crystal of celestine from the Boccheggiano mine. Specimen and photo: P. B. Scortecci.**

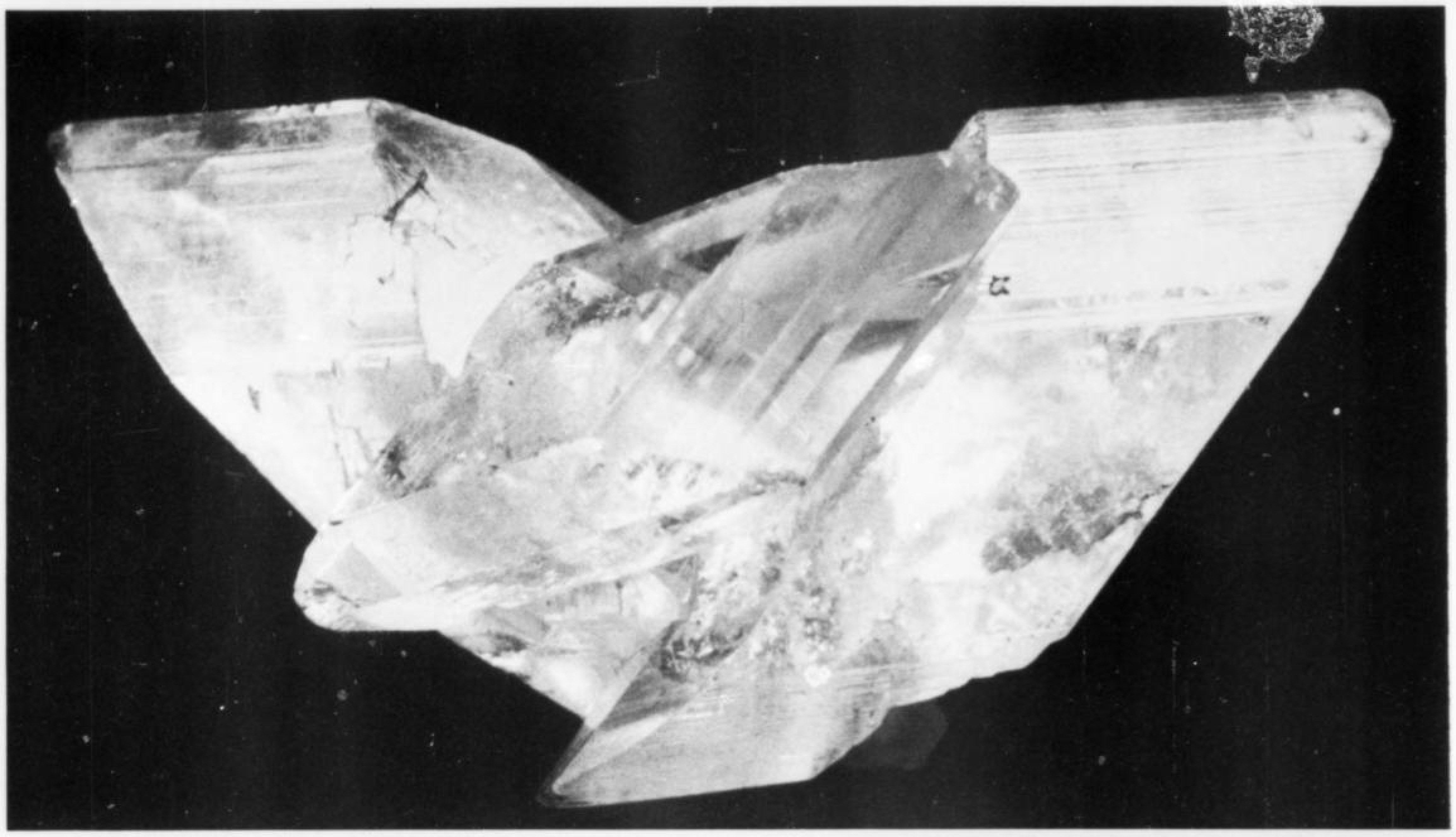

Figure 12. **A gypsum crystal group 8 cm across with inclusions of sulfur crystals. Specimen and photo: P. B. Scortecci.**

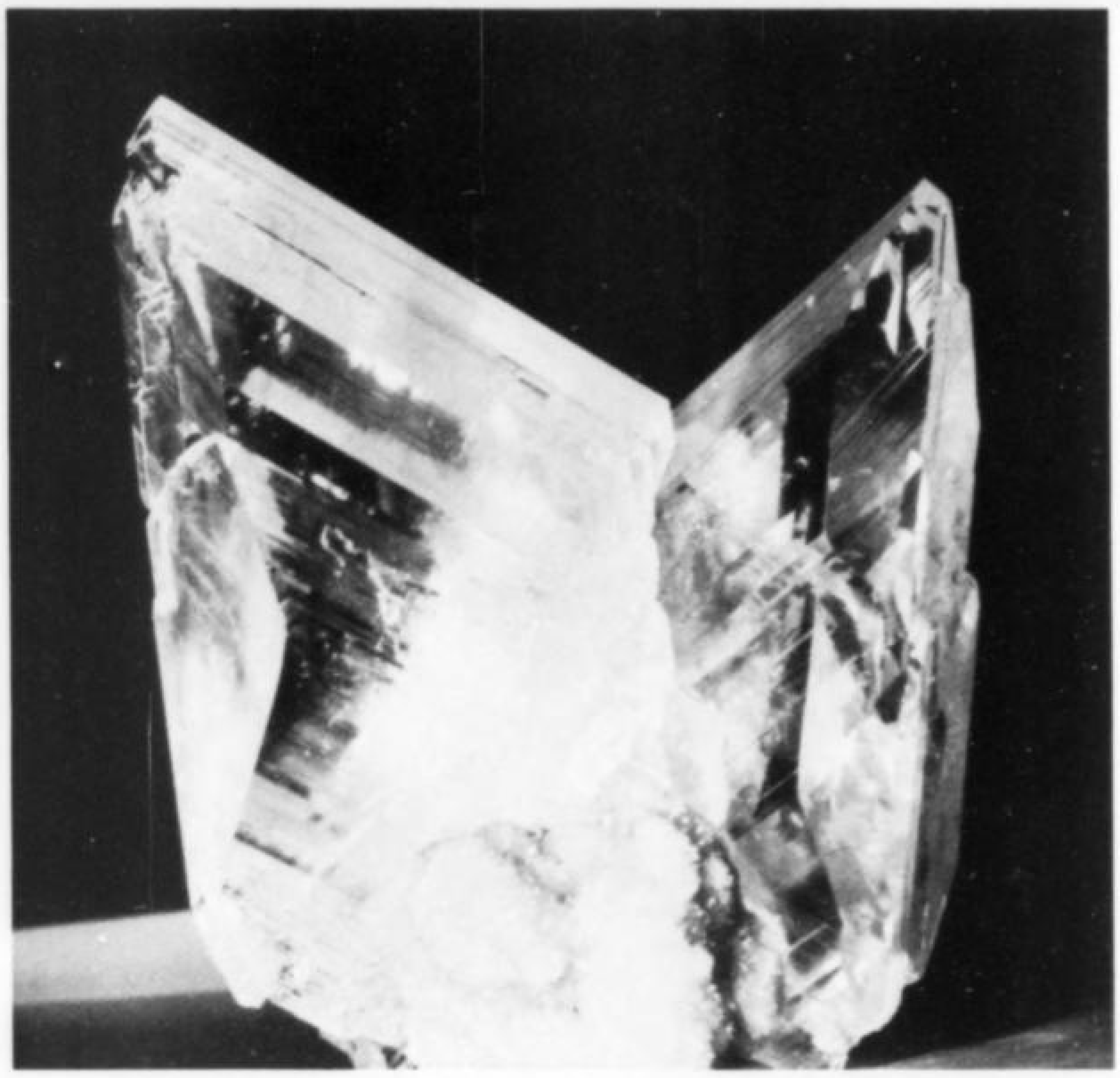

Figure 13. **A group of gypsum crystals 15 cm tall, with inclusions of sulfur crystals, from the Niccioleta mine. L. Fazzini specimen; P. B. Scortecci photo.**

to tetrahedral habit, always in association with pyrite, and typically covered by a dull gray patina.

Cinnabar has been found only rarely, as small quantities deposited on pyrite.

Dolomite is not common at either mine. It occurs as light pearly white rhombohedral crystals to 7 mm associated with quartz and pyrite.

Galena is also uncommon, although many fine specimens have been recovered at the Boccheggiano mine. Usually it is found with pyrite in crystals no larger than 2 cm and nearly always cuboctahedral in habit. It also occurs as a film or patina on pyrite.

Garnet (especially andradite) is common in the schist near the pyrite lenses at the Niccioleta mine. It occurs as small, light brown, dodecahedral crystals of little esthetic interest, but perhaps finer crystallizations will be encountered at lower levels.

Goethite can be found on the dumps of the old iron mine which operated from 1924 to 1940 on the Niccioleta ore body. It occurs only as massive concretions.

Gypsum is one of the species most commonly occurring in exceptional specimens at these mines. The crystals are typically large and transparent, especially at the Niccioleta mine, and are tabular on (010) or prismatic on [001]. These crystals reach a maximum length of 1 meter (!), and are almost always perfectly transparent, sometimes with inclusions of sulfur crystals and water and air bubbles. The best of the tabular crystals were found in 1973 on the 186 level of the north area (Niccioleta mine). There a small cave 1.5 by 1.5 meters was encountered, the walls of which were completely covered by large gypsum crystals, many with inclusions, on calcite crystals. The best of this pocket was saved, but the miners talk about even more exceptional discoveries, large caves full of gigantic crystals, which were completely destroyed in the days before mineralogical interest was fully developed. One such old cave, its crystals irreparably damaged, was rediscovered in 1963; it measured more than 4 by 4 m and was completely lined with prismatic gypsum crystals 1 to 1.5 m long and 8 to 10 cm thick. The largest gypsum crystal encountered, though damaged, was 2.5 m long by nearly a meter across.

Kaolinite occurs in white, massive, friable aggregates in the near-surface portion of the Niccioleta deposit.

Magnetite occurs primarily as granular and compact masses; crystals have not been reported.

Marcasite, though uncommon, has been found in good specimens at the Niccioleta mine where it forms concretions and small crystals, some irridescent, to 4 mm. Some calcite concretions around pyrite crystals show iridescent marcasite crystals on the pyrite cube edges. Botryoidal aggregates have been found as well which, when opened, show a radial structure.

Orpiment and **realgar** are uncommon, although extraordinarily esthetic specimens of these two minerals as inclusions together in clear gypsum crystals have been found. Massive realgar and orpiment have been reported in small veins on the 195 level, north zone, of the Niccioleta mine.

Pyrite is among the most beautiful and interesting minerals from this area. Crystals are abundant, commonly formed as perfect cubes, and

Figure 14. Pyrite crystals showing the cube and diploid faces, 5 cm across, from the Gavottano mine. Specimen and photo: P. B. Scortecci.

Figure 16. A cubic pyrite crystal 5 cm across on matrix from the Niccioleta mine. A. Marcantoni specimen; P. B. Scortecci photo.

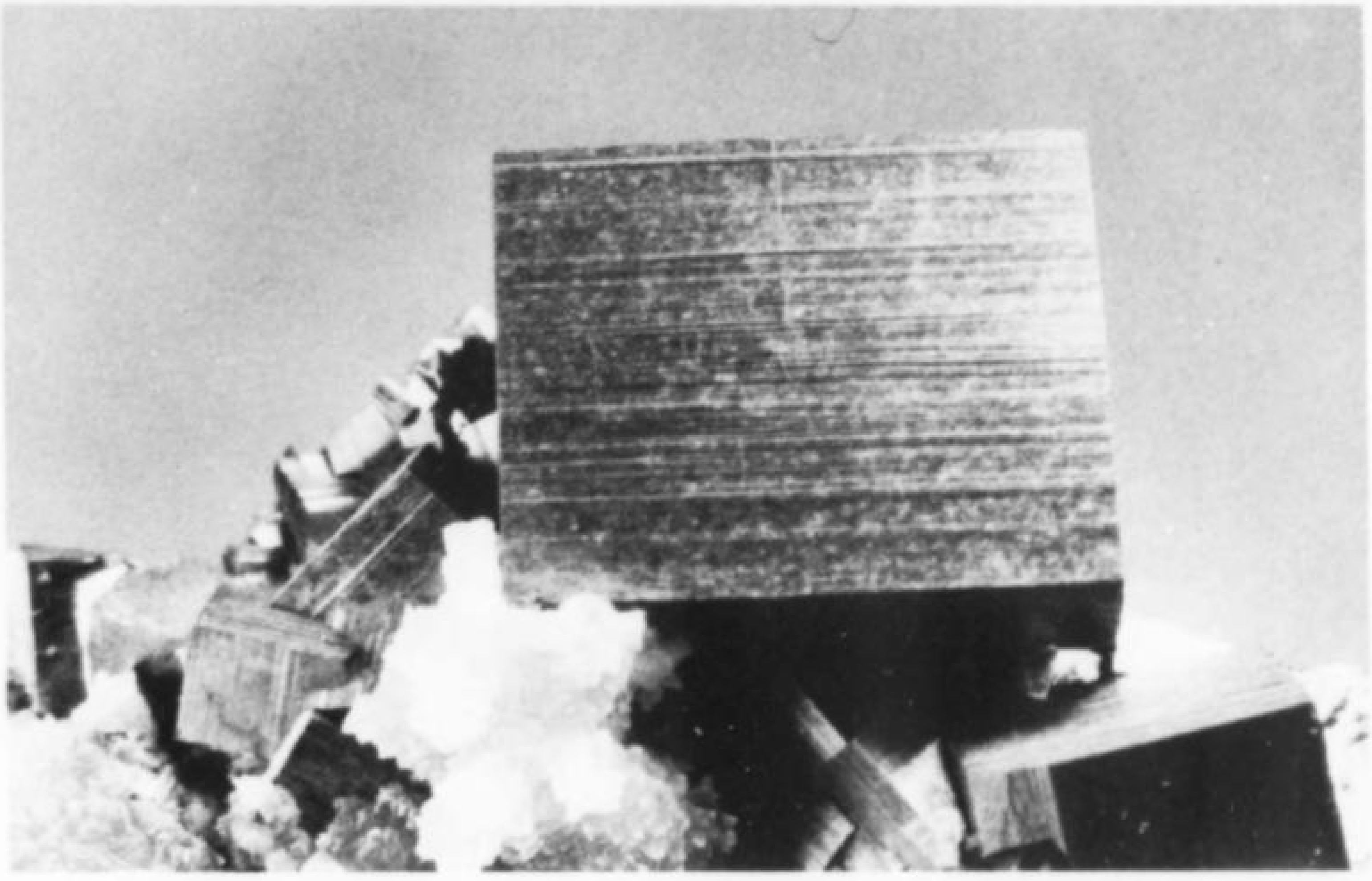

Figure 15. Pyrite specimen 8 cm across from the Niccioleta mine. Specimen and photo: P. B. Scortecci.

Figure 17. A group of cubic pyrite crystals 12 cm across from the Niccioletta mine. Specimen and photo: P. B. Scortecci.

(Continued on page 290)

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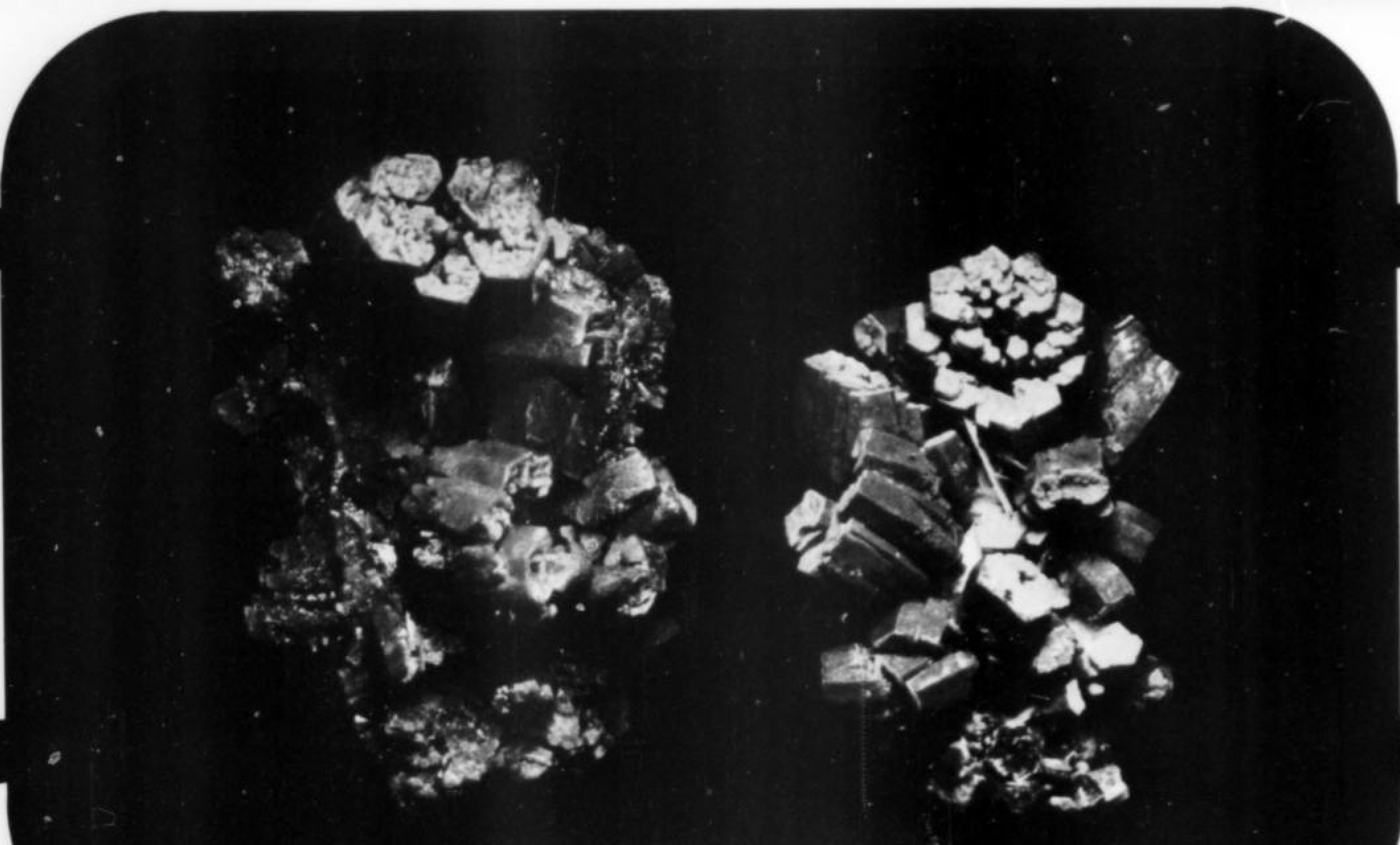

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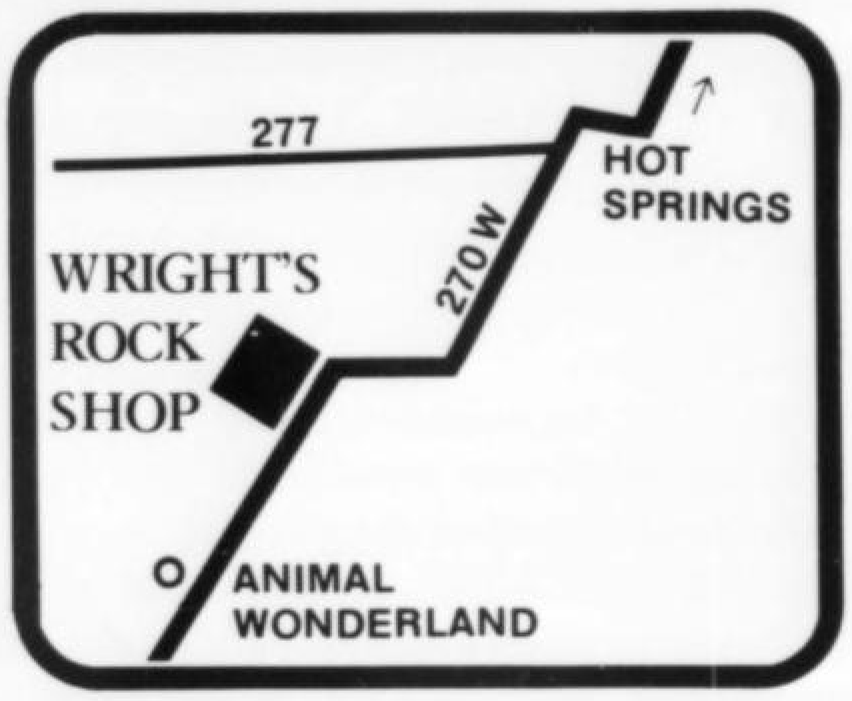

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Figure 18. **A 7-cm gypsum crystal with pyrite from the Niccioleta mine. Specimen and photo: P. B. Scortecci.**

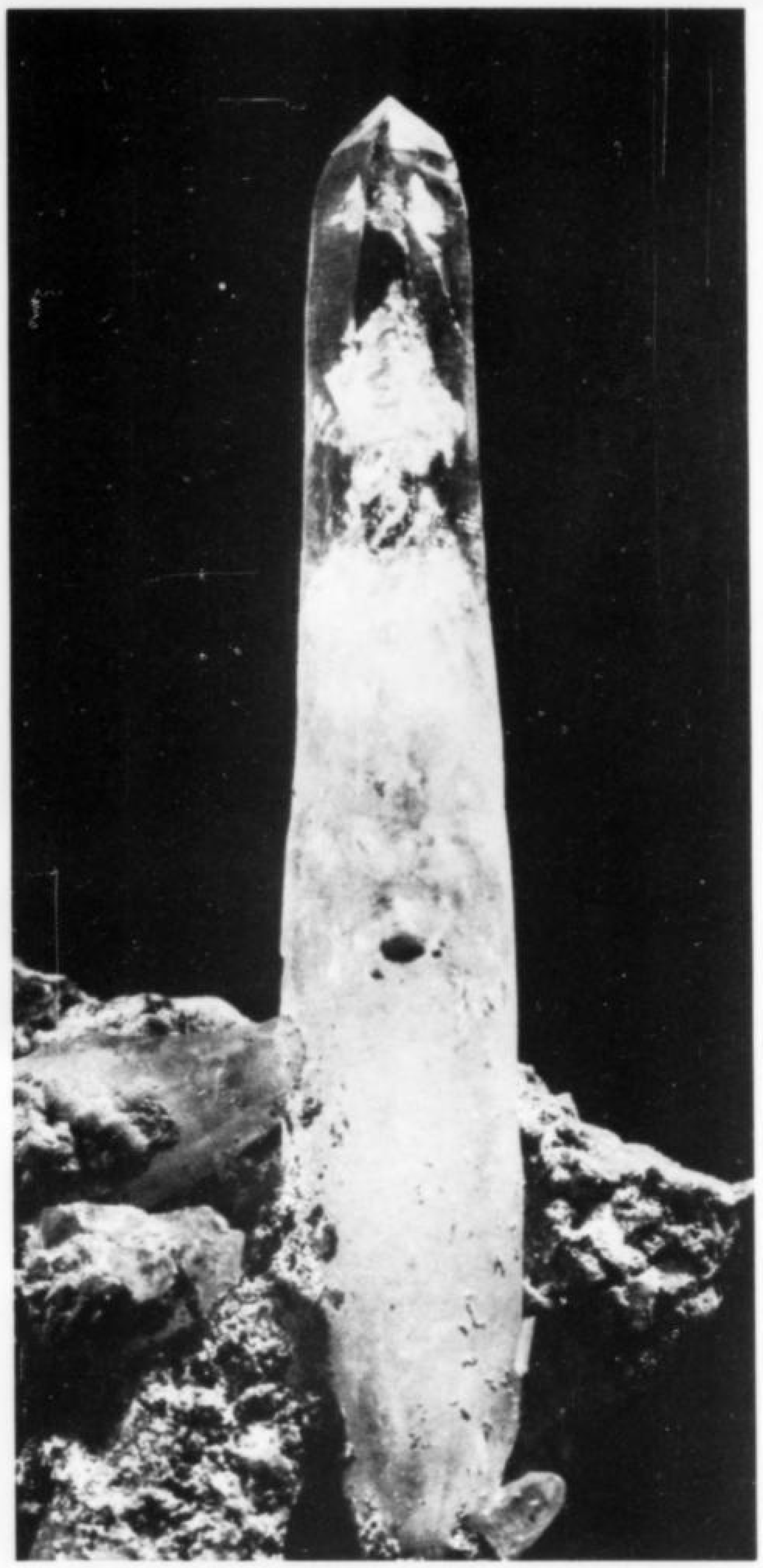

Figure 20. An amethyst crystal 6 cm tall from the north zone of the Niccioleta mine (found in 1977). Specimen and photo: P. B. Scortecci.

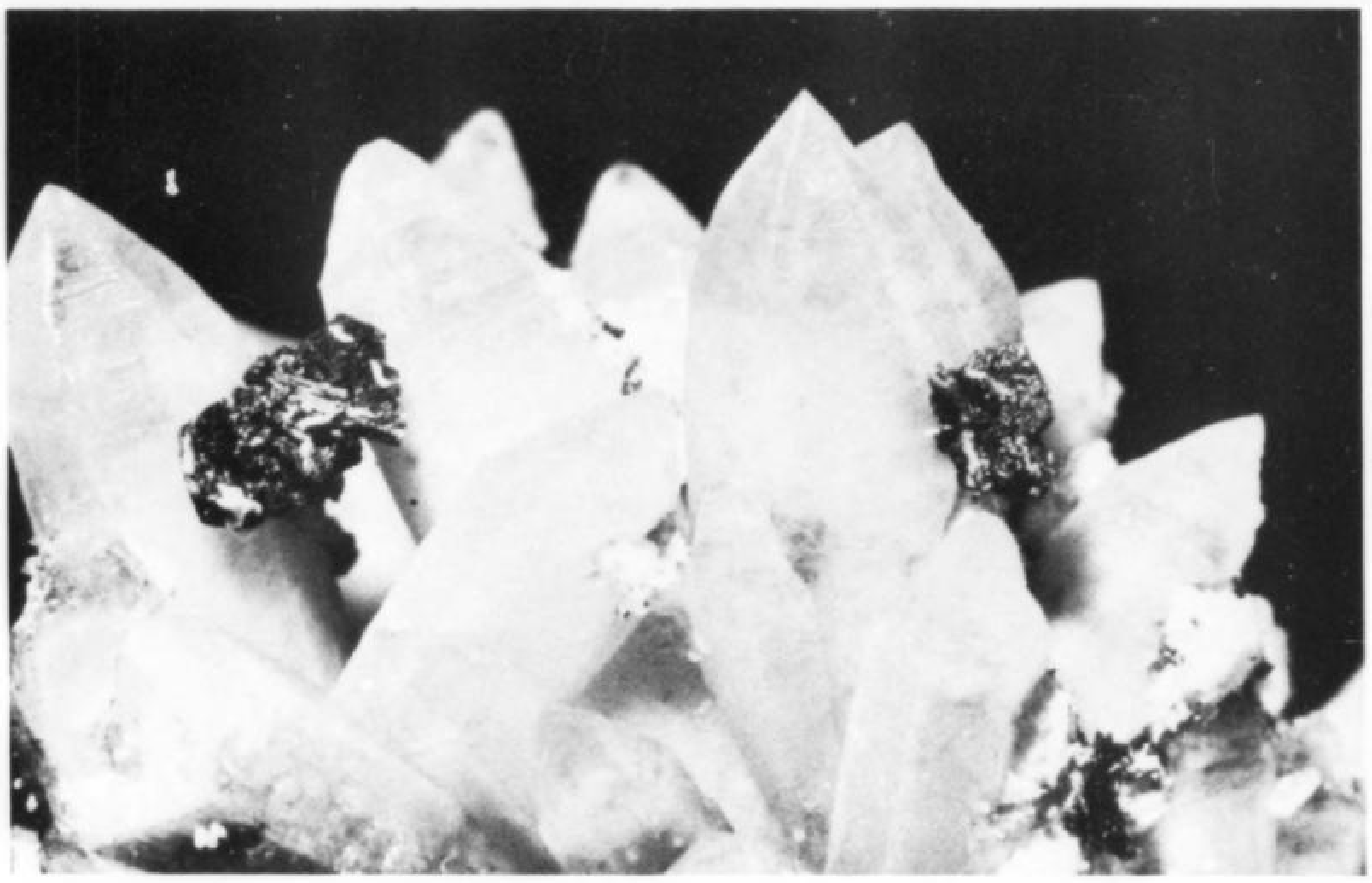

Figure 19. **A group of pale green quartz crystals 6 cm across with pyrrhotite from the Niccioleta mine. Specimen and photo: P. B. Scortecci.**

occasionally modified by the octahedron or, more rarely, the diploid. (Cube-diploid combinations are common at the other important pyrite mine in southern Tuscany, the Gavorrano mine.) Small and poorly formed crystals of pyritohedral or cubic-pyritohedral habit are known as well.

In the upper levels of the mines, especially in the limestone/schist contact zones, the crystals are perfect, bright cubes. In lower levels, beginning at about the 252 level, the pyrite tends to form deeply striated pyritohedrons and cube-pyritohedron combinations.

The cubic crystals are commonly bright and smooth but also occur deeply striated by oscillatory growth in combination with the pyritohedron. The crystals vary from a few mm to over 10 cm in size, typically forming bright groups and druses. Rare crystals to 20 cm in size have also been found, but these had been damaged by mining activity. Stalactitic and concretionary habits are also known, some nicely iridescent, especially in the lower levels. Innumerable specimens of high quality and large size have found their way into collections, especially those of the local inhabitants.

Pyroxenes, particularly hedenbergite, are commonly associated with the pyrite lenses in the schist.

Pyrrhotite is not common at Niccioleta and Boccheggiano, although a few specimens have been found on the 250 level of the Niccioleta mine. It occurs as tabular rosettes and single crystals rarely reaching 1 cm. Associations commonly include pyrite, quartz and sphalerite. A single, large zone of pyrrhotite was encountered on the 350 level of the Niccioleta mine but unfortunately no specimens were saved. Large amounts of pyrrhotite have appeared in the drill cores from the new Campiano mine in the Boccheggiano area.

Quartz is common at both mines. Splendid, elegant crystals of elongated habit, high transparency and amethystine color, some exceeding 10 cm, have been found at the 150 level of the Niccioleta mine. These resemble the more famous specimens from Traversella, although they are somewhat smaller, clearer and less deeply colored. In general the crystals range from a few mm to 10 cm, colorless, amethystine, and rarely a light green in color. The associations commonly include pyrite and calcite, and also sphalerite at the Boccheggiano mine. A common feature at Niccioleta is the narrowing and disappearance of three of the six prism faces resulting in crystals of triangular prismatic habit, at least in the upper third of the crystals. Three-faced terminations consist of one of the terminal rhombohedrons. Crystals of this habit have also been described from the ancient localities in Tuscany, especially the Pereta mine, in the late 1800's.

Smithsonite occurs in the near-surface portion of the Niccioleta deposit, where it has recently been found as a few rounded white

***Figure 21.* A group of stibnite crystals 4 cm across from the Niccioleta mine. Specimen and photo: P. B. Scortecci.**

crystals and concretions on calcite.

Sphalerite is not very common at Niccioleta but is common at Boccheggiano in specimens of unexceptional quality. Most typical is the ferroan variety *marmatite*, in crystals 1 to 4 cm in size. The sphalerite crystals from Niccioleta, though uncommon, form perfect tetrahedrons in bright druses on pyrite.

Stibiconite is uncommon. It has been found in only a few specimens of deep yellow pseudomorphs after stibnite, some covered by a thin coating of drusy quartz, ranging up to 6 cm long.

Stibnite is also uncommon. However the specimens that have been found at Niccioleta are very fine. It forms thin, lustrous, well terminated crystals to 10 cm on the 320 level. Larger masses of intergrown crystals were encountered on the 250 level. Associations commonly include pyrite, calcite, and rarely gypsum. A large amount of stibnite was found in the old tunnels of the Boccheggiano mine, together with chalcopyrite and pyrite.

Strontianite, though uncommon, has been found at the Boccheggiano mine in small, acicular, white or pale green crystals. Like all of the other carbonates from this mine, it fluoresces in both longwave and shortwave ultraviolet light.

Sulfur is a common species, forming in crystals to 1.5 cm, in an elongated bipyramidal habit with very small pinacoid faces. The yellow, transparent crystals are sometimes found included within perfectly clear gypsum crystals. Recently many fine sulfur crystals in association with celestine and as fine crystals on pyrite were found on the 175 level.

Tetrahedrite in beautiful specimens was found at the Boccheggiano mine during the removal of a quartz and mixed sulfides lode in the early 1900's. A few specimens were later found in the abandoned workings and on the old dumps. The recently collected crystals are no larger than 1 cm although larger ones were found at the time of the original strike. Boccheggiano mine tetrahedrite contains a small amount of nickel, like the tetrahedrite from the old Tuscan mine at Frigido.

We have heard of the discovery of exceptional **bismuthinite** crystals at the Boccheggiano mine, but have been unable to examine specimens for confirmation.

Recently an essay was presented at the University in Florence regarding the discovery of **cotunnite** in a geode in pyrite, and the occurrence of **berthierite,** both in ores from the Niccioleta mine.

ACKNOWLEDGMENTS

We wish to thank Alberto Marcantoni for the maps and Luigi Fazzini for interesting information on Niccioleta mine mineralogy.

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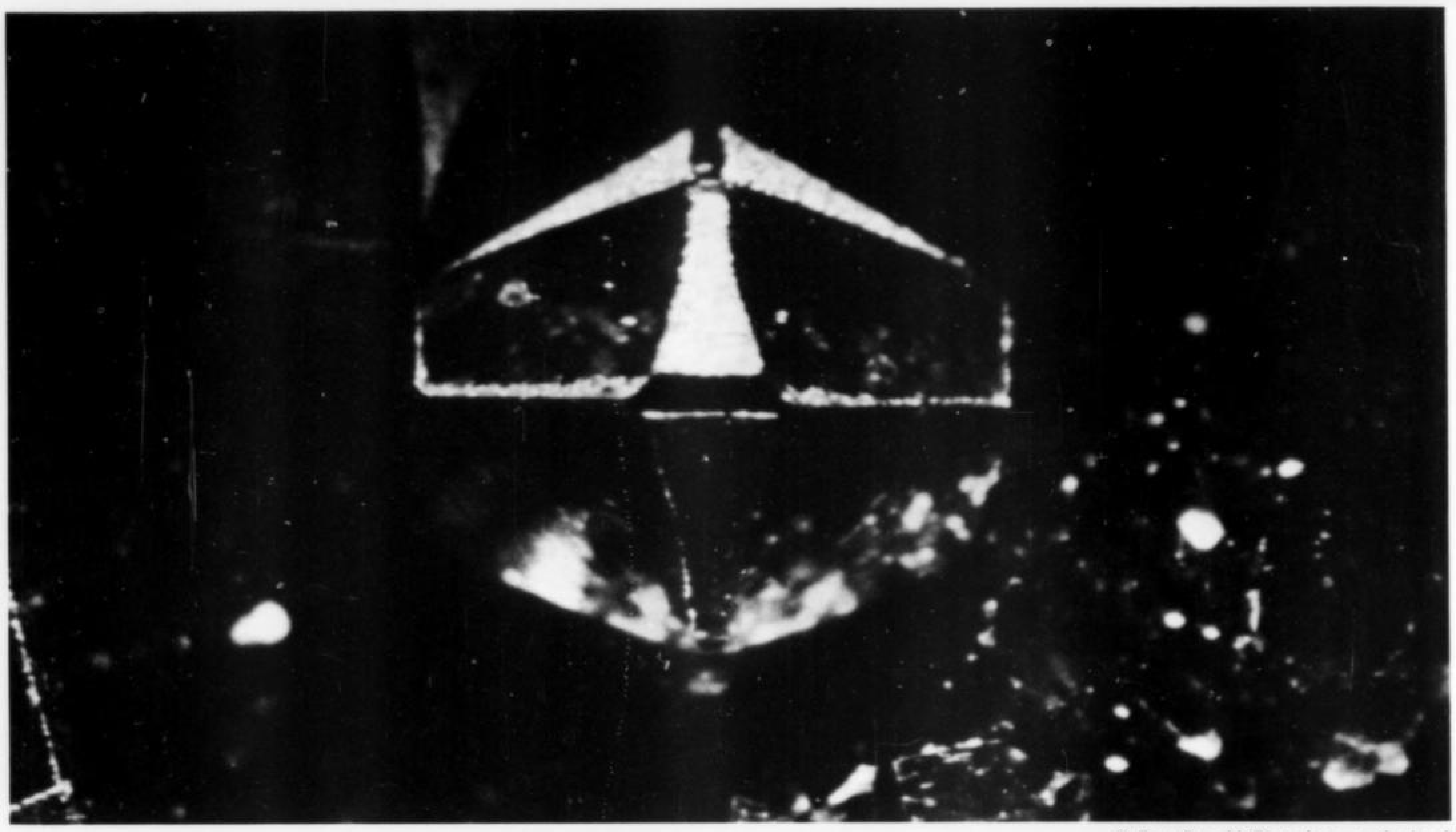

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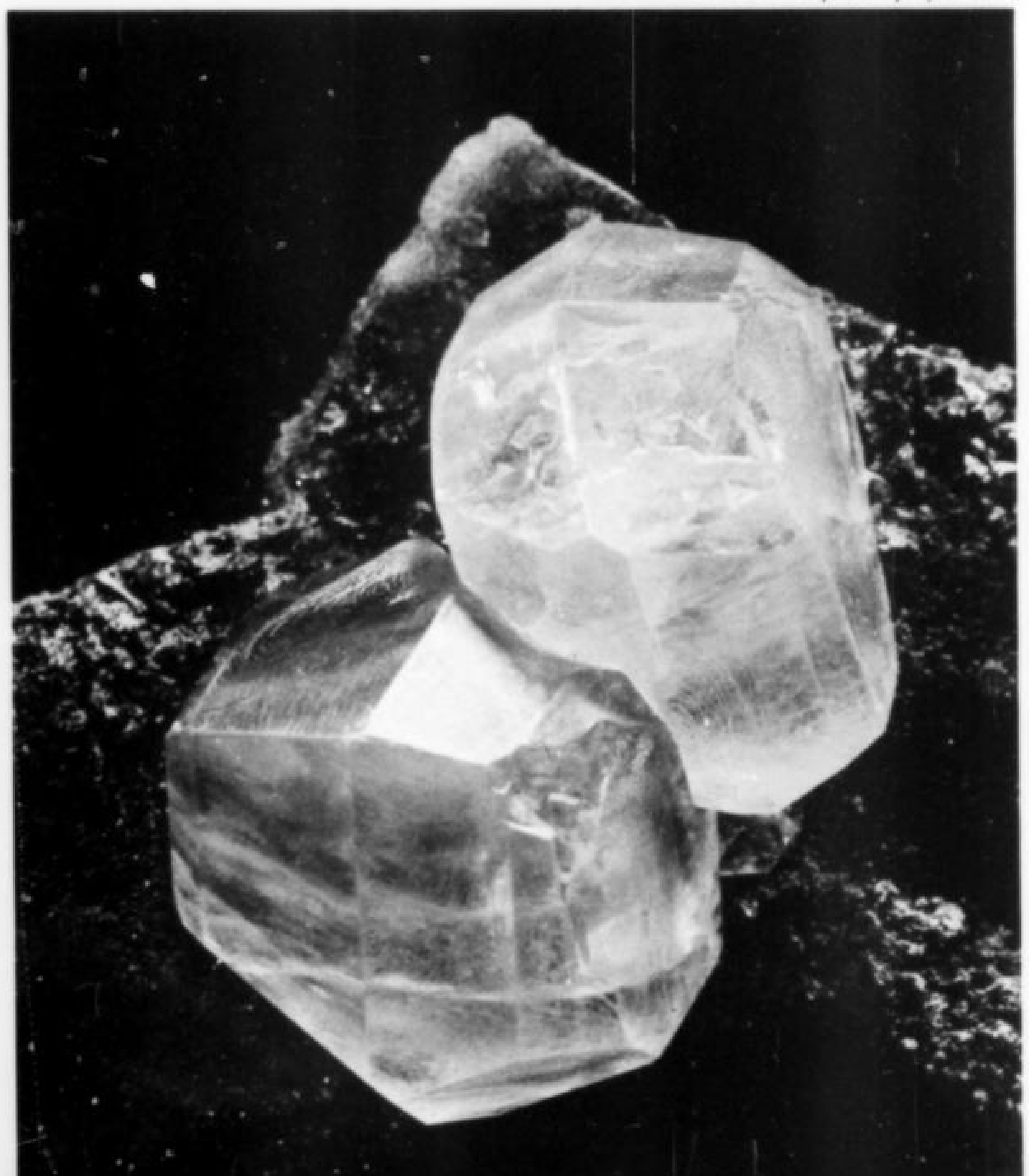
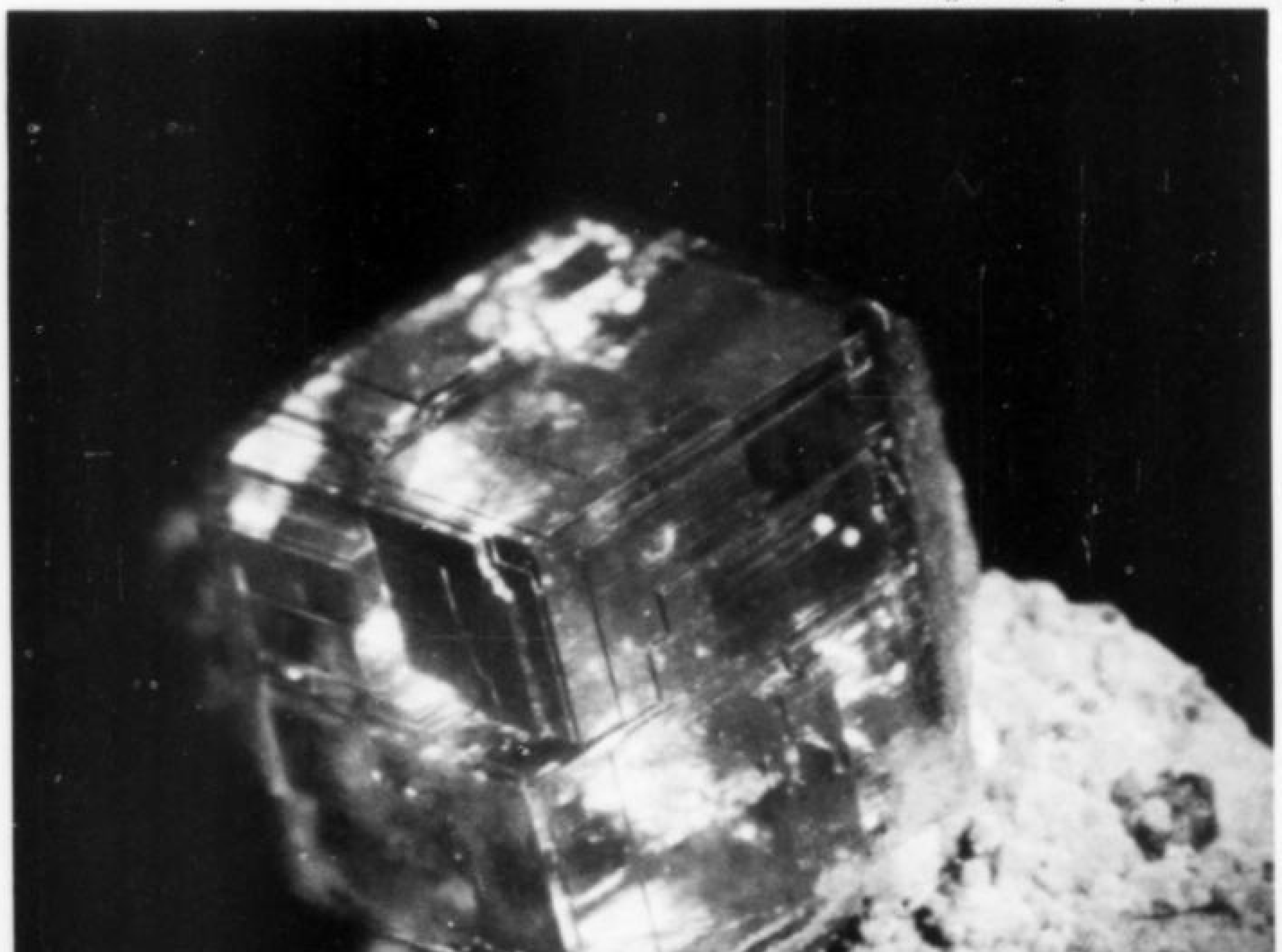


Above: pyrite selectively coating faces of a sphalerite crystal from the Ballard mine, Kansas. The crystal is about 1 mm; Hazel Tarcza collection. **Left:** sulfur from Girgenti, Sicily. **Below:** rhodochrosite from Santa Eulalia, Chihuahua, Mexico. First place winner in the amateur category appeared on the cover of vol. 10, no. 4.

Louis Perloff (Second place—professional)



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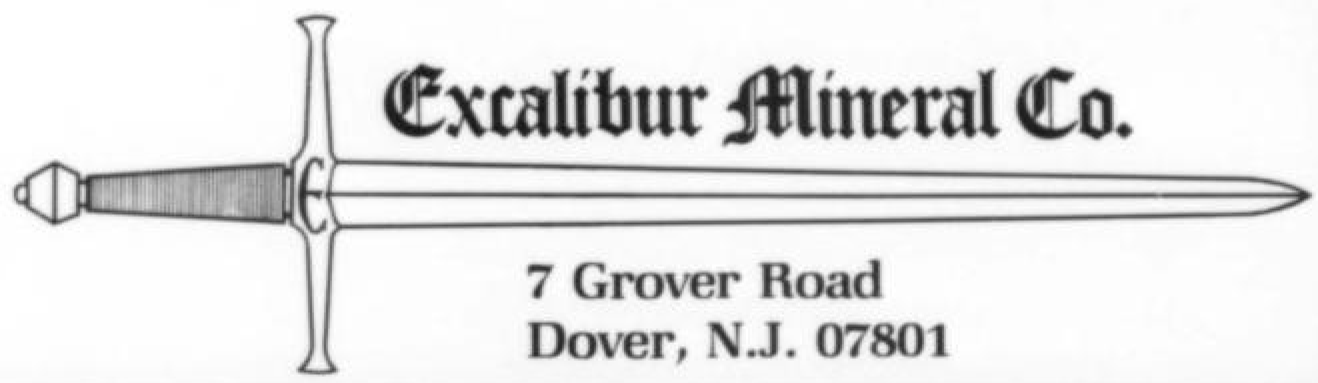

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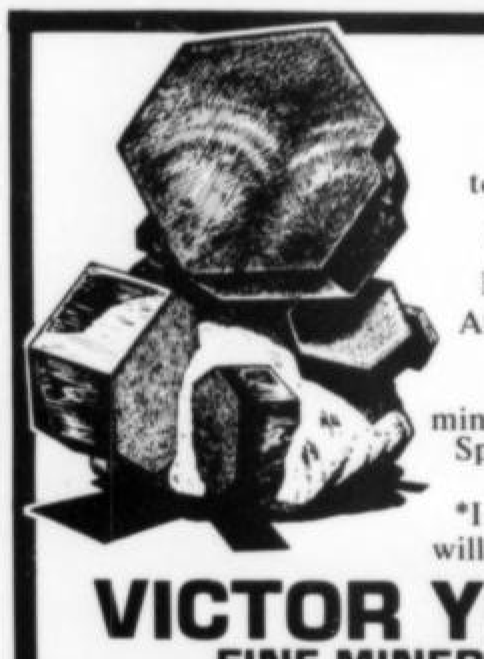

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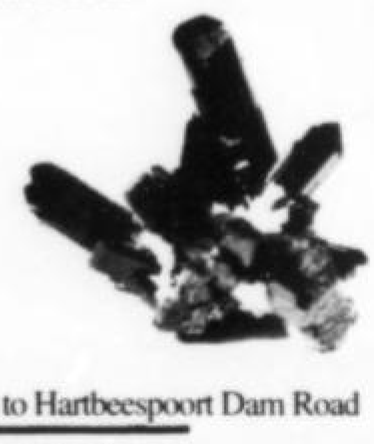

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Microminerals

by Violet Anderson

The distance between the cup and the lip is inevitably considerable in the world of publications. This column is being written in May; those who read it will be browsing through the *Mineralogical Record* for September-October. The long lazy summer (if you can find such a summer), or the summer of traveling hither and yon, will have gone. We shall all be in September, heading for the Baltimore Micromount Symposium (September 28, 29, 30) or, in October, gathering our forces together for the Detroit Show (October 12, 13, 14).

Back here in May, summer yet in the offing, the Rochester Symposium has just whirled us all through sturdy talks and much partying. This Symposium is probably the nearest thing to a real symposium available in the annual circuit of amateur mineralogical events, since talk and discussion are given priority. The aspect of the mart is evident only when no speeches are taking place, and then it is accompanied by a certain merriment natural to any symposium worthy of its name. The Symposium grows bigger each year, untouched, however, by the expanding universe, its spacious auditorium remaining quite Euclidian and earthbound. I can see the day coming when Rochester will have reached the limits of growth. But not yet! You should get there next April (17th to 20th); the three-hour discussion on "What's New in Minerals and Localities" alone is worth the trip.

Still in May, one wonders how field-trips are going to fare as the restrictions on gasoline become tighter. This is the month when a field-trip seems a definite turning of one's back on winter. Perhaps too many black flies—but no winter. People write me, inquiring about Mont St. Hilaire and Francon, two of the most interesting quarries in Quebec. The quarry owners allow collecting at St. Hilaire only on one particular Saturday each month, and then only if you are a member of a mineral club through which prior permission has been obtained. The conditions for collecting at Francon are similar, except that it is Sunday only on which entry is possible. Strong boots and hard hats are mandatory in both.

And it cannot be too strongly said that collecting at any quarry can be jeopardized by two or three determined collectors prepared to risk their necks to get hold of a few specimens. The gamble may seem strictly their own business, but it isn't. If they succeed in killing themselves, the gates of the quarry will certainly be slammed shut. (I have a feeling I've said all this before; if I haven't, I should have.)

So much for little black books filled with notes on birthdays, dentist appointments, mineral shows, and field-trips.

Much of my time recently has been spent photographing microminerals, either those bought or borrowed. Curtis Glenn lent me a bright, strangely blue wurtzite from Bolivia, decidedly layered, and reaching a point as dazzling as an ornamental Christmas tree. The blue is probably oxidization. If so, oxidization has its points.

Following this was a chance to photograph Bill Henderson's pagoda-like wurtzite crystals (from Thomaston Dam, Connecticut). Add to these the wurtzite in my own collection, a reversed scepter (Nagley Strip mine, Nagley, Ohio), looking more like a spaceship than anything else, and one comes to the conclusion that wurtzite, for all its humble origin among the simple sulfides, is a mineral that bears watching.

A specimen from Victor Yount displays yellow wulfenite with some of the most interesting distortions I have seen. Wulfenite is so often simply tetragonal, perhaps with fairly large pyramidal faces, and tiny prism faces at the corners. Victor Yount's material (from Oujda, Morocco) shows crystals with quite a number of pyramids to a crystal, prism faces as slender as threads where one was wont to see pyramidal faces, and collisions in growth producing effects almost twin-like.

Van King has a grossular crystal interesting enough to make anyone say, "Well . . . more of the same thing certainly wouldn't hurt." It is a small dodecahedron with the addition of tiny cube faces, all the cube faces nicely etched, the whole thing a little masterpiece. From Vesper Park, Snohomish County, Washington.

Figure 1. **Plattnerite on aurichalcite, with hemimorphite, from Mapimi, Mexico; the black platternite needles are about 0.25 mm long. Herbert and Geneva Corbett specimen.**

Figure 2. **Quartz crystals impaled on fluoborite from the New Method mine, Amboy California; the largest crystal, seen on the right, is about 0.7 mm long. Herbert and Geneva Corbett specimen.**

Also to report are some absolutely magnificent micromounts belonging to Geneva and Herb Corbett. Not many of these are recent acquisitions but are of a quality to drive any micromounter into distant and rugged terrain if traveling right now could produce such results, and to drive a photomicrographer crazy . . . for different reasons. There is the specimen with long (relatively) black needles of plattnerite sticking out all over a few crystals of aurichalcite (Mapimi, Mexico) (Fig. 1). There are minute and doubly terminated quartz crystals impaled on strands of fluoborite. The quartz crystals are like tiny glassy buds (New Method mine, Amboy, California) (Fig. 2). There is the vivianite in a fan of small blades, barely hinting blue (Magnet Cove, Arkansas), rings and tubes of boulangerite (Rogers mine, Madoc, Ontario), and, of course, the siderite and barite crystals from Frostburg, Maryland, with forms enough to make anyone ask, "Well now, which is which?"

Difficult to describe definitively are two platy species sent me by Sharon Cisneros. These are in vuggy material from Obsidian Cliffs, Lane county, Oregon, along with fine crystals of osumilite. The greyish to brownish crystals associated with the osumilite are said to be hortonolite, which the *Glossary* describes as a magnesian fayalite. What I see, looking through my scope, is a crystal striated parallel to the long dimension, probably impregnated along the striations and edges with some hematite, giving a slightly brownish aspect to the crystal. There are the beginnings of a diamond-shaped plate, one of the corners interrupted by another face (Fig. 3). I do not know how to orient it. Why write about it? Because it's there, neatly shaped, with the fine osumilite crystals, and with some mysterious hexagonal red plates. The latter are possibly alteration products of osumilite, possibly hematite, possibly biotite, possibly montmorillonite pseudomorphous after phlogopite. Every one of these suggestions has been given me, even one which gave the name hortonolite to the red plates rather than the greyish ones. Obviously more light is needed. Has anyone analyzed the Oregon red platy crystals?

With hortonolite, I wish to slip in a word for C. C. Rich, 115 Boot Road, Newtown Square, Pennsylvania 10073. He specializes exclusively in mircomounts, sends out a list three times a year when his advertisement appears in the *Mineralogical Record,* and this time lists hortonolite from Obsidian Cliffs, Oregon. His lists are clearly printed, in large type, on one side of the paper only, and his specimens are very reasonably priced. The babingtonite and embolite he sent me were excellent.

Before I go further, I must put in a remark about nordstrandite, which I declared in my Mont St. Hilaire column to be somewhat less than pleasing: a blobby sort of mineral. I have been introduced to some St. Hilaire nordstrandite which is more attractive: extremely small pointed blades, rather resembling the tiny splinter-like crystals of albite found with eudialyte in 1969, except that the nordstrandite is micaceous. There is a third type of St. Hilaire nordstrandite, glassier, certainly not elegant, but with some persistence recognizable as triclinic.

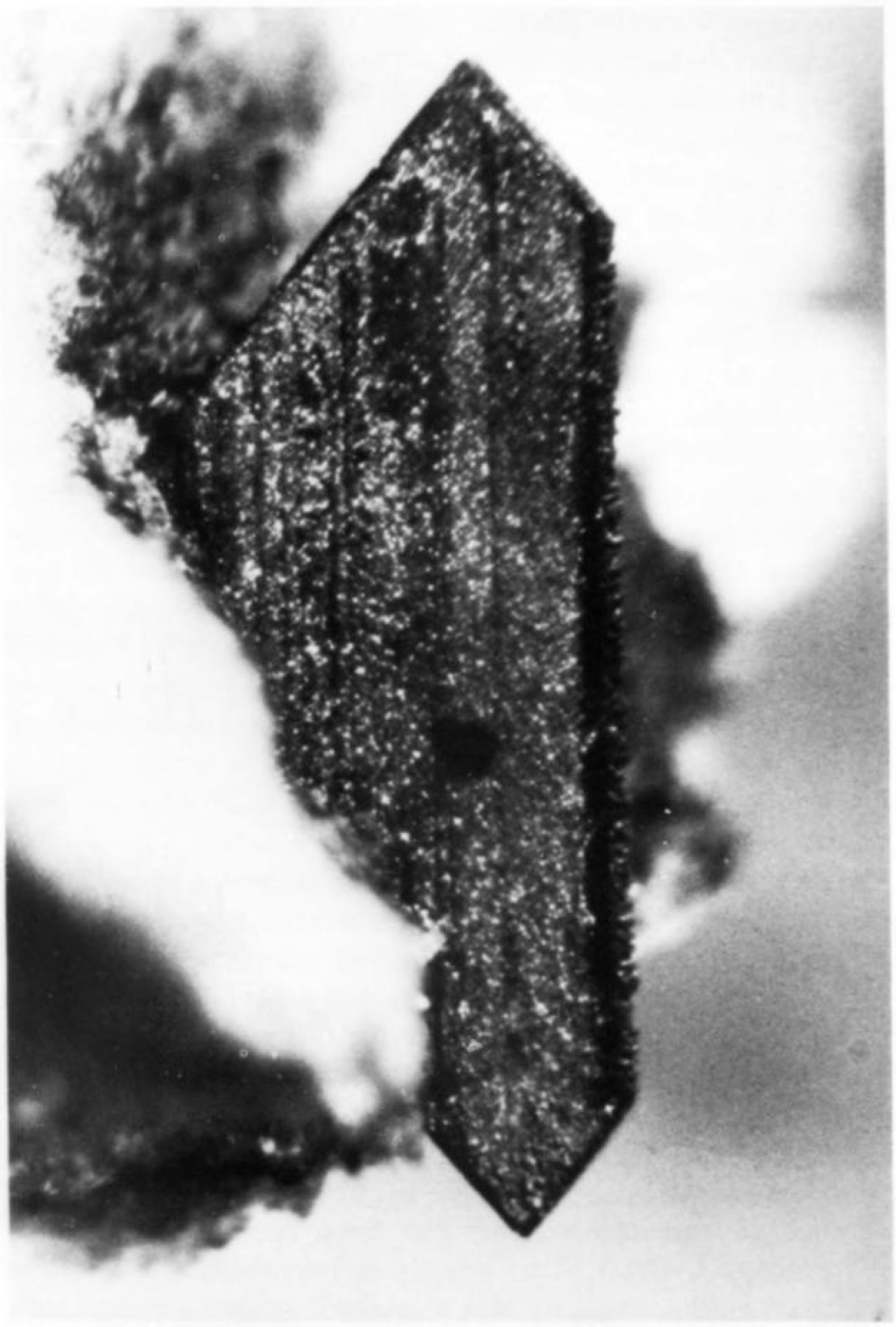

Figure 3. **Hortonolite from Obsidian Cliffs, Lane County, Oregon; length of the crystal is about 2.6 mm.**

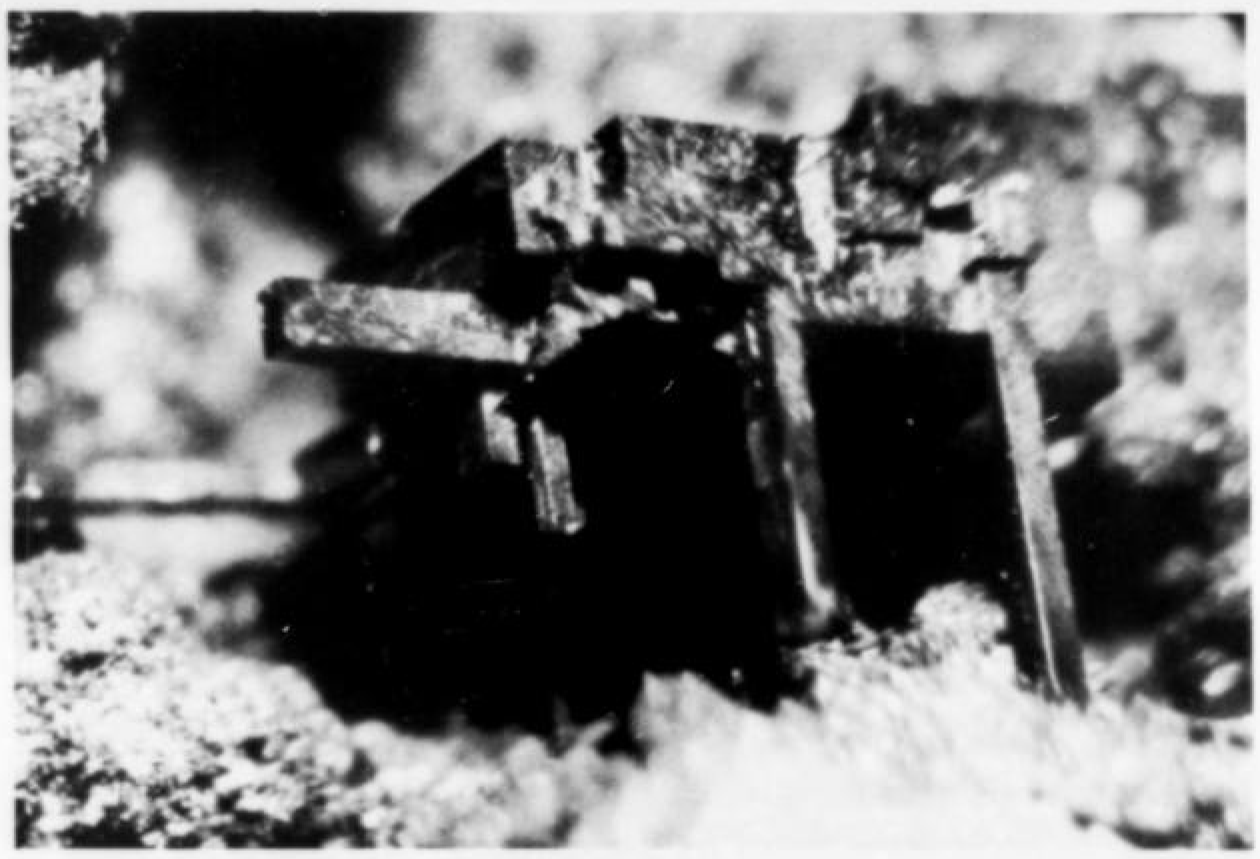

Figure 4. **Cuprite from Bisbee, Arizona; length of the area photographed is 2.7 mm. Herbert and Geneva Corbett specimen.**

These crystals, which are white on white, are difficult to photograph, requiring the light to strike from exactly the right angle. At which point I would like to mention two of my favorite photographic tools.

First, there is the small box full of short-grain rice. For some reason this tool seems to produce hilarity whenever suggested. The absurdity of anything so simple compared to the high-powered microscope and camera, not to mention the higher mathematics needed to understand what goes on below the surface of things, seems too much, just too much. But rice is the neatest, safest, cleanest, uncluttered way to position either a very small specimen or a small microscope box. Shifting the position is easy, and there will be plenty of shifting so long as faces shoot off undesirable specular reflections, or the best grouping of crystal forms is difficult to come by. Furthermore, photography aside, a specimen can be placed with its main feature center-field and then easily shared with another viewer, who need do no more than adjust the focus to his eyes; he will see exactly what you are trying to show him. Compared to guck, chips of wood, dead match boxes, paper clips (why don't they cause hilarity?) or even to those magnetic arrangements which hold micro boxes (but not unmounted specimens), rice is definitely superior.

A second aid is to be found in balsa wafers. Strips of balsa wood the exact width of your box can be purchased at a hobby shop, and sprayed with flat black enamel at home. The wafers are cut (with your X-ACTO knife or saw) to fit the bottom of your boxes. If you have erred on the large side, a light sanding on the edges will correct it. On the wafer is glued the pedestal, on the pedestal its crystal specimen. Be careful to allow for the thickness of the wafer when calculating the total height of your mounted specimen.

When all the glue has hardened, you can remove the specimen from the box with tweezers applied to the pedestal, and use the wafer to dig into the rice to achieve any view of the crystal you wish for photographing. Balsa is firmer than the black paper-lining to which specimens are often attached and which is equally removable. Mounting on the lids of boxes (if your boxes have detachable lids) offers a second-best method; I find the sharp corners of the balsa wood give greater maneuverability.

The only disadvantage is that you cannot turn an open box upside down without disaster (unless the wafer is a pretty tight fit, which itself can be troublesome). Best thing to do is to use double-sided scotch tape below the wafer to hold it in the box when you are through photographing, or wish to give away the specimen.

Now back to photomicrography and the challenging specimens. I am reminded of the time, some years ago, when we were having our house built. It went on forever, with a new problem developing every day. At the end of the harrowing experience I wrote an article entitled "If you are thinking of building a house, don't." I did not try to publish it, thinking the satire was, at the least, unfriendly. Today, after some weeks of photomicrography, I keep mumbling "If you are thinking of photographing microminerals, don't." (Note: I still keep on trying to do it.)

Let me relate a few encounters with a sea of troubles.

At the start, it should be made clear that the specimens are excellent, as unusual and attractive as you could find. It is only the photographer who has taken on a somewhat weathered appearance.

First, the splendid cuprite, halfway to becoming chalcotrichite (Fig. 4). (This specimen belongs to the Corbetts, as does the next one.) The elongated cubes are not hairs but little columns at right angles to each other or parallel. If you were to pass such a structure (an enlarged version) on the street, you would say, "Oh . . . a new building going up; I wonder what." But it's not on the street. It's in a small dark vug, and one must get the light into the vug. Fair enough. But when the light strikes the crystals in such a way as to bring out their inner fire—a gleaming red—it

Figure 5. **Copper on calcite from Bisbee, Arizona; full curve of the copper is about 14.0 mm. Herbert and Geneva Corbett specimen.**

is liable to produce, at the same time, some specular reflections, flashing white. Through a binocular microscope the brain ignores the whiteness, knowing perfectly well that the crystals are a gorgeous bright red. The camera does no such thing. It knows white when it sees it, and says so, emphatically, with a blinding glare. Trying to avoid the white lights may produce merely a sober opaque red, the structure accurately enough portrayed but lacking the essential "oomph" of the cuprite.

After an hour or so, a compromise is achieved, two-dimensional, with a glitter here and there promising something never quite delivered.

Then there is the lovely elongated copper (Bisbee, Arizona) (Fig. 5) appearing almost braided, or like a string of small copper crystals, and reaching with quirks and no doubt quarks from one small foothold in calcite at one end to a ceiling of sorts at the other. A speck of dust can tempt one towards the delicate operation required to remove it—a temptation fraught with such danger to the specimen that it must be resisted. However, the piece of white paper at the bottom of an otherwise totally black box creates a problem which does demand attention since the angle chosen as the best for lighting is going to result in a background for the copper which is part white and part black. Here begins the nerve-racking job of slipping into the box little pieces of white paper to cover one or two of the black sides. Certainly there will be signs of a joint where white meets white, but one can hope to conceal such substrata by a careful cover-up with the eye-catching copper. (Or fancy footwork later with an air-brush. Ed.)

Another hour or more goes by. Some degree of success has been achieved. But then comes the discovery that this particular black box is one of those which dislikes heat (most boxes take heat in their stride). A plastic edge has flipped a lip on one side of the box. Embarrassment!—if you are not the owner of the specimen.

In most tales, some sort of success is struck on the third try. There are two ugly sisters, and then there is Cinderella. Or there is a difficult feat to be performed, and sure enough the third brother manages it. I'm not so sure about these odds. My third example is just as horrendous as the first two, and I could go on and on.

I have a nicely twinned harmotome from Marcelle Weber. The interpenetration angles of the crystals have been partially filled in, as one might imagine an ekanite double-cross (Mont St. Hilaire) filling in between the various arms of the cross (which ekanite, however, does not do). The harmotome is sparkling, colorless, transparent. It rests on a white glistening matrix. To delineate the crystal, to separate it from its background one has only light. If the light sparkles, your two eyes can make out the shapes nicely through a binocular microscope. The one-eyed camera, however, is lost. There is little to do but try to produce shadows. Back-lighting may help, or perhaps placing the specimen inside a tissue tent. If any forms come clear, they will be those of an opaque white shadowy crystal. After the comedy of errors, even that much success might be welcomed; and perhaps not.

Well, that's only the beginning. Tomorrow night, same time, same place.

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Abstracts of New Mineral Descriptions

by Wendell E. Wilson

We continue here to present abstracts of the descriptions of new mineral species recently published, which have not previously been included in Fleischer's *Glossary of Mineral Species 1975* or subsequent updates thereto (*Mineralogical Record*, **7**, 91–95; **8**, 398–399; **9**, 371–374).

Rajite

$CuTe_2O_5$ Monoclinic

From a prospect near Lone Pine, Catron County, New Mexico; color, Duesbury green; resinous to dull; Mohs hardness 4, brittle, cleavage on {010}; pale whitish green streak; specific gravity (meas.) 5.75; no fluorescence observed; crystals to about 1.5 mm; occurs as sprays of bladed to tabular crystals and also in bundles of more prismatic crystals which may be pseudomorphous after teineite; crystals forms curved and not measurable; found in rhyolite breccia at the surface in an arid region; associated with mackayite; with the probable exception of mackayite, rajite is the only known pyrotellurite; named in honor of Robert Allen Jenkins (R.A.J.) of Phelps Dodge Corporation, who first found the new species.

WILLIAMS, S. A. (1979) Rajite, naturally occurring cupric pyrotellurite, a new mineral. *Mineralogical Magazine*, **43**, 91–92.

Polhemusite

(Zn,Hg)S Tetragonal

From the B and B deposit, Big Creek district, Valley County, Idaho; black, locally with dark red internal reflections; resinous to adamantine luster; cleavage perhaps on {001}; crystal size under 25 microns; as imbedded, stubby tetragonal prisms, dipyramids, and irregular grains; twinning on {605} and perhaps others; occurs in a replacement deposit of stibnite and associated mercury minerals in a quartz lode; forms as a microscopic constituent of mercury-bearing antimony ore associated with stibnite, cinnabar, mercurian sphalerite, zincian metacinnabar and quartz; studied in polished section; rather variable in composition; somewhat resembles sphalerite; inferred to be a metastable disordered form of (Zn,Hg)S, a polymorph of mercurian sphalerite; named for the late Clyde Polhemus Ross, a student of the mercury deposits and geology of Idaho and a member of the U.S. Geological Survey for 40 years.

LEONARD, B. G., and DESBOROUGH, G. A. (1978) Polhemusite, a new Hg-Zn sulfide from Idaho. *American Mineralogist*, **63**, 1153–1161.

Thadeuite

$Mg(Ca,Mn)(Mg,Fe,Mn)_2(PO_4)_2(OH,F)_2$ Orthorhombic

From the Panasqueira mining district, Portugal; yellow-orange; vitreous luster; Mohs hardness slightly less than 4, very good cleavage on {010}, another at 90° to that; translucent; streak white; specific gravity (calc.) is 3.21, density (meas.) is 3.25 g/cm^3; no fluorescence observed; massive and coarse-grained; occurs in the selvages of a hydrothermal tin-tungsten vein; associations include fluorapatite, wolfeite, chlorite, vivianite, siderite, arsenopyrite, chalcopyrite, pyrrhotite, althausite, topaz, quartz, muscovite, and the (OH) equivalent of isokite; structurally and chemically similar to the sarkinite and tilasite groups; named in honor of Professor Décio Thadeu of the Instituto Superior Técnico, Lisbon, Portugal.

ISAACS, A., PEACOR, D. R., and KELLY, W. C. (1979) Thadeuite, $Mg(Ca,Mn)(Mg,Fe,Mn)_2(PO_4)_2(OH,F)_2$, a new mineral from Panasqueira, Portugal. *American Mineralogist*, **64**, 359–361.

Carlhintzeite

$Ca_2AlF_7 \cdot H_2O$ Triclinic (pseudomonoclinic)

From Hagendorf, Bavaria, Germany; white to colorless; vitreous luster; white streak; density (calc.) is 2.89, density (meas.) is 2.86 g/cm^3; no fluorescence observed; crystals up to 2.00 mm in size; as tufts and bundles of crystals which are prismatic along [010] and flattened on (001); forms include {100}, {001}, and {110}; always twinned about [010]; formed during hydrothermal alteration of primary pegmatitic triphylite; associations are rockbridgeite, pyrite, strengite, apatite; resembles pectolite in appearance; named in honor of the late Carl Hintze (1851–1916), Professor of Mineralogy at the University of Breslau, and author and compiler of *Handbuch der Mineralogie*.

DUNN, P. J., PEACOR, D. R., and STURMAN, B. D. (1979) Carlhintzeite, a new calcium aluminum fluoride hydrate from the Hagendorf pegmatites, Bavaria, Germany. *Canadian Mineralogist*, **17**, 103–105.

Burckhardtite

$Pb_2(Fe,Mn)^{3+}AlTeSi_3O_{10}(OH)_2O_2 \cdot H_2O$ Monoclinic

From the second and third levels of the Moctezuma gold mine, Moctezuma, Sonora, Mexico; violet-red to pale pink; adamantine to slightly pearly luster; Mohs hardness 2; perfect basal cleavage on [001]; streak pale violet-red to pale pink; density (calc.) is 4.96 g/cm^3; no fluorescence observed; forms as crystalline rosettes less than 0.3 mm across composed of crystals to 0.1 mm in size and pseudohexagonal in appearance; occurs coating surfaces in a quartz breccia, perhaps as oriented overgrowths on dickite; associated with dickite, quartz, moctezumite, zemannite and barite; relatively common on the third level of the mine; paramagnetic; named in honor of Carlos Burckhardt (1869–1935), Mexican geologist.

GAINES, R. V., LEAVENS, P. B., and NELEN, J. A. (1979) Burckhardtite, a new silicate-tellurite from Mexico. *American Mineralogist*, **64**, 355–358.

Veatchite-A

$(SrO)_4(B_2O_3)_{11} \cdot 7H_2O$ Triclinic

From the Killik and Hisarcik mines, Emet colemanite deposit, Kütahya, Turkey; white, colorless; pearly luster on cleavage faces; perfect cleavage on {100}, good on {011} and {01$\bar{1}$}; transparent; density (calc.) is 2.77, density (meas.) is 2.73 g/cm^3; forms cauliflower-shaped nodules 0.5 to 10.0 cm in size composed of well-developed crystals to 2 mm showing plate form and rhombic shape; forms include {100}, {011}, and {01$\bar{1}$}, twin lamellae observed parallel to {100}; occurs in a sedimentary borate deposit; associations include colemanite, hydroboracite, realgar, orpiment and montmorillonite; 2 kilograms of type material are on deposit at the Istanbul Technical University Mining Facility; named for its polytype relationship to veatchite.

KUMBASAR, I. (1979) Veatchite-A, a new modification of veatchite. *American Mineralogist*, **64**, 362–366.

Surite

$Pb(Pb,Ca)(CO_3)_2(Al,Fe,Mg)_2(Si,Al)_4O_{10}(OH)_2$ Monoclinic

Found at the Cruz del Sur mine, Rio Negro province, Argentina; white to pale green; glossy like talc; Mohs hardness 2 to 3; perfect cleavage on {001} parallel to the elongation; white streak; density (meas.) is 4.0; occurs as compact aggregates of microscopic tubular lath-shaped crystals; found in the oxidation zone of a lead-zinc-copper deposit, in veinlets to 5 cm wide; effervesces in 0.75% HCl at room temperature; a clay mineral of unique type, with a structure composed of intercalated layers of cerussite structure and dioctahedral smectite structure; named for the locality.

HAYASE, K., DRISTAS, J. A., TSUTSUMI, S., OTSUKA, R., TANABE, S., SUDO, T., and NISHIYAMA, T. (1978) Surite, a new Pb-rich layer silicate mineral. *American Mineralogist*, **63**, 1175–1181.

Georgeite

$Cu_5(CO_3)_3(OH)_4 \cdot 6H_2O$ Amorphous

From the Carr Boyd nickel deposit of Western Australia; light blue; luster vitreous to earthy; very soft and brittle; conchoidal fracture; no cleavage; transparent to sub-opaque; pale blue streak; specific gravity 2.55; as thin, pulverulent to dried-gel-like coatings; occurs in the oxide zone, associated with malachite, chalconatronite, tremolite (matrix), nickelian magnesite and gypsum; probably formed as a decomposition product of malachite or chalconatronite; named in honor of George Herbert Payne, past Chief of the Mineral Division, Western Australia Government Chemical Laboratories.

BRIDGE, P. J., JUST, J., and HEY, M. H. (1979) Georgeite, a new amorphous copper carbonate from the Carr Boyd mine, Western Australia. *Mineralogical Magazine*, **43**, 97–98.

Schreyerite

$V_2Ti_3O_9$ Monoclinic(?)

Found in the Kwale district, south of Voi, Kenya; reddish brown in reflected light in polished section; Knoop hardness 1100–1200 Kp/mm²; crystals to 0.2 mm; as exsolution lamellae and particles in microscopic rutile grains; associated with rutile, kyanite, sillimanite, tourmaline, and emerald-green, gem-quality crystals of kornerupine; named in honor of Dr. Werner Schreyer, Professor of Mineralogy at Ruhr University, Bochum, West Germany.

MEDENBACH, O., and SCHMETZER, K (1978) Schreyerite, $V_2Ti_3O_9$, a new mineral. *American Mineralogist*, **63**, 1182–1186.

Tsumoite

BiTe Hexagonal (trigonal)

From the Tsumo mine, Shimane Prefecture, Japan; silver-white; metallic; Vickers hardness 51–90 kg/mm², 15g load; perfect basal cleavage; opaque; streak steel-gray; specific gravity (meas.) is 8.16, density (calc.) is 8.23; crystals are tabular in habit, a few millimeters in size, forming irregular aggregates to 1 cm across; occurs in a pyrometasomatic ore deposit in a clinopyroxene-garnet-quartz skarn; associations include tetradymite, bismuthinite, cosalite and galena; perhaps related to inadequately characterized materials reported from other localities as "wehrlite"; named for the locality.

SHIMAZAKI, H., and OZAWA, T. (1978) Tsumoite, BiTe, a new mineral from the Tsumo mine, Japan. *American Mineralogist*, **63**, 1162–1165.

Garavellite

$FeSbBiS_4$ Orthorhombic

From Valle del Frigido, Apuane Alps, Tuscany, Italy; gray in reflected light; Vickers hardness (50g) is 212–222 kg/mm²; density (calc.) is 5.64 g/cm³; occurs as small aggregates to 200 μm across composed of anhedral crystals; found in an ore body of spathic siderite and disseminated chalcopyrite; usually in direct contact with tetrahedrite, antimony-rich bismuthinite, chalcopyrite and siderite; samples found in polished section studies; named in honor of Professor C. L. Garavelli in recognition of his contributions to the mineralogy of Tuscan ore deposits.

GREGORIO, F., LATTANZI, P., TANELLI, G., and VURRO, F. (1979) Garavellite, $FeSbBiS_4$, a new mineral from the Cu-Fe deposit of Valle del Frigido in the Apuane Alps, Northern Tuscany, Italy. *Mineralogical Magazine*, **43**, 99–102.

Kleemanite

$ZnAl_2(PO_4)_2(OH)_2 \cdot 3H_2O$ Monoclinic

From Iron Knob, South Australia; ochre-yellow to colorless; bright luster; density (calc.) is 2.76 g/cm³; maximum crystal length about 60 μm(?); occurs as veinlet fillings 1 to 2 mm thick and as thin layers of felted masses of fine, hair-like crystals on fissure surfaces in manganiferous iron ore; named in honor of Dr. Alfred William Kleeman, Department of Geology, University of Adelaide, Australia.

PILKINGTON, E. S., SEGNIT, E. R., and WATTS, J. (1979) Kleemanite, a new zinc aluminum phosphate. *Mineralogical Magazine*, **43**, 93–95.

Manganochromite

$MnCr_2O_4$ Isometric

From Shepard's Hill quarry, Brukunga, South Australia; brownish gray in reflected light in polished section; VHN_{20g} hardness is 1000 ±70; specific gravity (calc.) is 4.86 to 4.90; crystals 10 to 800 μm and of elongate habit; occurs in a Cambrian pyrite bed of metasedimentary origin, in tension gash veins; associated with pyrrhotite, diopside, rutile and others; found in one polished section; the type specimen is a highly vanadiferous variety; spinel structure; named for its analogous relationship to magnesiochromite.

GRAHAM, J. (1978) Manganochromite, palladium antimonide, and some unusual mineral associations at the Nairne pyrite deposit, South Australia. *American Mineralogist*, **63**, 1166–1174.

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Memoirs of a Mineral Collector

by
Fred W. Cassirer
with the assistance of Amanda Martin


Photo by Lotta Jacobi

Fred W. Cassirer (1888–1979)

The Second of Three Parts

On February 15 of this year, Fred Cassirer passed away at the age of 90. Before doing so, however, he was able to put down, for publication in the Record, *many of the mineralogical memories he had accumulated over his long and interesting life.*

We continue here with part two of his memoirs, illustrated with pictures of specimens from Fred's collection. (Part one appeared in volume 10, number 4, of the Record.*) The mineral photographs are by Henry Janson.*

Romania

During one of my visits to the British Museum, the curator of the mineralogy department, Dr. L. I. Spencer, asked me whether it would not be more effective to exhibit one large, representative specimen of each mineral group instead of hundreds of small pieces. The idea was that such large pieces would attract the uninitiated visitors to the department, laymen who had never before been interested in mineralogy, but who might suddenly feel encouraged to know more about the subject and study the permanent collection. I knew what he wanted, and replied that I would try to aquire for him some large, well-crystallized specimens of high quality. Dr. Spencer seemed pleased, and wanted to know my fee for doing such work for the Museum. I explained that collecting in order to sell minerals was not my business. My real business was manufacturing paper; that was how I made my living. "But I will gladly collect for you," I said, and added, "That will give me an opportunity to collect for myself too. That's the way I have always done it before." I proposed to name the value for each specimen when I returned, and then the Museum could decide. "My prices will be acceptable," I assured him. This was, of course, a gentleman's agreement convenient for everybody.

For my purposes I chose the Balkan countries (Romania in particular) because I had studied the literature on mineral deposits in the Balkans, and because Romania was close to Czechoslovakia, my "foster country" at the time. The center for mineralogical finds in Romania was in the area of Baia Mare, a small village in Transylvania, generally the most important European source of gold. According to the literature about Baia Mare, large amounts of ore had been found there, including a variety of sulfosalts and, in former times, also native gold and silver. The main production, however, centered on pyrite and galena.

On the train to Baia Mare I talked with a man sitting next to me. "What do you do?" he asked me. "I am an immigrant," I answered "who has run away from Hitler. I have come here to

Figure 1. **(Left) Galena with siderite, 4 by 4½ inches, from Neudorf, Harz Mountains, Germany. (Right) Galena with pyrite from the Pfannenberg mine, Siegen, West Germany.**

collect minerals for the British Museum." The stranger became interested and told me that he owned a mine which produced mostly galena containing traces of gold and silver. I told him about my project of finding large specimens representing different mineral groups to be used for display. He had no appreciation for such ideas; nonetheless he wanted to be helpful to a newcomer and an immigrant. He promised to give orders to his miners to look out for such large specimens which he would be happy to donate. I thanked him, and told him he was very kind indeed. When we arrived in Baia Mare I got off the train and immediately set out for the mine. There I was told it was a charming offer the owner had made, but that they had not come across such specimens as I describe during their time. I didn't pay much attention to their words, and instead went to find the mine foreman, an experienced old-timer who confirmed what the owner had told me earlier on. His family, it turned out, had been miners in the area for generations. I met the man again in the evening and we decided to go out and eat together and share a glass of local wine. It was 11 o'clock at night, after a good supper; we were about to part when he said to me, "Why don't you come over and take a look at my collection. My father left it to me." I did indeed take a look and it sufficed for my whole trip! This man had all kinds of large and small specimens. Like his ancestors, he referred to them as "flowers" because of their beautiful colors and petal-like shapes. I offered him a good price for the whole collection, and you can't imagine how excited and happy the old miner was about this unexpected turn of events. What was much more important to me: he loaned me one of his miners and we took off to some long-deserted localities, entrances to large caverns neglected long ago as not supplying enough massive ore for production. For days we went from pit to pit, entering small holes and excavating outstanding crystal groups which included excellent crystallized stibnite in single crystals and groups on matrix. During weeks of difficult work we found many rare specimens such as fülöpite, zinkenite, jamesonite, sylvanite, nagyagite, petzite, and bournonite; in short, quite a line of minerals, but especially sulfosalts. Excellent material was found for later scientific research at the different university laboratories, a task still under way to this day.

I stayed on for another two or three weeks, every day going from pit to pit and mine to mine, staying underground most of the time, exploring in half-darkness the old and abandoned passages, getting tired and dirty. To go down into a mine in those days meant descending many meters down a rough shaft while hanging in a basket, the same way by which the ore was hoisted out. It was neither the most secure nor the most pleasant way of traveling. Visitors and miners alike went down into the mine at 6 o'clock in the morning and came up again together at 6 o'clock in the evening. During the day each person worked to penetrate further into the mine, holding a carbide lamp in one hand and a pickaxe in the other, climbing and crawling through old rocky passages, attempting to hew out new ones, carefully breaking new openings into the rock where there promised to be unbroken crystals. On few of these mining trips did I find specimens which were good enough for my purposes. After a couple of weeks I went to the head office and thanked them for their courtesy in having admitted me to their mines. I asked their permission to make up a list of the different localities, deposits, and minerals, possibly to be published later with geological details I had studied on the spot.

Before leaving the area I met a state mining official who asked whether I had seen the company's beautiful specimens. I said "No," and he invited me to see them. "You can look at them if you want to," he said, whereupon he opened a door leading to a room filled with the most marvelous specimens I had ever set my eyes upon. I had never dreamed of anything as beautiful as these specimens. "Would you like a specimen?" my guide asked me. I answered "No." Somewhat surprised he asked, "Why not?" And then I said, "I don't want one of these specimens, I want them ALL." He told me that this was a deal if I could manage to get them out by the same evening, and that he did not want to be paid anything for them "because we are interested in having these pieces in a museum of the kind you are talking about." We went

***Figure 2*. Gold crystals, 2 inches tall, from Baja Mare, Romania.**

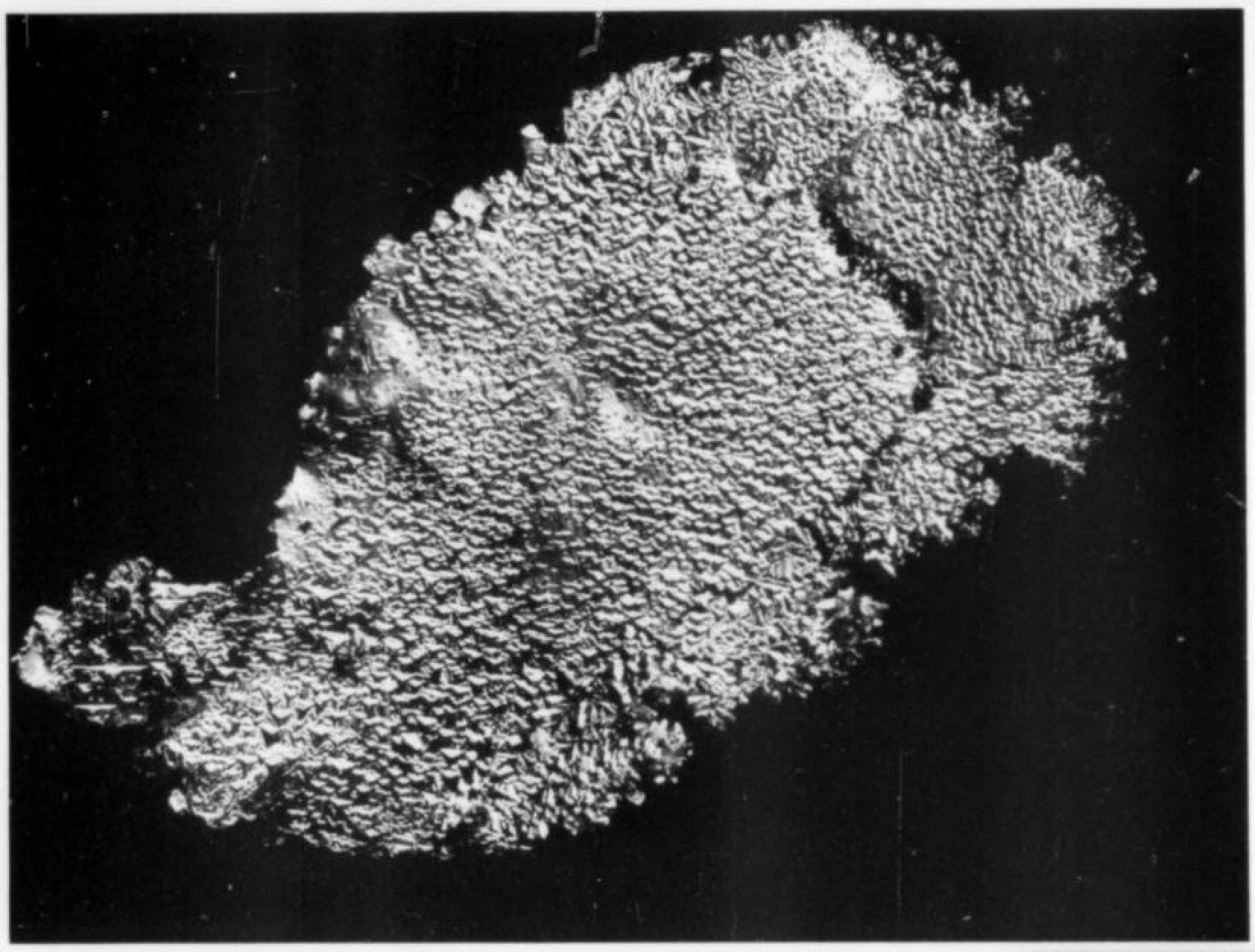
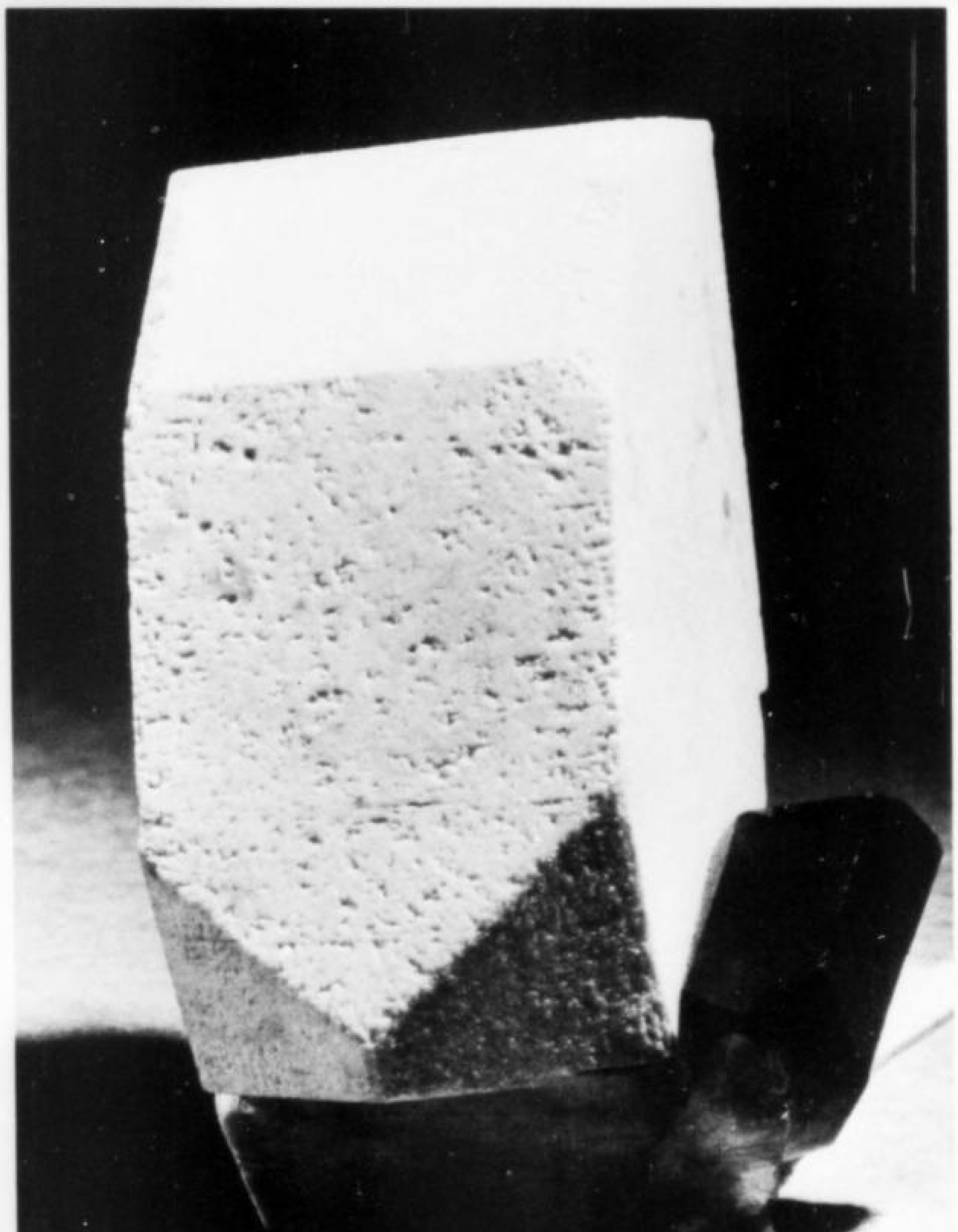


Figure 3. A plate of fine gold crystals about 2 inches across from Baja Mare, Romania.

Figure 4. Microcline with smoky quartz, 4 inches tall, from Haute Vienne, France.



out to a restaurant and ordered what proved to be the only two bottles of champagne there were. We drank them and had dinner together.

Meanwhile we had arranged to have all of the peasants in the neighborhood come with their carts filled with hay at 8 o'clock that evening. We packed the specimens in the hay, but more packing material was needed, so we went on to the next village and came to a tavern decorated with streamers and paper garlands for a local dance festival. I went in and asked the owner whether I could buy his decorations. He laughed, and said that I would do him a favor if I took them away because the dance and the festivities were over. I took all of the streamers and garlands down, and they served as our precious packing material, for no newspaper existed in this forgotten place. Minerals and streamers . . . I took them all to Baia Mare where I could pack them properly and from there they traveled to Prague.

That tiny village, just a tavern really, was Felsobanya. Near Felsobanya I collected a 10 by 10-inch stibnite group (which I recently gave to the American Museum of Natural History). The mines in these places were particularly dangerous. A mine foreman, at the prospect of earning some extra money for himself, told me about two mines a short distance away from Baia Mare. They had been abandoned because of the dangerous conditions of the tunnels. The foreman and his two sons volunteered to go with me to try to find one of the slopes which had been known for its marvelous stibnite crystals. We went there by horse-cart and, because the mine went upward, we had to climb up the shafts until we came to a seam in the ground where there was an underground waterfall. To reach the end of the shaft we had to pass through the water and there, with chisel and hammer, we spent hours removing stibnite groups from the walls. They were of a finer crystallization than the material that was presently being mined nearer the surface, and many sulfosalts were bound up with the stibnite.

St. Joachimsthal

The years after 1920 had not been very attractive in either field, be it minerals or paper. My family, as everyone else, was busy rebuilding from the disastrous effects of the war years as well as inflation. We were trying to salvage whatever we could from the "rubbish heap." A few years of this kind of activity was enough for me. So I decided to look around and try and find out what we could offer our neighboring countries which would also give us a chance at a new business. A pending patent matter as well as many other open and unsettled questions gave me an excuse to visit our London lawyer who represented, so we hoped, our "chances." The result was absolutely NIL.

In order to give myself a break from such problems I visited the mineralogical department of the British Museum. The few people there whom I knew from earlier times were also not in high spirits. Dr. Smith, whom I had met during a previous visit, asked me whether I could be helpful in the following question. In 1902, Madam Curie had announced the discovery of radium. According to Dr. Smith, the mineralogy department of the British Museum had so far not been able to get much information about the new material, and was especially interested in obtaining some of the "ore" (pitchblende) which the Curies had used in their work. "Can you be of help in this?" Smith asked. I couldn't promise anything but, as I was on very good terms with the Narodny Museum in Prague, I told her I would try on my next trip out there. "How much?" she asked, and I said, "No, I am glad to be of help," and, indeed, I loved the charge, but it took some time before I got any closer to it.

On sunny, wintry day, together with my friend Phillip Harth, a sculptor and designer, I went on a ski trip to the Riesengebirge in Southeast Germany. Looking down a hill I saw a roadsign saying *St. Joachimsthal.* I descended, left my skies with Phillip and went straight to the Joachimsthal Mining Office. I spoke to a man from the management who told me that I had no chance at all to obtain any of the specimens I wanted since none would be given away: "If further studies will be made, we shall publish them here ourselves," he concluded. "If you did make such studies," I replied, "on pitchblende or uranium, I hope you will let me have some copies since my friends in London and elsewhere would be greatly interested to learn more about this exciting new subject." He answered that they would be happy to but that "nothing had been done yet." His cryptic reply was not very encouraging. I realized that I had to change my method of approach.

I stayed on a while, looking around and familiarizing myself with the area, and met an old miner who had worked in the mines for many years and knew everything about them. I asked him for advice, how I should go about getting the specimens I wanted, when he offered me some which he had at home. I left him that evening carrying three boxes of specimens. They included all the varieties of ore which contained radium! The old miner did not ask for any payment for this material. (What could have been the price, I wonder now, anyway?) He was glad to hear that the material was going to be used for research. Two of the specimens which he gave me, both pitchblende, one 2 by 4 by 2 inches and another smaller one, are still part of my collection. All of the specimens that the miner gave me were accompanied by labels carrying precise locality information. I supplied the material to the British Museum and it goes without saying that I was profoundly stirred to have worked with specimens of such historical significance.

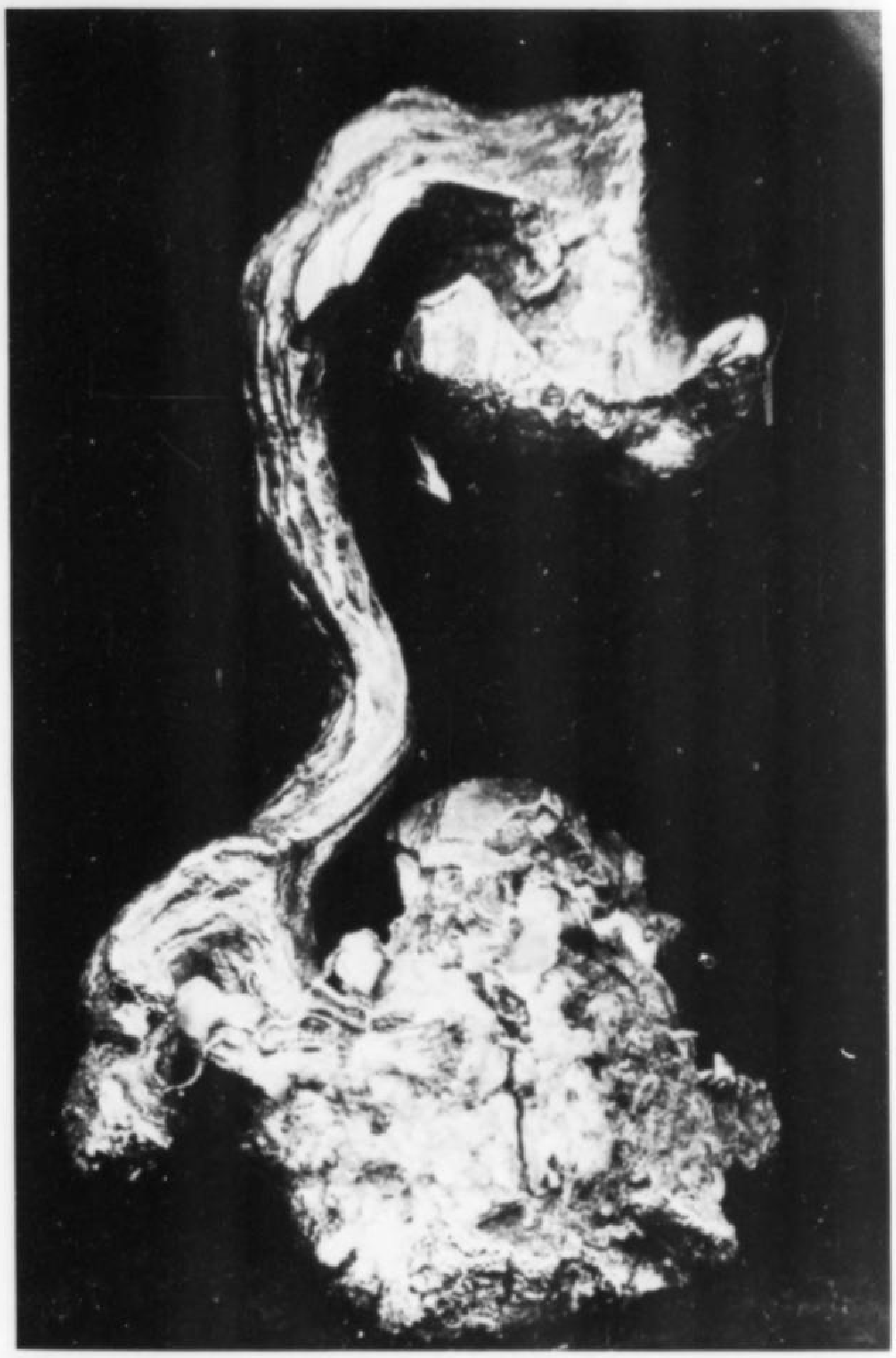


***Figure 6*. Silver, about 4 inches tall, from Kongsberg, Norway.**

***Figure 5*. Pyrite, 3¾ inches across, from Spain.**

Greece

My experiences in Romania encouraged me to travel farther. I decided to visit the famous Laurium mines in Greece. My flight to Athens involved a change of planes in Budapest. While I was waiting there for my plane, a porter picked up my two suitcases and a flight attendant guided me to the boarding area. When I arrived in Athens I was told by the airline that my luggage had been shipped to Marseilles! It contained all of my belongings including a letter of credit from a London Bank. What a start! To make matters worse, travelers at that time were allowed to take only small amounts of cash from one country to another.

In Athens I did not stop to look at the Parthenon. I immediately went to the mineralogical department of the local museum to find out from the curator what chance I had of visiting the Laurium mines. Many centuries ago these had been mined for lead, silver and zinc. Of the minerals for which Laurium was famous, I was particularly interested in smithsonite.

I had already owned a piece of Laurium smithsonite, 6 by 6 inches. It was finely cut and polished like a plate of glass. When

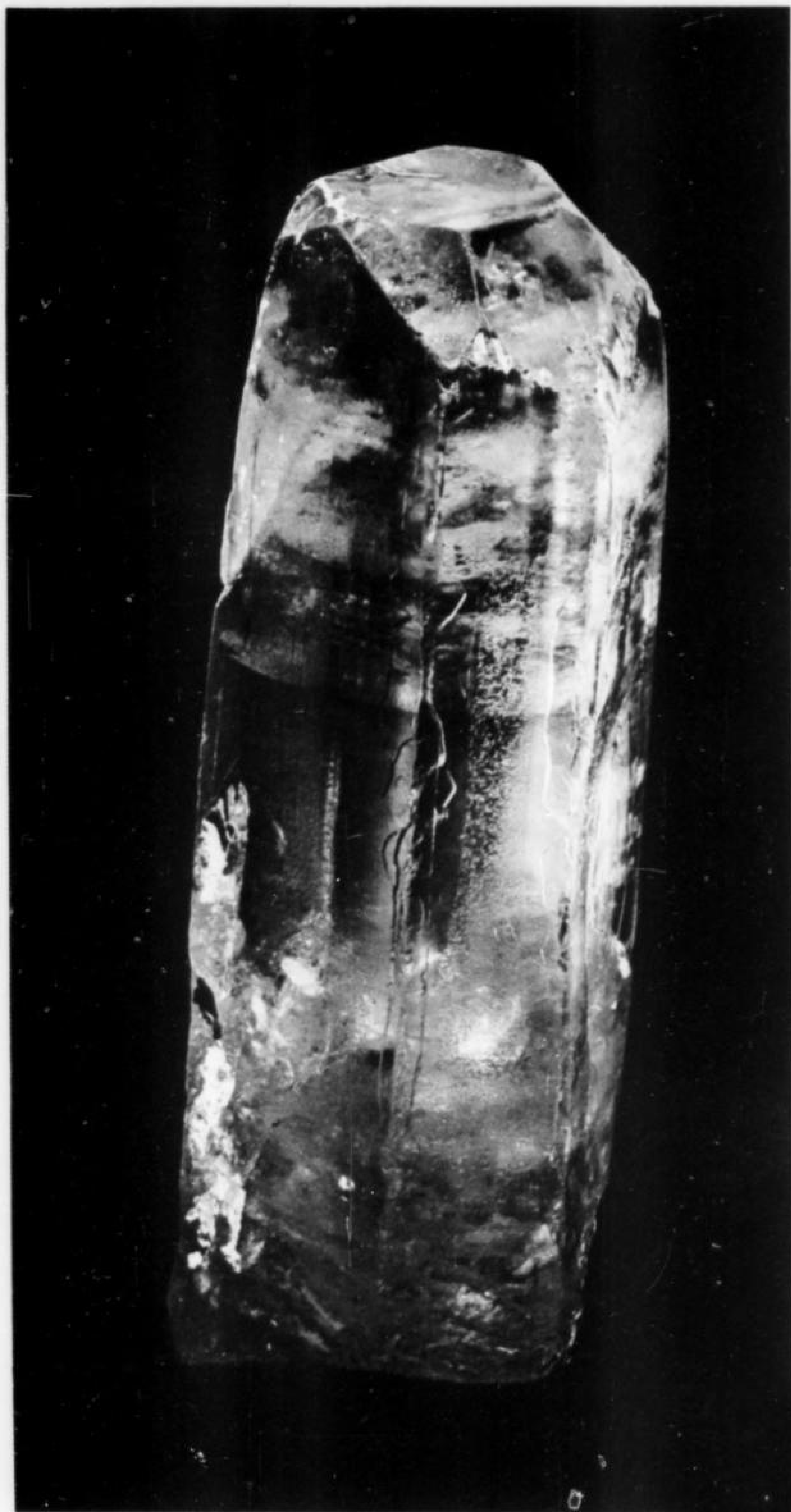


Figure 7. Golden beryl crystal 3¼ inches tall from Brazil.

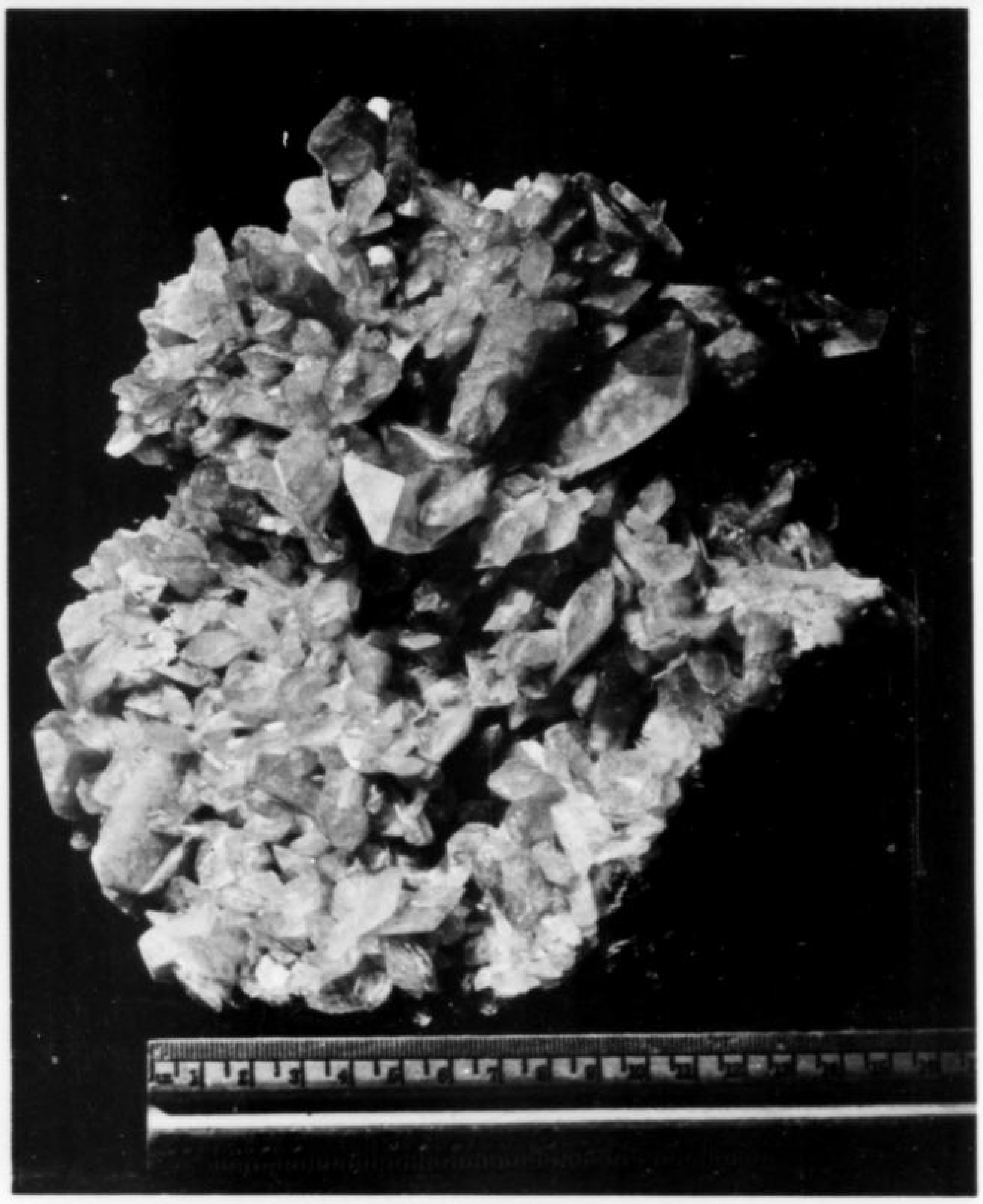


Figure 8. A large group of fine brazilianite crystals from Minas Gerais, Brazil.

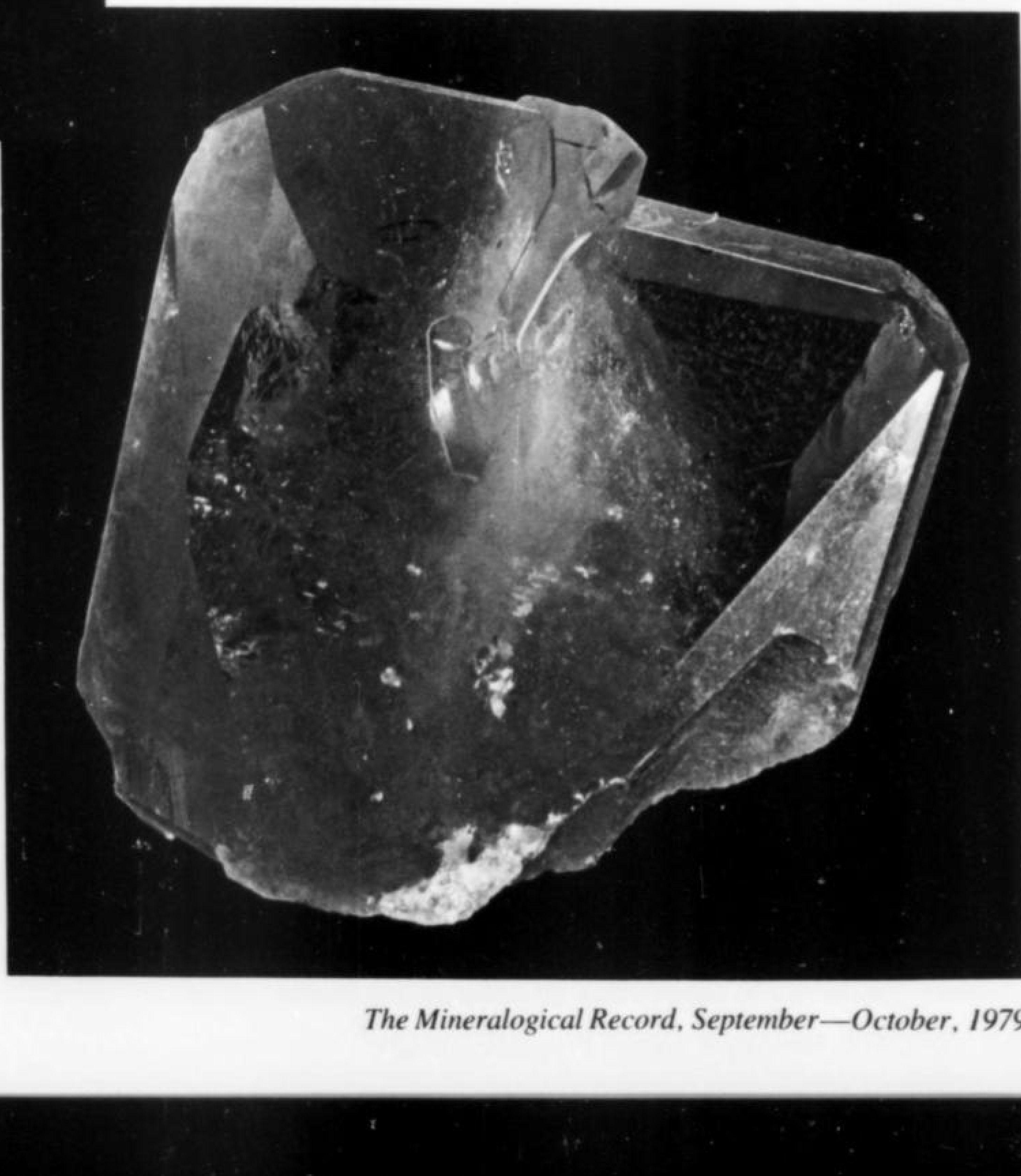


Figure 9. Topaz crystal, about 2½ inches across, from Brazil.

held up against the light it shimmered in a watery green-blue. The shiny and intense green-blue color of this variety of smithsonite always makes it look as if it were wet, resembling the green-blue shades of the Mediterranean Sea. In Greece, smithsonite had been used for decorative purposes. I had come there with the hope of bringing home more specimens, but when I told the curator what I wanted, he was not too optimistic about the possibilities. Nonetheless, he was very willing to arrange a visit to the abandoned mines for me.

Like most deserted mines, these were filled with water and the immediate result of my visit there was to get thoroughly wet. When I climbed out, I sat down at the entrance to the passage which had taken me into the mountain. There I was joined by some local workmen. One of them spoke a fair amount of French and he asked me why I had come. I explained that my idea had been to find some specimens from the Laurium mines including, perhaps, some smithsonite. A cunning smile dawned on his face and he said, "If you can lift and carry away an old, heavy rock, I'll give you a piece of smithsonite." I agreed without knowing what kind of impossible, Herculean feat I was letting myself in for. "Where is the rock?" I asked anxiously. He looked straight in my direction and said, "Just get up. You're sitting on it." I got up, and he pointed to the rock I'd been sitting on. "That's it!" It was, indeed, a block of solid smithsonite about 30 by 30 inches. To everyone's satisfaction I was able to lift it, but I had it carried away and then packed up and sent home to Prague, where later I published an article about this interesting find. I had it cut into slices which I gave away to interested museums in Europe and overseas.

After the episode at the entrance to the Laurium mines I returned to Athens and got my suitcase and letter of credit. Before I left the city I went back to the curator and thanked him once more for arranging my visit to Laurium. I "forgot"—as it were—to tell him what had happened with the smithsonite. He was eager to show me his collection, which consisted largely of different Laurium minerals. I had hoped to get some of them, but did not succeed. In this collection some specimens were already deteriorating for lack of proper care. Later the curator opened several drawers containing two collections of the most marvelous specimens from the Ural Mountains in Russia, which had been given to the Museum as "having no interest for the donor." To my amazement, the curator was not interested in these specimens either! They were specimens of gem quality, including aquamarine and emerald. His one interest was teaching and educating beginners. What he needed most was not gems, but a complete "Dana series," a systematic collection without which the teacher of mineralogy has a difficult time instructing students in the field. "How would it be if I sent you a copy of *Dana* and the accompanying specimens in exchange for these collections or part of these collections?" I asked him. "That would be better than owning an aquamarine." he said. I knew of a company in Germany that would ship complete collections of up to 200 specimens anywhere, and I intended to add 25 pieces from my Prague collection. It was an outstandingly good arrangement for both of us, and to come home from Greece with the most marvelous and rare specimens from Russia was certainly unusual and unexpected. These rarities are still part of my collection today.

My Experiences in Russia

Seeing actual crystals from the Urals reminded me of the contacts I had in Russia. I had formerly been the director of a paper factory my family had in Poland which, in those days, before World War I, belonged to Russia. It is common knowledge that any cellulose factory depends on the presence of a river. Vast quantities of water are needed for the manufacturing process, and equally vast quantities of waste water must be disposed of. In establishing this factory the seniors of my family had not considered it objectionable to discharge possibly harmful waste water into the Vistula River above a small town near Thorn, on the German border. My long and repeated stays in Poland had, of course, included visits to the Warsaw Mineralogical Museum, and these, in turn, led to contacts with the Mineralogical Museum in Moscow.

When that little town I spoke of sued the factory, I, as its chairman, had to attend court proceedings in Leningrad and Moscow. This suit, incidentally, dragged on for 30 years! The factory lost because of anti-pollution laws, and a special sewer had to be constructed for the waste water. During the several months I spent in Leningrad and Moscow, I found time to pursue my real interests. Between court sessions I traveled to the foot of the Ural Mountains, an extraordinarily rich area for gemstones. According to the season it was still autumn, but winter had come early and was so severe that I could not reach my goal. A visit to the mines, above all the Nerchinsk mines, was impossible. Armed with letters of introduction, provided mainly by my lawyer, I had to limit myself to visiting local dealers. Visiting dealers and buying their gems at exhorbitant prices had not been the purpose of my trip. What I wanted was not gems as clear as water, but to collect minerals in interesting habits, on matrix if possible. My presence became known and a miner from Sverdlovsk visited me. He brought with him beautiful specimens of emeralds on matrix and was glad to sell them to me at a reasonable price. Thus the disappointment of not being able to visit the mines was offset by the advantage of examining these specimens in comfort and at leisure.

Back in Moscow I went to the Fersman Museum where we came to an agreement that, in the future, all publications from the Institute concerning new and interesting minerals, plus specimens of finds in the Urals, were to be sent directly to me. Such publications were then to be translated and passed on to important English and French museums. I, on the other hand, sent important communications and interesting European minerals to Moscow. The specimens sent me grew into a collection of very beautiful Russian minerals, a fine addition to the collection I had been able to acquire during my stay in Moscow. Unfortunately, this collection had to be left behind when I fled from the Nazis, left France, and sought refuge in America.

From Prague to Paris

One evening in 1937 my telephone in Prague rang. Well-informed newspaper people, friends of ours, called me from Vienna repeating again and again, "You must be leaving Czechoslovakia by tonight. You must be leaving . . . you know that, right?" I understood what was being said; we had no choice but to leave or we would have been done for. Another dream was over, again all but one shirt, a profession and a background was lost. The family enterprises disappeared, a little commercial start was cut off, my third mineral collection given up. My whole life changed without my ever intending it to change, as happens again and again to so many people.

We took the train to Paris that same evening with a stop-over in Budapest. In Budapest I had conducted substantial business with Count Zsivny, the curator of the Mineralogy Department of the State Museum. Count Zsivny received me kindly and as soon as I had told him that we were moving to Paris "forever," he said to me, "Mr. Cassirer, we still owe you money on account of the specimens with which you supplied us." I said immediately that the money was not yet due according to the agreement. "But," he continued, "I imagine you may need it now and I can give you 20,000 *pengoe* on account. I shall have the sum ready this afternoon if you would come back around 3 pm."

When I told my wife about this unexpected offer, she said right away not to go there, "for it might be a trap and very dangerous." I went anyhow at the appointed time and was given 15,000 *pengoe*. These I even got through the exit control at the Hungarian border, but with the final result in Paris that the exchange of *pengoes* had already been stopped because of the uncertain political situation in Europe. Professor Zsivny, nonetheless, had been kind to expedite payment as he did; but more so, the transaction had given me one last chance to visit once more the museum's world-famous gold collection, literally a hall *filled* with gold, beautifully displayed under glass cases to focus on the excellent crystallizations of these specimens. They had all been found in the northern part of the Balkan countries while Budapest had been the center of Balkan pride. A fine last impression! (Last also in the sense that we can never set eyes on this collection again since all was lost without a trace after the museum was leveled during Societ occupation of Budapest in 1956.)

We had taken along another "life-saver" to Paris, a letter of credit from the Prague State Traveling Office which, on our arrival in Paris, turned out to be entirely worthless. When I presented the letter in Paris I found that the Paris branch of the Czech office had been closed because the Germans had already entered Czechoslovakia.

Since my sister lived in Paris, our decision to go there was natural. There was great happiness at our reunion, but especially in our feeling of having gotten away in time before the German troops had reached us. In addition, there was also this happiness: the break in my life turned my attention from my commercial life again back to my earliest dream, to work in mineralogy!

(to be continued)

The Record Bookshelf

The Science of Minerals in the Age of Jefferson, **by John C. Greene and John G. Burke. Transactions of the American Philosophical Society, Volume 68, part 4, (1978), 113 pages, 2 figures. Available from the American Philosophical Society, 104 South Fifth Street, Philadelphia, PA 19106; $10.00 plus $1.00 handling charge.**

It was in November of the year 1802 that Benjamin Silliman traveled from New Haven to Philadelphia with Yale College's entire mineral collection packed in a small candle box, hoping to find there someone who could correctly identify the specimens, a task which neither he nor any of his colleagues at Yale was able to do. Silliman, who would soon play a leading role in establishing the science of mineralogy in America, wrote: ". . . so little had been effected in forming collections, in kindling curiosity, and diffusing information, that . . . it was a matter of extreme difficulty to obtain, *among ourselves,* even the *names* of the most common stones and minerals; and one might inquire earnestly, and long, before he could find any one to identify even *quartz, feldspar,* or *horneblende,* among the simple minerals . . ."

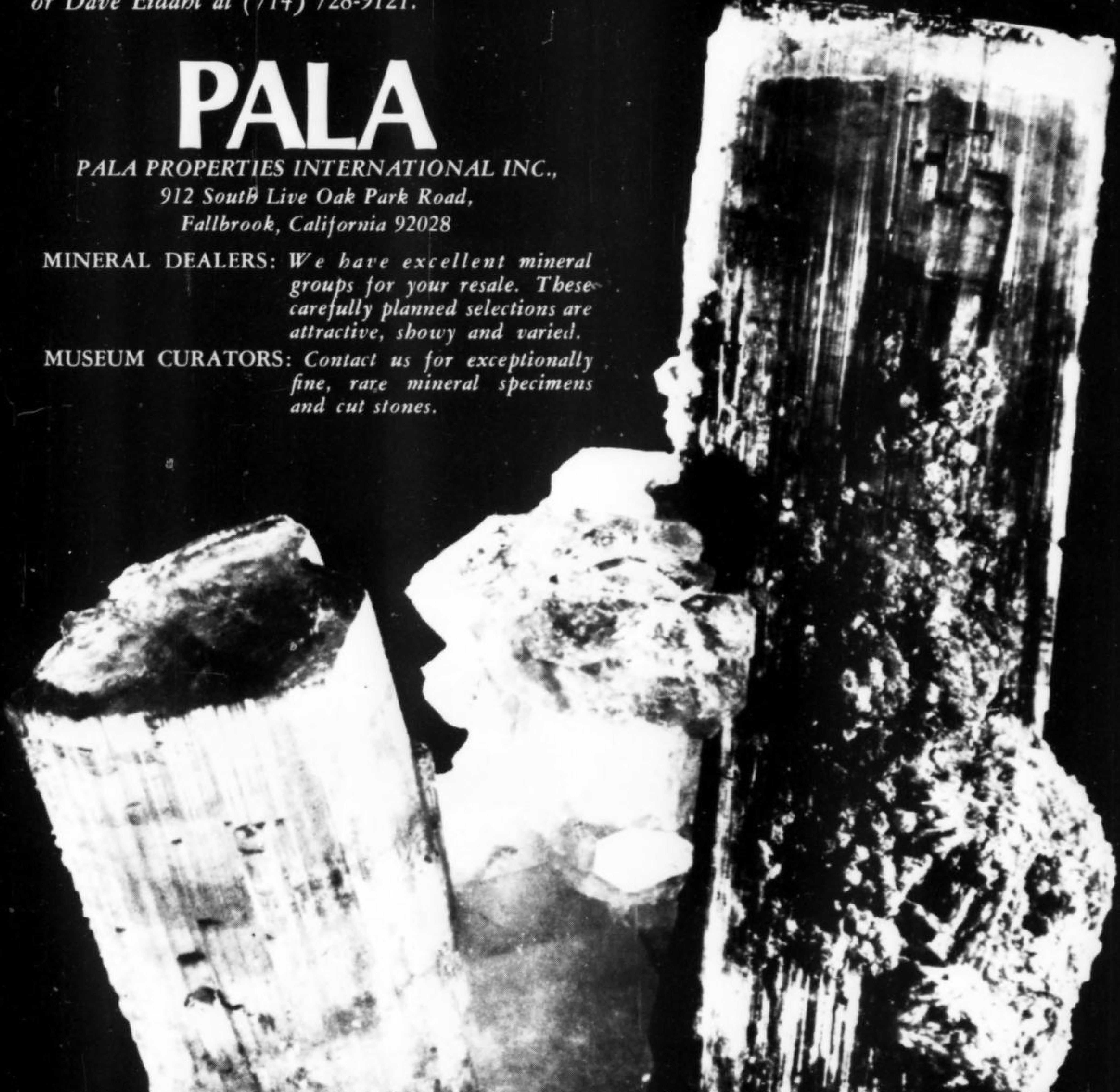
Such was the state of the young science of mineralogy in America at the beginning of the nineteenth century. In Europe, mineralogy was already a well-established science but in America it was still in its infancy despite the vast mineral treasures waiting to be discovered and described. But due to the efforts of a few dedicated and enthusiastic scientists, including Silliman, the future development of American mineralogy was assured. *The Science of Minerals in the Age of Jefferson* is an account of the vigorous and sometimes nearly heroic efforts of that pioneering generation of American mineralogists.

The authors begin by outlining the development of mineralogy in Europe from its earliest beginnings to the significant achievements made by the end of the eighteenth century. They then proceed to describe in detail the efforts of the small group of mineralogists scattered throughout America whose accomplishments, while relatively insignificant when compared to those of the more advanced scientific community in Europe, provided a firm foundation for American mineralogy. The period covered is 1780–1820, referred to as the "Age of Jefferson". As the authors point out, the sciences in America developed regionally, so their treatment of the development of mineralogy in America is on a regional basis. A look at the Table of Contents shows their plan: I. Mineralogy becomes a science; II. Europe and America; III. Mineralogy in Philadelphia; IV. The New York mineralogists; V. First efforts in the Cambridge-Boston area; VI. Parker Cleavelend and the unification of American mineralogy; VII. Yales moves to the fore; VIII. Mineralogy in 1822.

Professors Greene and Burke are to be congratulated for having compiled an enormous quantity of valuable and interesting information about our mineralogical "ancestors," the collections they assembled, the organizations and journals they founded, the hardships under which they often worked, and the rivalries and controversies which sometimes arose among them in their eagerness to make new discoveries. The information on very early mineral collections in Europe and America and the role these collections played in stimulating the development of mineralogy is particularly interesting.

Reading this important publication will be both educational and entertaining for any amateur or professional mineralogist who has an interest in the history of mineralogy and of mineral collectors. It is a pleasure to recommend it.

Robert Middleton



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